IMPROVEMENT OF VOLTAGE CONDITIONS IN THE LOW VOLTAGE DISTRIBUTION NETWORK INTRODUCING "VROT-X-Y" – AUTOMATIC VOLTAGE REGULATOR

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CURRENT POWER QUALITY ISSUES and SOLUTIONS

Both the electric utilities and end users of electrical power are becoming increasingly concerned about the quality and efficiency of delivered electrical energy. The issues that are related to power quality and efficiency are not necessarily new, and can be generally categorized as:

- Aging and deterioration of existing infrastructure
- Continuous demand and load growth
- No capacity to expand and accept additional loads
- Transmission and distribution efficiencies
- **Bad power / voltage quality**

As the condition of the infrastructure continues to deteriorate and load continues to grow, power quality, transmission, and distribution efficiency, public safety, cyber security, and economic impact to resolve these issues become more of a concern not only for the utilities but also the industrial and residential consumers. These are some of the biggest challenges to the Utilities.

Solutions for these issues are addressed in many ways:

- **Traditional methods** can be quite expensive, requiring major reconstructions
- Long duration of construction
- Large capital investment
- Long term returns and public hearings.

This article is focused on **EGC innovative solution** for the improvement of the bad power and voltage quality within low voltage lines, but at the same time addresses and resolve other issues as a snowball effect, such as:

- Increasing electrical distribution grids efficiencies
- Balancing loads
- Improve impact to selectivity and sensitivity of grid protection
- Possible remote control / reading of revenue meters
- Significant reduction in power losses, harmonics, and flickers
- No currents in neutral line
- Possible to extend length of existing power lines coverage – no new substations needed
- …

Voltage is the basic and main parameter of the power system, based on which all the remaining parameters that define the technical performance of the power system are formed. When distributing electric power, it is very important to maintain a satisfactory standard voltage levels along the distribution network. Beside considering (active, inductive, capacitive) characters and factors for the quality of electric power along a low-voltage power line, the mode of the load (balanced, unbalanced) is also very important as well. The character and load regime that prevail on the low-voltage power line during the distribution of electrical power significantly affect the change in voltage, which affects the quality, quantity, and time of delivered electric power / energy.

Most common power issues are due to the long distance of the end customer from the 13.8/7,8 kV substation and the overloading of the low voltage feeder, where the quality of voltage is often not within the allowed limits. This article presents solving bad low voltage conditions in feeder, by introducing an automatic regulation transformer, innovative, fast installation, economically superior EGC solution that will satisfy **IEC EN 50160** standard for power quality and is in use in Europe and Asia from 2009. VROT can easily be adopted within Ecuador existing low voltage grids / networks.

Keywords: voltage quality, regulation transformer, voltage conditions improvement, innovative solution

Voltage Regulating and Optimizing Transformer:
VROT-X-Y

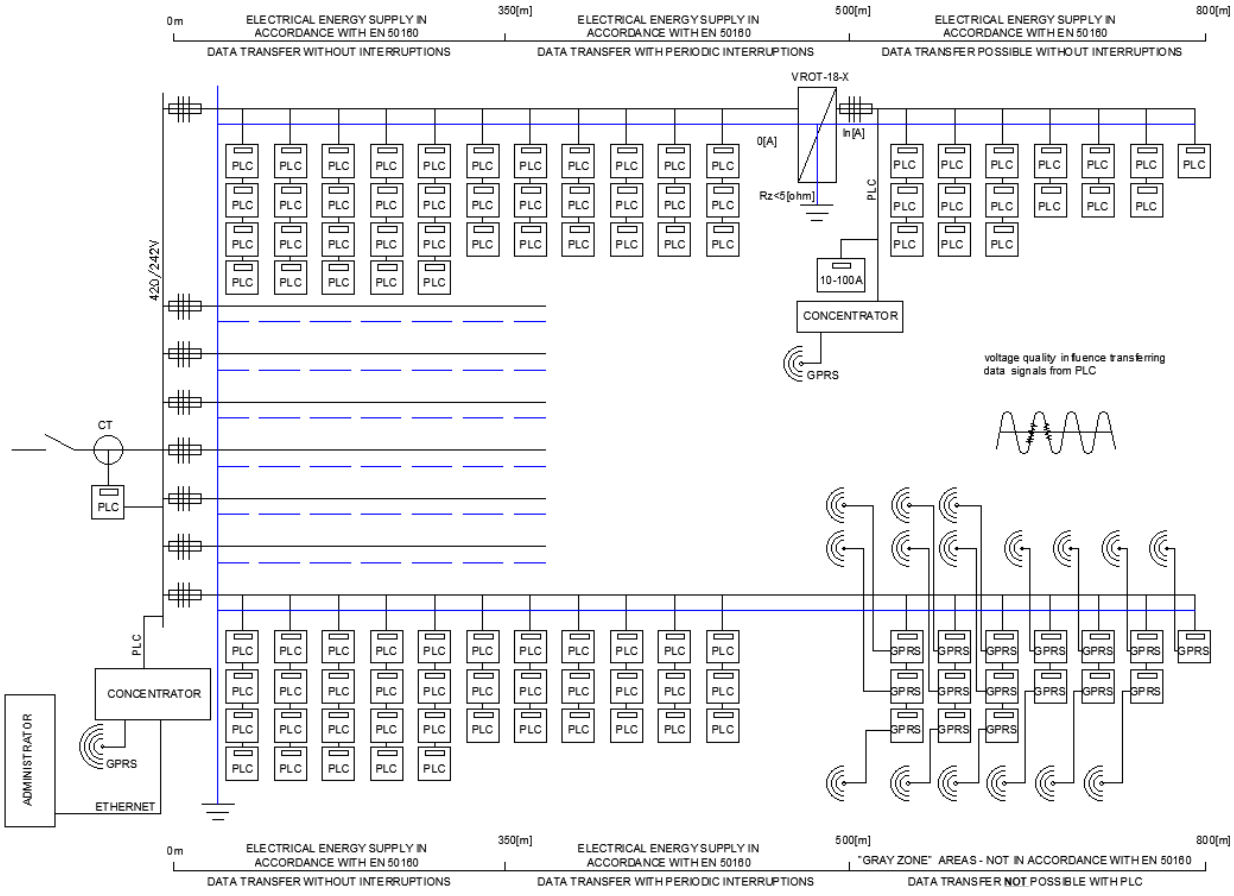
X = power [kVA],
Y = phases (1, 2 ,3).

Pictures on the right are showing single phase and three phase installed configuration of VROT-18 in Europe.

With the advent of VROT technology /automation making leaps and bounds into the electrical distribution areas, it's incumbent that the utility companies and to a lesser extent the end user or consumer, understand the ramifications of this technological transformation. With the EGC technology advancements the traditional grid model is now being transformed into a newer smart grid. This paradigm shift will allow for a better-informed, knowledge-based decision-making process in distribution utilities.

Implementing VROT, into the low voltage grids, a good automation balance is achieved. With this automation, in balancing the delivered power, the need to construct new substations and appurtenances will be reduced, thus providing a significant reduction in required funds. The Utility assets such the existing substations will be able to operate at steady state, extending its design life cycle. In general, the VROT provides grid with the visibility, automation, and control capabilities where none were existent before. The Utility companies will now have a clearer and better understanding of their operational grids in real time, giving them the flexibility to make the most efficient and optimal changes and improvements. Converting the system to Smart Grids. The net effect is maintaining the existing status quo or even a whereas other similar Utilities without VROT could see rate hikes on an ongoing basis.

Below is an example schematic diagram showing how VROT can be integrated within any additional hardware systems, local utility companies are using to remotely read meters. This gives Utilities ability to quickly identify any defected meters.



ONE PROJECT EXAMPLE IN EUROPE - ED Subotica (electric power distribution utility)

After confirmation that low voltage conditions are below the prescribed values, according to the EN 50160 standard, due to the long distance from the 13,7(22,8)/0.22kV substation and the overloading, determining the location where to set regulation transformer on a low voltage utility grid comes first. The choice of location determines what type and power rate the regulation transformer will be installed. Next, the pole loading of the selected pole should be examined according to the size and weight of the selected regulation transformer, and, if needed, the replacement of the pole should be predicted, too. After selecting a suitable pole, it is necessary to check the grounding of the pole according to the transformer manufacturer instructions and technical recommendations.

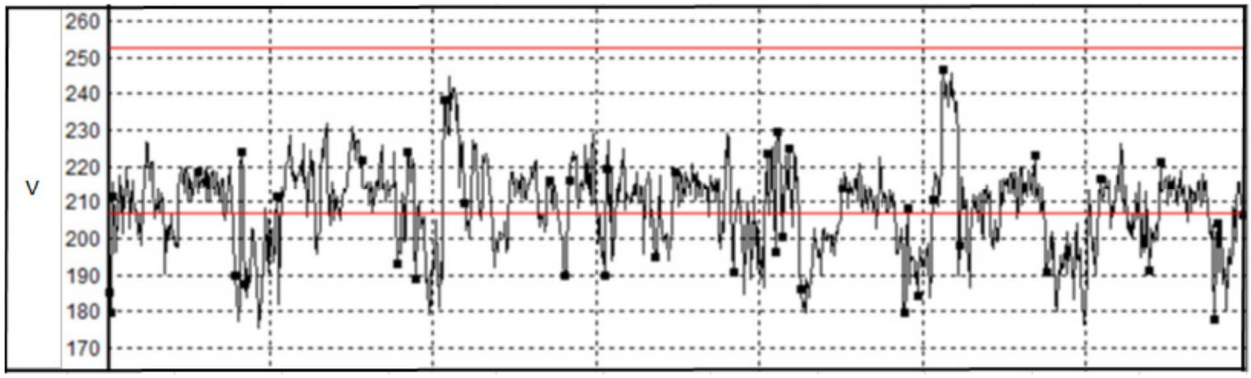
Upon the installation, voltage quality measuring results before and after the installation are given. The measurement of voltage quality was performed by network analyzers at the customer with the worst voltage quality conditions at the observed low voltage feeder. At the end of this article are enlisted and described advantages of VROT-18-1 regulation transformer installation. Here, we are addressing only high-level summary results from this Project full report.

EN 50160 standard prescribes that under normal operating conditions, except situations arising from malfunction or interruption in power supply, during each period of one week, 95% of the ten-minute mean effective voltage level values must be in the range of Un ± 10%, and 100% of ten-minute mean effective voltage level values must be in the range Un +10% / - 15%.

READINGS RECORDED:

Name Aggregation Number of aggregations	Test results % OK needed % OK	Nominal AVG of aggregations	Lower Limit % Lower Limit MIN of aggregations	Upper Limit % Upper Limit MAX of aggregations
Slow Variations V rms L1 10 min 1006	Test failed 95,0 60,0	230,0 V 208,9 V	-10,0% 207 V 175,7 V	+10,0% 253 V 246,7 V
Slow Variations V rms L1 10 min 1006	Test failed 100,0 85,9	230,0 V 208,9 V	-15,0% 195,5 V 175,7 V	+10,0% 253 V 246,7 V

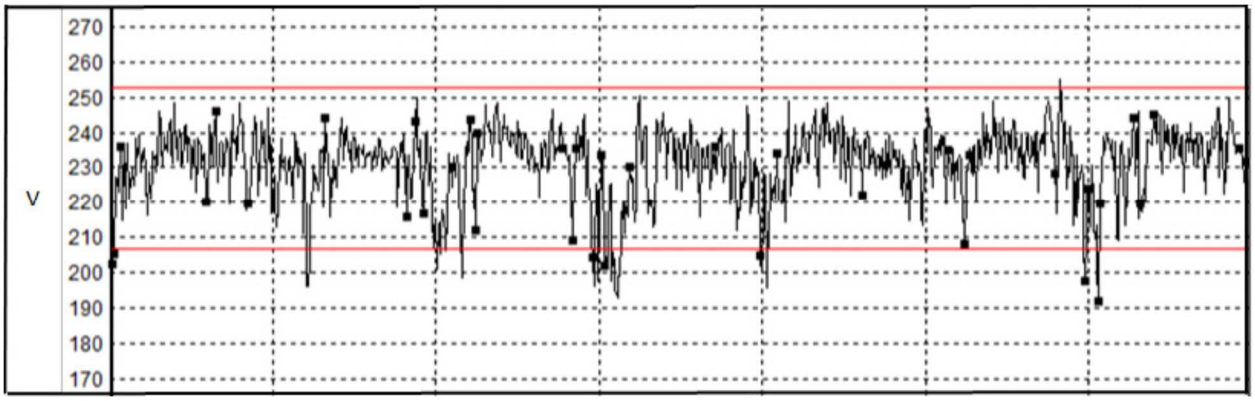
Table 1 – Voltage levels in accordance with EN 50160 at the existing last consumer in low voltage line **before** VROT-18 regulation transformer installation



Graph 1 – Voltage level diagram in accordance with EN 50160 at the existing last consumer in low voltage line **before** VROT-18 regulation transformer installation

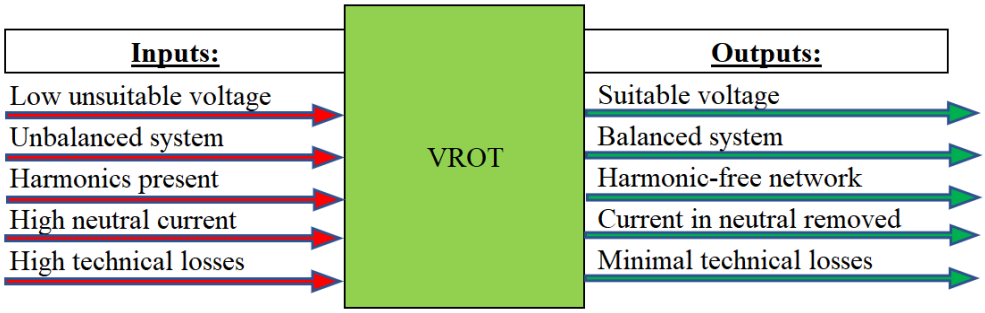
Name Aggregation Number of aggregations	Test results % OK needed % OK	Nominal AVG of aggregations	Lower Limit % Lower Limit MIN of aggregations	Upper Limit % Upper Limit MAX of aggregations
Slow Variations V rms L1 10 min 1006	Test failed 100,0 99,5	230,0 V 231,7 V	-15,0% 195,5 V 192,1 V	+10,0% 253 V 255 V
Slow Variations V rms L1 10 min 1006	Test passed 95,0 96,4	230,0 V 231,7 V	-10,0% 207 V 192,1 V	+10,0% 253 V 255 V

Table 2 – Voltage levels in accordance with EN 50160 at the existing last consumer in low voltage line **after** VROT-18 regulation transformer installation



Graph 2 – Voltage level diagram in accordance with EN 50160 at the existing last consumer in low voltage line **after** VROT-18 regulation transformer installation

BASIC VROT FUNCTIONS



ECONOMIC BENEFITS

Analyzing traditional method (rearrangement of single-phase users, increasing substation voltage, increase conductors' cross sections, installation of condenser batteries, did not result in satisfaction of the standard and economical solution. In this Project example new distribution lines and substation would need to be built to provide quality of power to the end users at the very end of the line. That was extremely solution costly with longer time construction. The investment will be high and return on investment (ROI) would be extremely low or none as there are not many end users impacted.

VROT solution offered here one day installation and instant guaranty of power quality to those end users. Very low investment in comparison to the traditional method and ROI is high. We can say in this case ROI comparison was in the range of 5:1 (VROT : Traditional solution).

CONCLUSION

- Above results demonstrate rapid improvements of the voltages to satisfy standards and improve overall low voltage grid.
- The VROT application solution is financially viable and much more convenient than traditional solutions.

BONUS PAGE-#1 – FEW PICTURES FROM VROT-18-1 INSTALLATION

1. Installation place VROT-18-1 in LV feeder from substation

2. Remote village - supplied power from VROT-18-1

3. Lifting VROT-18-1 on pole

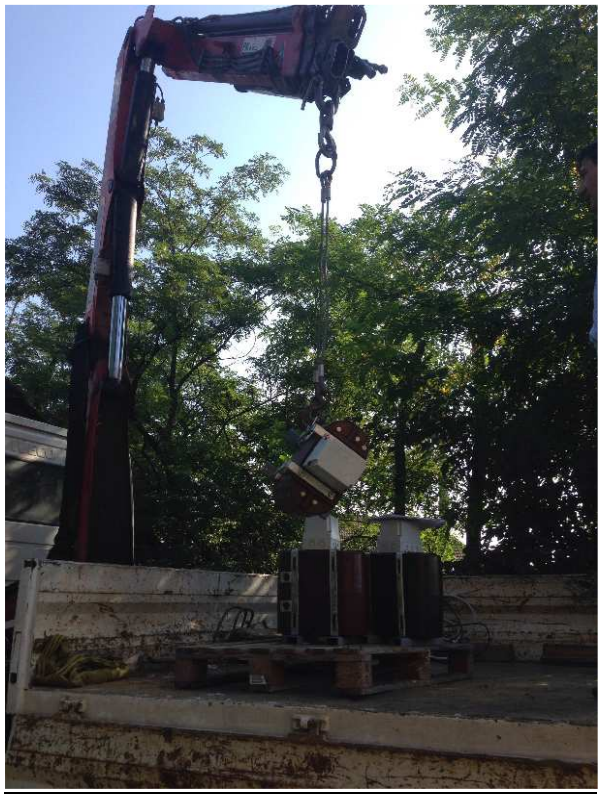
4. Mounting VROT-18-1 on pole

5. VROT-18-1 installed on pole

6. Atmospheric Lightning break surge arrestor, VROT-18-1 is not damaged

BONUS PAGE-#2 –VROT-18-3 INSTALLATION – REPLACE NEED FOR NEW SUBSTATION

1. Console installation for VROT-18-3



2. Lifting, VROT-18-3 on pole

3. Mounting VROT-18-3 on the pole

2. VROT-18-3 installed and energized