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Application Note

Basler ES-32 Reverse Power Relay Improves Performance by Measuring Real Power

The ES-32 is a protective relay that provides reverse power operation. A reverse power relay is typically used in applications where protection from excessive power flow in an undesired direction is required. Common applications include the loss of prime-mover power in generator applications, detection of an islanded condition in a distributed generation application, or detection of power flow into a transformer from the secondary side. A very sensitive setting can operate on transformer core loss, which is indicated by power input to the transformer, thus detecting loss of the primary-side source.

ES-32 Reverse Power Relay

The ES-32 is a microprocessor-based relay that measures real power (P). Measuring true, real power improves performance in that it provides an accurate measurement of the actual system power flow. In synchronous generators, for example, the generator rating is specified in terms of maximum apparent power in kVA or MVA at a specified power factor and voltage under steady-state conditions. Voltage variation can affect the rated capabilities of a generator due to internal heating within the core. Increased core heating and losses are caused by increased magnetic flux, either by a reduction in operating frequency or an increase in terminal voltage. By utilizing the ES-32, which measures real power (VI cosθ), increased generator protection sensitivity can be achieved since the terminal voltage (V) is included in the determination of real power as defined by the following equation and illustrated in Figure 1.

$$P_{single\text{-}phase} = (VI \cos \theta)$$

Where:

P = single-phase real power (watts)
I = line current
V = line-to-neutral voltage
θ = power factor angle

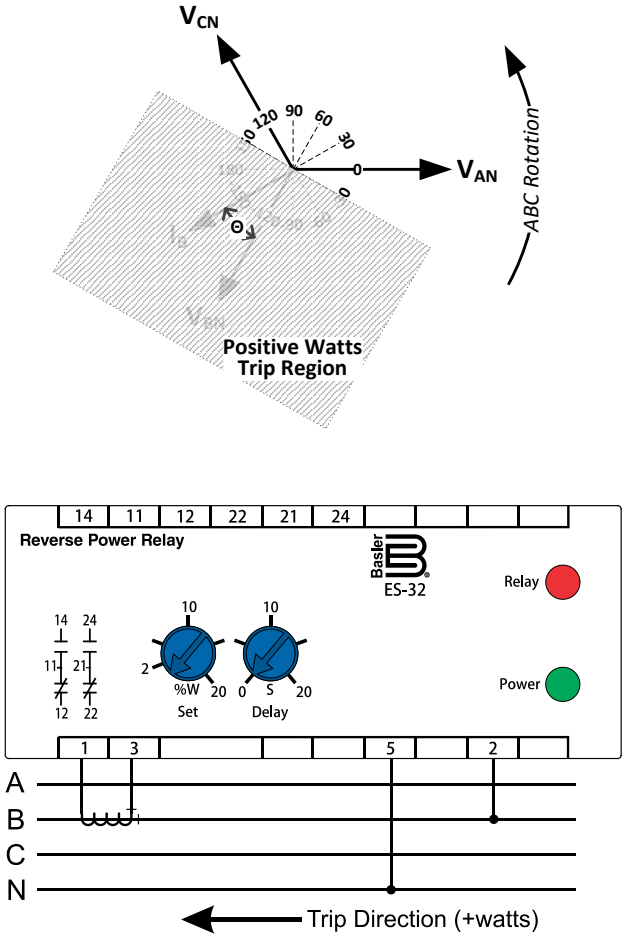

Figure 1 - Single-Phase Power Trip Region (0.87 PF Illustrated)

In addition to its ability to accurately measure and respond to real power, the ES-32 relay can also be used to detect reactive power (Q) through a simple wiring change.

Reactive power (Q) is defined by the equation:

$Q_{single\text{-}phase} = (VI \sin \theta)$

Using the identity: $\sin \theta = \cos(\theta - 90)$

Then: $Q_{single\text{-}phase} = VI \cos(\theta - 90)$

Where:

Q = single-phase reactive power (vars)
I = line current
V = line-to-neutral voltage
θ = power factor angle

The ES-32 can be used to monitor reactive power by shifting the sensed voltage -90°. This is achieved by applying the appropriate line-to-line voltage to a relay designed for line-to-neutral sensing. Figure 2 illustrates how a single-phase-voltage ES-32 relay can be connected to measure reactive power (Q) in a three-phase system. Note that the var measurement is in single-phase vars and is scaled (increased) by a factor of $\sqrt{3}$ because the monitored voltage is line-to-line.

The ES-32 relay operates on the fundamental component of sensed voltage and current, thus filtering out all harmonics. The relay can be ordered as either a single-phase or three-phase voltage sensing type. The three-phase voltage sensing type ES-32 relay is connected in a three-phase, three-wire voltage configuration and senses a single-phase current with three-phase line-to-line voltage. The positive-sequence voltage component (V1) is derived from the three-phase sensed voltage to improve the phasor representation of the sensed voltage for use in the power calculation which utilizes a single-phase current measurement.

The ES-32 is designed for use with 5-ampere nominal current sensing and requires no control power supply. The protective relay is equipped with two Form C output contacts and mounts on a standard IEC60715-compliant DIN rail.

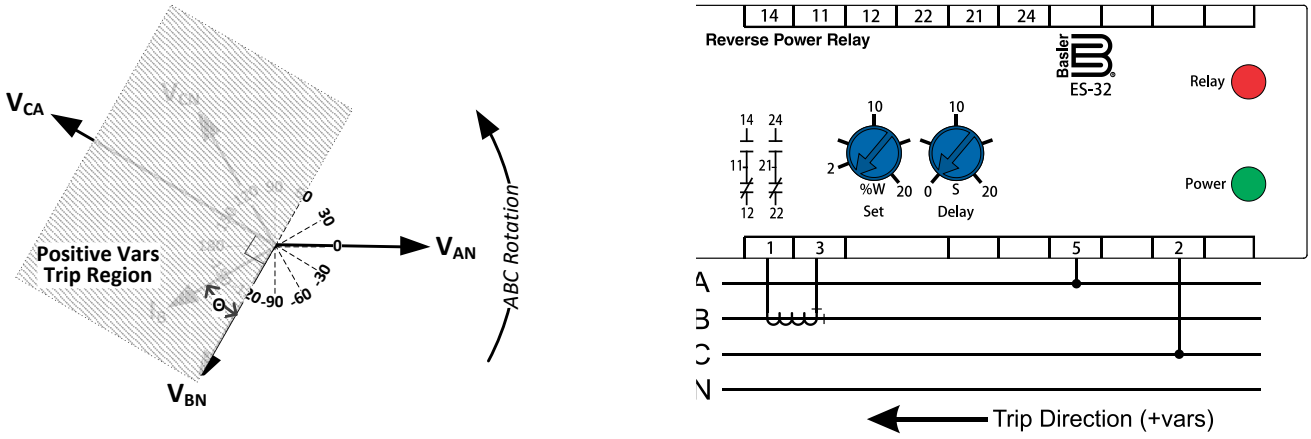

Figure 2 - Single-Phase Reactive Power Trip Region (0.87 PF Illustrated)

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