7EN72-0168-03
01/2016

Red/High Leg Delta configuration

The Red Leg Delta (also called High Leg Delta or 4-wire Delta) configuration was first used in the 1950s for industrial and factory applications. In this configuration, lighting loads were connected phase-to-neutral at 120 V and machinery was connected 3-phase at 240 V.

NOTE: This document applies to all PowerLogic™ ION meters.

In this document

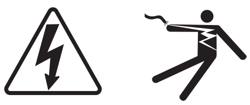
Schneider Electric

35 rue Joseph Monier
92500 Rueil Malmaison - France
Phone: +33 (0) 1 41 29 70 00
www.schneider-electric.com

Safety information

Important information

Read these instructions carefully and look at the equipment to become familiar with the device before trying to install, operate, service or maintain it. The following special messages may appear throughout this bulletin or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.



The addition of either symbol to a “Danger” or “Warning” safety label indicates that an electrical hazard exists which will result in personal injury if the instructions are not followed.

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

⚠ DANGER
DANGER indicates a hazardous situation which, if not avoided, **will result in** death or serious injury.

⚠ WARNING
WARNING indicates a hazardous situation which, if not avoided, **could result in** death or serious injury.

⚠ CAUTION
CAUTION indicates a hazardous situation which, if not avoided, **could result in** minor or moderate injury.

NOTICE
NOTICE is used to address practices not related to physical injury.

Please note

Electrical equipment should be installed, operated, serviced and maintained only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material.

A qualified person is one who has skills and knowledge related to the construction, installation, and operation of electrical equipment and has received safety training to recognize and avoid the hazards involved.

Notices

Legal information

Electrical equipment should be installed, operated, serviced and maintained only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material.

As standards, specifications and designs change from time to time, please ask for confirmation of the information given in this publication.

Safety precautions

Installation, wiring, testing and service must be performed in accordance with all local and national electrical codes.

⚠ DANGER

ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

- Apply appropriate personal protective equipment (PPE) and follow safe electrical work practices. See NFPA 70E in the USA, CSA Z462 or applicable local standards.
- Turn off all power supplying this device and the equipment in which it is installed before working on it.
- Always use a properly rated voltage sensing device to confirm that all power is off.
- Treat communications and I/O wiring connected to multiple devices as hazardous live until determined otherwise.
- Do not exceed the device’s ratings for maximum limits.
- Never short the secondary of a potential/voltage transformer (PT/VT).
- Never open circuit a current transformer.
- Always use grounded external CTs for current inputs.
- Replace all devices, doors and covers before turning on power to this equipment.

Failure to follow these instructions will result in death or serious injury.

Meter configured for 4-WYE (9S wire WYE/Delta) mode

Phase to neutral voltages

VAN, VBN,VCN are measured correctly, as V1, V2 and V3 are measured with respect to VREF (Neutral).

VLN AVERAGE will be correct, but invalid.

Phase to phase voltages

VAB, VBC and VCA are correct.

Current

IA, IB and IC are unaffected by the voltage configuration. The magnitudes measured by the meter are correct. A balanced three-phase load has currents IA, IB and IC equally spaced at 120 degrees. Single-phase loads connected between Phase A and Neutral, and Phase C and Neutral have current phasors at a phase angle relative to VAN and VCN respectively. The resultants IA and IC are the vector sum of their three phase and single phase currents.

Real power

The per-phase kWA, kWB and kWC readings are incorrect. In WYE mode, the meter calculates per-phase power as the product of VAN and IA (instantaneous values).

The total kW is correct.

Reactive power

The per-phase kVAR A, kVAR B and kVAR C readings are incorrect. The same analysis applies for real power.

The kVAR total is correct.

Apparent power

The per-phase kVA readings are obtained from the rms values of voltage (VAN) and current (IA). The same holds true for real power analysis.

The total kVA reading is correctly obtained by taking the square root of the sum of the squares of the total kW and the total kVAR.

Power Factor

As the load is a combination of single-phase connected and three-phase connected loads, the per-phase power factor readings are meaningless. The meter derives the correct total power factor value from the total real power and total apparent power.

Valid	Not Valid
Van, Vbn, Vcn	Vln avg is meaningless
Vab, Vbc, Vca	—
Vll avg	—
Ia, Ib, Ic	—
kW tot	kWa, kWb, kWc incorrect
kVAR tot	kVARa, kVARb, kVARc incorrect
kVA tot	kVAa, kVAb, kVAc incorrect
pf tot	pf a, pf b, pf c incorrect

Meter configured for DELTA (35S-3 wire) mode

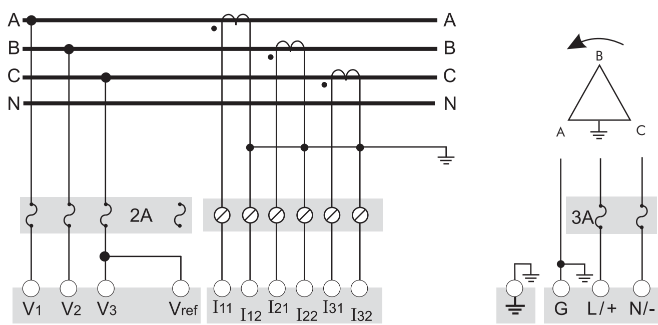
DELTA mode uses the two wattmeter method. Because the purpose of a Red-Leg Delta configuration is also to support single-phase loads, there is normally a neutral current. For this reason, setting the meter for DELTA mode is not a solution. If there is no current in the neutral, however, the readings will be correct.

⚠ DANGER

ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

- Never bypass external fusing. Install properly rated fuses in voltage measurement circuits and in auxiliary (control) power circuit.
- Connect protective ground (earth) before turning on any power supplying this device.
- All electrical connections to the meter terminals must not be user-accessible after installation.
- Confirm that the meter is matched to the correct socket type.

Failure to follow these instructions will result in death or serious injury.



Analysis

The following diagrams show phasors for the single phase load (1), the balanced three-phase load (2) and the resultant combined phasors that would be seen by a meter connected to measure the total load (3). In each diagram, **V** is the line-to-line voltage; single-phase and three-phase current is **I**. The power factor is **unity** (i.e. current is in phase with its associated voltage).

Diagram 1. Red Leg Delta connected single-phase loads on B and C phases

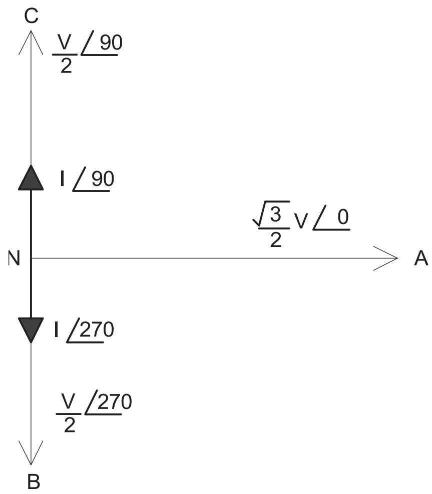


Diagram 2. Three-phase balanced load

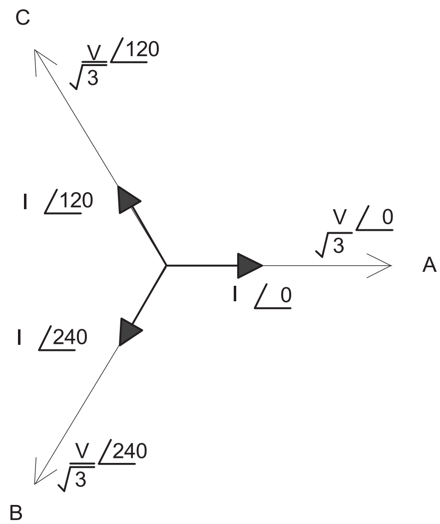
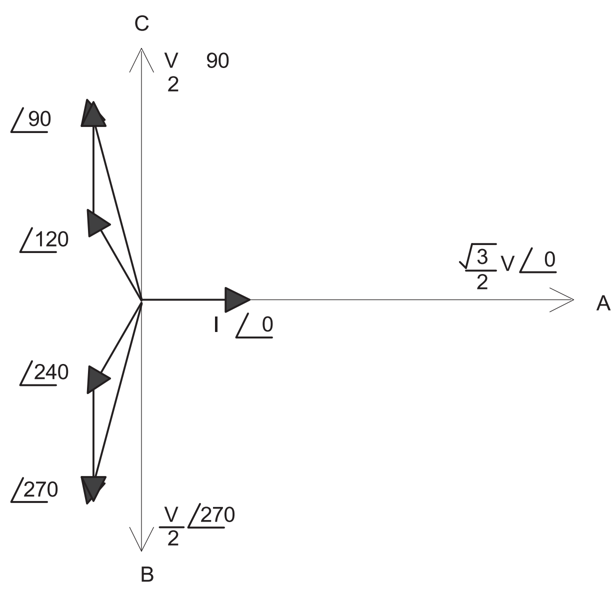


Diagram 3. Quantities as measured by the meter



The following analysis compares the resultant power readings of the previous three phasor diagrams. If the single-phase loads are balanced and the 3-phase loads are balanced, the total power will be correct.

Using S = V * Iconjugate, P = V * I cos ϕ and Q = V * I sin ϕ

For diagram (1) the power per phase is:

$S_A = 0$

$S_B = V/2 \angle 270° * I \angle (-270°) = (V*I)/2$

$S_C = V/2 \angle 90° * I \angle (-90°) = (V*I)/2$

$P_A = 0$

$P_B = V/2 * I \cos(0°) = (V*I)/2$

$P_C = V/2 * I \cos(0°) = (V*I)/2$

$Q_A = 0$

$Q_B = V/2 * I \sin(0°) = 0$

$Q_C = V/2 * I \sin(0°) = 0$

For diagram (2) the power per phase is:

$S_A = V/\sqrt{3} \angle 0° * I \angle 0° = (V*I) /\sqrt{3}$

$S_B = V/\sqrt{3} \angle 240° * I \angle (-240°) = (V*I) /\sqrt{3}$

$S_C = V/\sqrt{3} \angle 120° * I \angle (-120°) = (V*I) /\sqrt{3}$

$P_A = V/\sqrt{3} * I * \cos(0°) = (V*I) /\sqrt{3}$

$P_B = V/\sqrt{3} * I * \cos(0°) = (V*I) /\sqrt{3}$

$P_C = V/\sqrt{3} * I * \cos(0°) = (V*I) /\sqrt{3}$

$Q_A = V/\sqrt{3} * I * \sin(0°) = 0$

$Q_B = V/\sqrt{3} * I * \sin(0°) = 0$

$Q_C = V/\sqrt{3} * I * \sin(0°) = 0$

The correct combined real power per phase is derived by adding the per phase powers from (1) and (2):

$S_A = 0 + (V*I) /\sqrt{3} = 0.577 (V*I)$

$S_B = (V*I)/2 + (V*I) /\sqrt{3} = 1.077 * (V*I)$

$S_C = (V*I)/2 + (V*I) /\sqrt{3} = 1.077 * (V*I)$

$P_A = 0 + (V*I) /\sqrt{3} = 0.577 (V*I)$

$P_B = (V*I)/2 + (V*I) /\sqrt{3} = 1.077 * (V*I)$

$P_C = (V*I)/2 + (V*I) /\sqrt{3} = 1.077 * (V*I)$

$Q_A = 0$

$Q_B = 0$

$Q_C = 0$

Using one meter to measure the combined load (diagram 3) gives incorrect values for the power per phase. The total power parameters presented by the meter are correct.

First, calculate phase currents:

$I_A = I \angle 0°$

$I_B = I \angle 240° + I \angle 270° = 1.932 * I \angle (-105°)$

$I_C = I \angle 120° + I \angle 90° = 1.932 *I \angle 105°$

$S_A = \sqrt{3}/2*V * I = 0.866 (V*I)$

$S_B = V/2 \angle 270° * 1.932 * I \angle 105° = 0.966 * (V * I) \angle 15°$

$S_C = V/2 \angle 90° * 1.932 *I \angle (-105°) = 0.966 * (V * I) \angle (-15°)$

$P_A = \sqrt{3}/2*V * I \cos(0°) = 0.866 (V*I)$

$P_B = V/2 * 1.932 * I * \cos(270°-(-105°)) = 0.966 * (V * I) * 0.966 = 0.933 (V*I)$

$P_C = V/2 * 1.932 * I * \cos(90°-105°) = 0.966 * (V * I) * 0.966 = 0.933 (V*I)$

$Q_A = \sqrt{3}/2*V * I \sin(0°) = 0$

$Q_B = V/2 * 1.932 * I * \sin(270°-(-105°)) = 0.966 * (V * I) * 0.259 = 0.250 (V*I)$

$QC = V/2 * 1.932 * I * \sin(90°-105°) = 0.966 * (V * I) * -0.259 = -0.250 (V*I)$