

# Chapter 10

## Undervoltage (27) Protection Testing

### 1. Application

Equipment operating at lower than nominal voltages could overheat due to the increased amperage necessary to produce the same amount of power at the lower voltage. Undervoltage protection (27-element) is used to protect equipment from thermal stress created from lower than rated voltages. 27-elements almost always incorporate time delays to prevent nuisance tripping caused by transients or sags in the system voltage.

While the actual 27-Undervoltage protection is relatively simple, it can be difficult to determine the correct application. The voltage element settings are often related to the nominal voltage setting of the relay which could be line-line or line-ground voltages depending on the system, number of potential transformers (PTs), and/or the PT connection as discussed in the “Instrument Transformer” section of Chapter 1.

After you have determined whether the relay measures phase-to-phase or phase-to-neutral, you should review the relay’s 27-element and nominal voltage settings to make sure that they are correct. For example; If a relay is connected to a system with two PTs, the nominal voltage is likely to be between 115-120V and would be phase-phase voltages. A 27-element setting above 110V will likely cause nuisance trips.

Sometimes a 27-element will be applied to monitor breaker status or to determine whether a bus or line is de-energized. These applications will have lower voltage settings (approximately 30V) and are for control applications.

Undervoltage (27) protection is almost the opposite of overvoltage protection but there are additional complications. When the protected equipment is de-energized, the input voltage should fall below the undervoltage setting and causes an undervoltage trip. The trip indication from the 27-element can be a nuisance for operators and even prevent the breaker from closing in some control schemes.

Relay voltage inputs are supplied by PTs and an open circuit PT fuse could cause a 27-element to trip. Would you want your entire plant to shutdown because someone accidentally touched a

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PT circuit? There are many methods for dealing with these problems and some are automatically applied by more sophisticated relays:

- Interlock 27-element operation with a breaker signal to block tripping unless the breaker is closed.
- Interlock 27-element operation with a 50-element to block tripping unless a preset amount of current flows.
- Only allow 27-element operation within a voltage window between pickup and minimum voltage. For example; if the voltage window is between 30 and 90V. The 27-element will not operate if the voltage is above 90V or below 30V.
- Interlock 27-element operation with a loss of fuse or PT fuse failure protection to block tripping if a PT fuse opens.
- Block 27-element operation if the positive sequence voltage is less than a predefined value to prevent nuisance trips if a PT fuse opens.

The test voltage must be initially higher than the 27-element pickup setpoint or the 27-element will always be on. Therefore, there must be some kind of pre-fault voltage applied for timing tests.

The input voltage is continuously turned off and on during relay testing and 27-elements often interfere with tests or are just a plain nuisance. I often disable 27-element while testing and save it until the very last test. Remember, disabled elements should be tested AFTER the settings have been enabled.

## 2. Settings

The most common settings used in 27-elements are explained below:

### A) Enable Setting

Many relays allow the user to enable or disable settings. Make sure that the element is ON or the relay may prevent you from entering settings. If the element is not used, the setting should be disabled or OFF to prevent confusion.

### B) Pickup

This setting determines when the relay will start timing. Different relay models use different methods to set the actual pickup. Make sure you determine whether Line-to-Line or Line-to-Neutral voltages are selected in the relay. The most common pickup setting definitions are:

- **Secondary Voltage** – Pickup = Setting
- **Multiple of Nominal or Per Unit (P.U.)** – If the relay has a nominal voltage setting, it could be a multiple of the nominal voltage as defined in the relay settings or it could be a multiple of the nominal PT secondary if a nominal PT secondary setting exists in the relay.  
Pickup = Setting x Nominal Volts, OR  
Pickup = Setting x Nominal PT secondary setting
- **Primary Volts** – There must be a PT ratio setting if this style exists. Check the PT ratio from the drawings and check to make sure that the drawing matches the settings.  
Pickup = Setting / PT Ratio, OR  
Pickup = Setting \* PT secondary / PT primary