Advel Application Note – AAN2014.1

Using a 3-phase line with mono-phase loads

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1. Introduction

Very often in an industrial plant you have available a three-phase line, at industrial frequency (50 Hz for Europe, 60 Hz in the USA). Despite the advantages of three-phase systems, many devices operate with a single-phase line. In that way it is possible to feed a single phase load, when they have a three-phase line?

2. Overview of the three-phase system

A three-phase line consists of three mono-phase generators, with the same voltage but 120° out of phase each other, with a terminal in common. For example, Italy is using 230Vac voltage phase to neutral and 400Vac voltage phase to phase. The wire to the common point is called **NEUTRAL** (blue cable), the three other wires are called **PHASES** (cables: brown, black, gray).

Advantages of three-phase line

The comparison between the weight of wires is one of the criteria that determines the economic viability of the line. In fact, the weight of the wires affects both the cost of material, the cost of laying work, etc.. Well, for the same transmitted power P [W], the more convenient transmission system is the three-phase line.
Furthermore, the generation of electricity occurs almost entirely in the form of three-phase alternating current, which allows the use of the three-phase asynchronous motor, a simple, robust, inexpensive and therefore constitutes the vast majority of engines used in industry.
Currently, the electricity transmission voltage 230kV - 400kV is realized by three-phase lines.

Sistema trifase a 3 o 4 fili

Si consideri una linea trifase, che come detto è costituita da tre generatori monofase di tensioni alternate, con lo stesso valore efficace ma sfasate tra loro di 120°, con le tre tensioni di fase identiche: è evidente che sommando le tre tensioni vettorialmente, si ha $\overline{V1}+\overline{V2}+\overline{V3}=0$.
Se si mette un carico identico per ogni fase, $Z1=Z2=Z3=0$, si ottiene il sistema di Figura1.

Three-phase with 3 or 4 wires

Consider a three-phase line, which as said consists of three mono-phase generators, with the same voltage value but 120° out of phase each other. It's evident that:
$\overline{V1}+\overline{V2}+\overline{V3}=0$ (note, it's a vector sum)
If you put a load, identical for each phase, we obtain the system of Figure1.

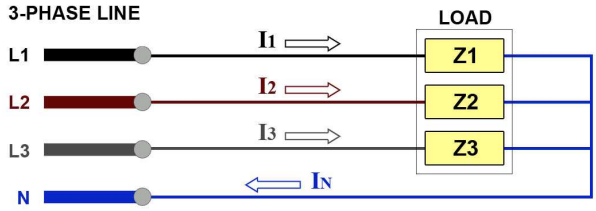

***Figure1** – Typical three-phase system, with 3 identical loads.*

The system is symmetrical, thus:
$\overline{I_N}=\overline{I_1}+\overline{I_2}+\overline{I_3}=0$.
Therefore in this system the return wire may also be omitted, since its current is zero. In this case, it's a "3-wire" three-phase system, which as seen is suitable for balanced loads.
However, the energy distributor doesn't know what is the user load, but often there is neither balance nor symmetry in the phases, then the return conductor, the Neutral, is always present in low-voltage installations.
It's referred as "4 wires" three-phase system.

More details about the three-phase lines are found in all the electrical engineering books and is beyond the scope of this discussion.

3. Using three-phase line as for mono-phase

From a three-phase 4-wire line is possible to obtain three-phase lines (**L1-N**, **L2-N**, **L3-N**), from which is possible to power single-phase devices.
Unfortunately, however, it's not simple the equale sharing of the load current over the three supply phases. This can be a major drawback in the case of large loads. As seen previously in fact the return current on the Neutral is equal to the sum of the currents of the individual phases and is greater the greater is the imbalance of loads. The Neutral cable has a section ypically smaller than that of Phases, and may be inadequate if the imbalance is excessive.
In addition, having access to a three-phase line with a total power **P**, each of the three single-phase lines can give a power up to **P/3**. So having

phase balance lets you use all the available power.

Three-phase transformer

The three/single-phase transformers distribute the load on the three phases of the three-phase line, even if not so perfectly symmetrical.

The three/single-phase transformers can be manufactured in different ways and are particularly useful when you need to power one large single phase load and you only have a three-phase system.

It must be said, however, that these transformers are very cumbersome, given that operate at low frequency, and also heavy: a three-phase transformer 1kVA weighs 15 to 20kg, a 10kVA weighs 80 to 90kg.

Power supplies with active current-sharing

The power manufactured by Advel can be placed in parallel and the functionality of the active current-sharing (**CSa**) allows to obtain a perfect distribution of the load between the power supplies in parallel. This gives rise to the idea of using three power supplies manufactured by Advel in parallel with CSa enabled: each power supply powered by a mono-phase line of a three-phase system, as in Figure 2.

The three power supplies, thanks to CSa, absorb exactly the same power from each of the three mono-phase lines, then the three-phase system is perfectly balanced.

Moreover, the system can be sized to achieve redundancy of type n +1. In case of failure of one of the 3 power supplies, the load would still be powered, while the three-phase line would remain unbalanced for a short time and in any case not excessively.

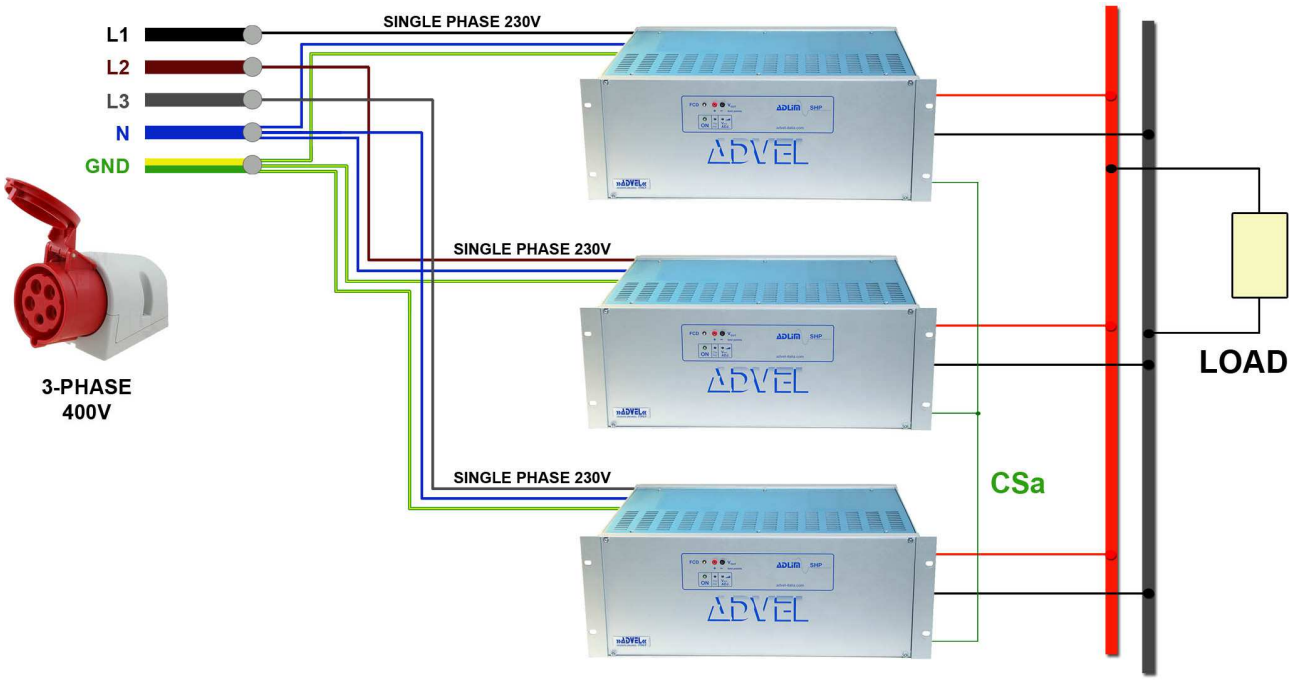

Figure 2 *- Three mono-phase power supplies SHP-series, manufactured by Advel, put in parallel with active current-sharing enabled, powered by three-phase system: this is perfectly balanced.*

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