AN ALTERNATIVE TO THE LV NETWORK REINFORCEMENTS

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ABSTRACT

The Problem
In France, LV customers who do not exceed 18 kVA are largely fed in single-phase.

So, LV networks are unbalanced and it generates important voltage drops.

- *In urban zone, there are many customers on the same LV feeder and bulking effect is sufficient to make this phenomenon less annoying.*
- *In the rural zones, some LV networks are long and supply few customers. It is on this type of networks that the LV unbalanced currents generates most problems regarding voltage drops.*

The solutions
The solution to solve this problem is mostly the reinforcement of the LV network.
Sometimes the customer impact is not enough to justify significant reinforcement costs.

So it was considered convenient to develop new equipments to minimize the single-phase customers effect by compensating the unbalance currents effects.

THE RANGE OF THESE EQUIPMENTS

Today there are four different equipments designed:

- Two old systems were designed in the early 2000s.
- Two new systems have been developed quite recently.

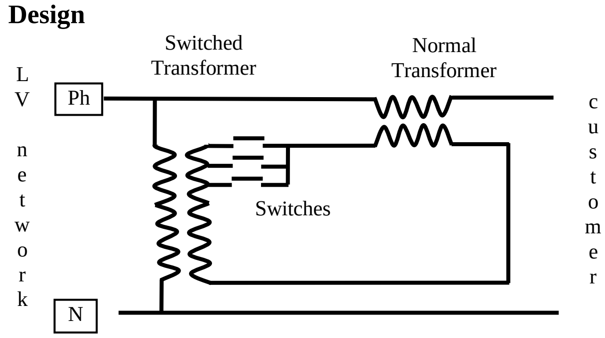
For each system, its electric scheme and the way it is integrated in the electricity network is explained below.

They are the VAS and the TMC who were the first ones to be installed on the LV networks of ERDF.

Voltage Adapter Slipper (VAS)

The VAS is an electronic control load regulator which maintains the output voltage within the range of 230V +10/-10%.

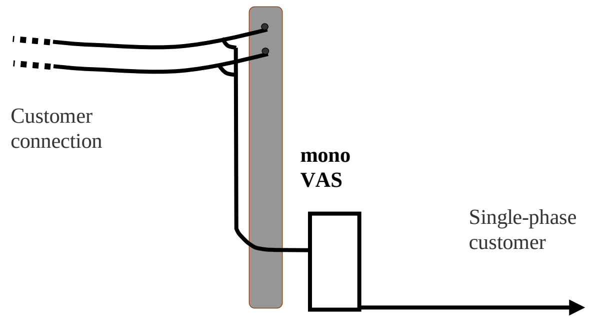
Design



The above plan represents the single-phase version. In the three-phase version, three single phase systems are used, one per phase, with an independent control for each one.

Four versions of VAS were initially created: the single-phase in 12 kVA and 18 kVA versions, the three-phase in 18 and 36 kVA versions. Nowadays only the single-phase 18 kVA and three-phase 36 kVA versions are installed.

Location



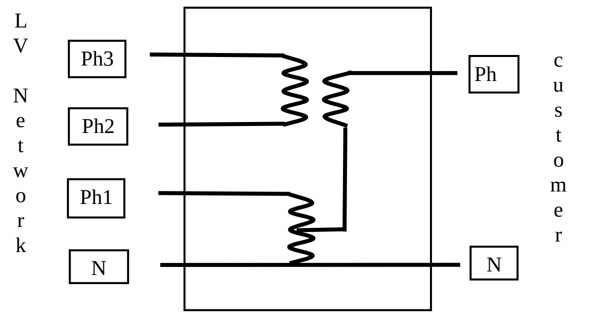
It is constituted by a cubicle which is, either put on the ground, or suspended from a pole.
In its three-phase version, it can be placed upstream to several single-phase and\or three-phase customers

These equipments, cost between 15 to 25 k€ (including installation), and weigh 200 to 450 kg according to the models.

Tri/Mono Converter (TMC)

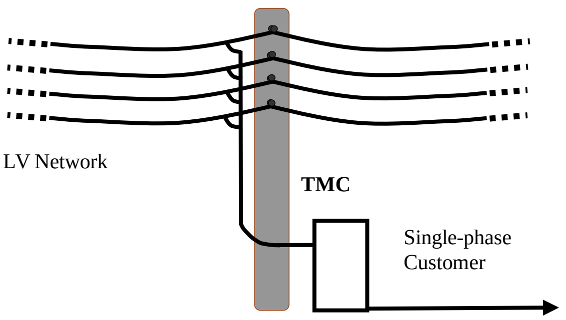
The TMC is an interface between the single-phase customer and the network. It allows the network to see this customer as a three-phase customer well-balanced. It is installed just upstream of the single-phase customer to reduce at most the voltage drop.

Design



Two versions, 9 and 12 kVA single-phase, had been developed. Only the 12 kVA version was marketed.

Location



The TMC is planned to be settled on a base in concrete.

This equipment costs around 10 k€ (including installation) and weigh 250 kg.

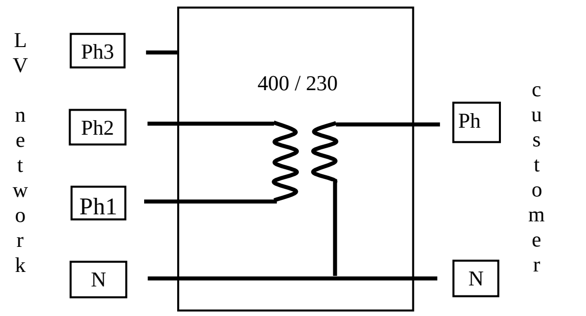
Assessment after 10 years of experience

In front of these high costs and delicate installation due to the weight, two new equipments were developed at the end of 2009: the BMC and the TNB.
Their main advantages are a cost and a weight decreased by half.

Bi/Mono Converter (BMC)

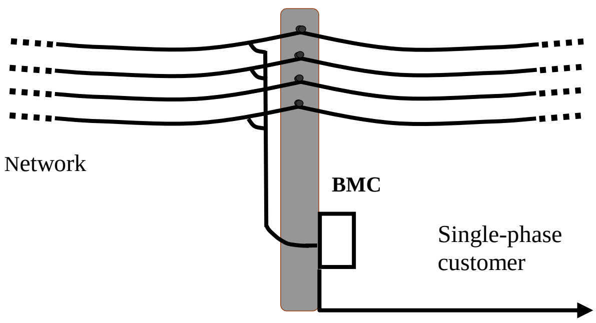
The BMC is an interface between the single-phase customer and the three-phase network which allows to distribute the power of the single-phase customer on two phases.

Design



The 9 kVA version received its authorization from ERDF for use in networks in December 2009.

Location



The BMC is inside a cabinet fixed on a pole. As the TMC, it is also as near as possible of the customer.

It presents two advantages with regard to both first ones:

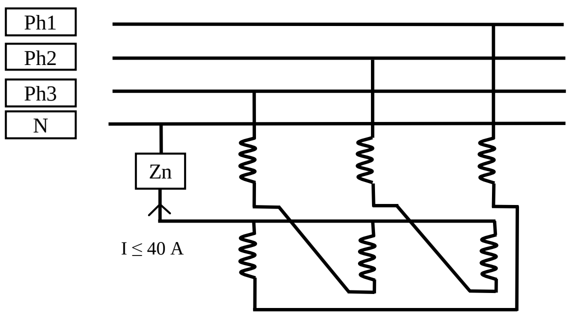
- its cost, including installation, is only around 5 k€
- its weight reduced to only 70 kg.

Three-phase Network Balancer (TNB)

The TNB is an equipment which is connected in parallel of the network. A coupling ZIGZAG between the network three phases allows to create a neutral point. This last one is connected with the neutral of the network by a resistor (Zn). When the network is unbalanced, there is a current circulation in the resistor which contributes to rebalance the network.

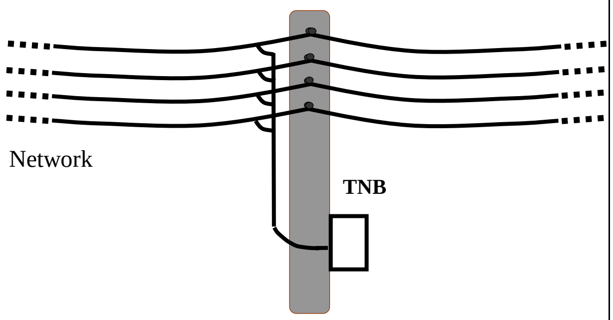
The peculiarity of TNB is that upstream the network is balanced (the current value on the 3 phases is identical) but the current value in the neutral is not null.

Design



It is at present available in the 40A version corresponding to 9 kVA.
Please note: It can be connected upstream to few customers and it is possible to equip the LV feeder of several TNB.

Location



The TNB is inside a cabinet and fixed on a pole. It is connected directly to the LV feeder and there is no customer connected directly to the TNB.

Its cost and its weight are similar to those of the BMC: 5 k€ and 70 kg.

DOMAIN OF USE OF THESE FOUR EQUIPMENTS

Each of these equipments has a specific application field. The system selection results from both electric and economic considerations.

This paragraph specifies for each equipment their set up conditions to guarantee that it deliver the expected service within the best cost.
So it is necessary to take into account:

- the voltage correction allowed by the equipment
- the capacity of the equipment
- the cost of the equipment compared to a classic network reinforcement

Voltage correction allowed

Each of these equipments allows to reduce the voltage drops. We can remember:

Equipment	Performance
Three-phase VAS	Compensates Voltage drop till 20 %
Single-phase VAS	Compensates Voltage drop till 20 %
TMC	Divides the voltage drop by 6
BMC	Divides the voltage drop by 3
TNB	Divides the voltage drop by around 2

Capacity of the equipment

We shall remember that these five equipments can be set up on the LV feeders with few customers and when the customers affected by voltage drops have the following characteristics. Otherwise its capacity is exceeded.

Equipment	Performance
Three-phase VAS	1 or 2 single-phase and/or three-phase customers up to 12 kVA on each phase
Single-phase VAS	1 single-phase customer up to 18 kVA
TMC	1 single-phase customer up to12 kVA
BMC	1 single-phase customer up to 9 kVA
TNB	Single-phase and three-phase customers up to 45 A on each phase.

Economic conditions

To simplify the decision-making between:

- the classic solution of network reinforcement,
- the installation of a compensation equipment

We simply compare

- the complete cost C of the compensation equipment (including installation & initial studies)
- the cost R of the network reinforcement.

These equipments are economically justified if:

	t-p VAS	s-p VAS	TMC	BMC	TNB
C / R	< 0,42	< 0,42	< 0,45	< 0,49	< 0,49

We are in a ratio less than 0,5 for two reasons.

- First, we had to compare two solutions with different life expectancies, 10 years for the equipments and 40 years for the network. At ERDF, we use capitalised cost to compare two solutions. For this case, the result gives a factor 0,5.
- So why in the board above, the numbers are smaller than 0.5? In fact these coefficients going from 0,42 to 0,49 reflect the equipment level of Joule losses. On this aspect, we can see that the least successful is the tri-phase VAS and the best are the BMC and TNB.

We can illustrate this rule by the following example.

The more frequent is the reinforcement of bare overhead lines (4x12² CU) by twisted overhead lines (4x70² AL).

If the reinforcement length is superior to the value in the board below, the compensation equipment is the best solution.

	t-p VAS	s-p VAS	TMC	BMC	TNB
Equivalent length of reinforced network	900 m	700 m	310 m	130 m	150 m

These numbers suppose that the equipment allows to postpone of at least 10 years the network reinforcement.

So it is necessary to be sure that during this period:

- the LV network will not have to be replaced;
- the customers will not wish an increase of power;
- there will be no new customers.

A DIFFICULT ELECTRIC CALCULATION

But all these equipments don't like to have upstream customers as they can produce voltage drop in the upstream network. In this case, installation of these equipments requires detailed electrical studies.

If we do not simply want to appreciate the performance of these equipments through too simple rules, it is necessary to realize a calculation tool. It has to calculate the real voltage drops in unbalanced networks and also reproduces the effects of these very particular compensation equipments.

This tool will also have to look for the best distribution of the customers along the LV network (phases connections) to achieve an optimal efficiency.

Be careful, the voltage drops are often maximal when the imbalance is extreme. For example, on a network with three customers distributed each on a phase, the maximum voltage drop occurs when only one customer consumes electricity. The tool will have to test all the scenarios not to forget these particular cases

CONCLUSION

In conclusion, the presented compensation equipments are a real answer for management of LV overhead lines regarding the voltage drops.

They bring a set of efficient solutions:

- They are complementary and consistent to reduce voltage drops on LV feeders which supply few customers.
- They prove to be very often less expensive than classic LV reinforcement.

However, installation possibilities are limited by the following precautions for use:

- LV networks should still be in suitable & stable conditions for the next ten years at least.
- Upstream customers should not be disturbed by the system.
- Equipment Capacity should be sufficient.