# CALCULATION AND ANALYZE OF DISTRIBUTION NETWORKS FOR DIFFERENT LOAD MODELS

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**Abstract**:

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In this work there has been performed a calculative simulation of regime of middle-voltage radial distributive networks for different load models. The load has been made through exponential model. Characteristic values are shown in two-dimensional form.Calculation results are shown for 10 kV feeder Zupce.

Author' s basic intention is to present system which will help easier resolution of practical problems. Estimation power flow, power losses and voltages fall down are showing us the usage of PDM KMpq applicative program in electrical engineering.

**Key words**: distribution networks, power flow, power losses, load models

## 1. INTRODUCTION

Calculation of stationary positions of transmitting and distributive networks are usually carried out with load of constant power , which is independent from the voltage. However, the power of load depends on voltage in bigger or smaller amount, depending on the structure of the load in concrete network, i.e. in the network knob. This fact need to be respected if exact calculations of actual regime or of some perspective regime.

In this work there has been performed a calculative simulation of regime of middle-voltage radial distributive networks for different load models. In distributive network of Kosovska Mitrovica-Zupce, due to extremely high overloading, voltage deviations are very expressive which significantly influences on quality of electricity supply. With application of PDM ( 2 ) program packet, an analyze of one distributive 10 kV feeder has been carried out. The load has been made through exponential model. Coefficients of power self regulation varied in range of 0 to 2.

Usage of adapted program PDM $KM_{pq}$ determined certain sizes ( curent of the most encumbered branch, minimal voltage of network, power flow, power losses and losses of reactive power ).

In conditions of expressed overloading in distribution of active and reactive powers, losses in feeder in this distributive network occur. In work, through tables and graphic schemes are shown the results of calculations for different voltage values of voltage knob.

## 2. THE PROCEDURE OF CALCULATION OF CERTAIN VALUES

Overloading of loads are presented through its static characteristics:

$$P_i = P_{ni}\left(\frac{U_i}{U_n}\right)^{k_{pi}} \qquad (1)$$

$$Q_i = Q_{ni}\left(\frac{U_i}{U_n}\right)^{k_{qi}} \qquad (2)$$

where:

$k_{pi}, k_{qi}$ - coefficients which could have values of 0, 1, or 2.

When coefficients $k_{pi}, k_{qi}$ are equal to 0, 1, or 2 we are getting models of consumers of constant power, constant electricity or constant impendance.

Method of knob voltage is iteritive method ( 1 ), and iterative procedure ends when changes of total losses is smsller then specific punctuality, and then demanded results are being calculated, such as, electricity in branches, losses in each branch and total losses in the feeder. Losses in transformers are not being calculated.

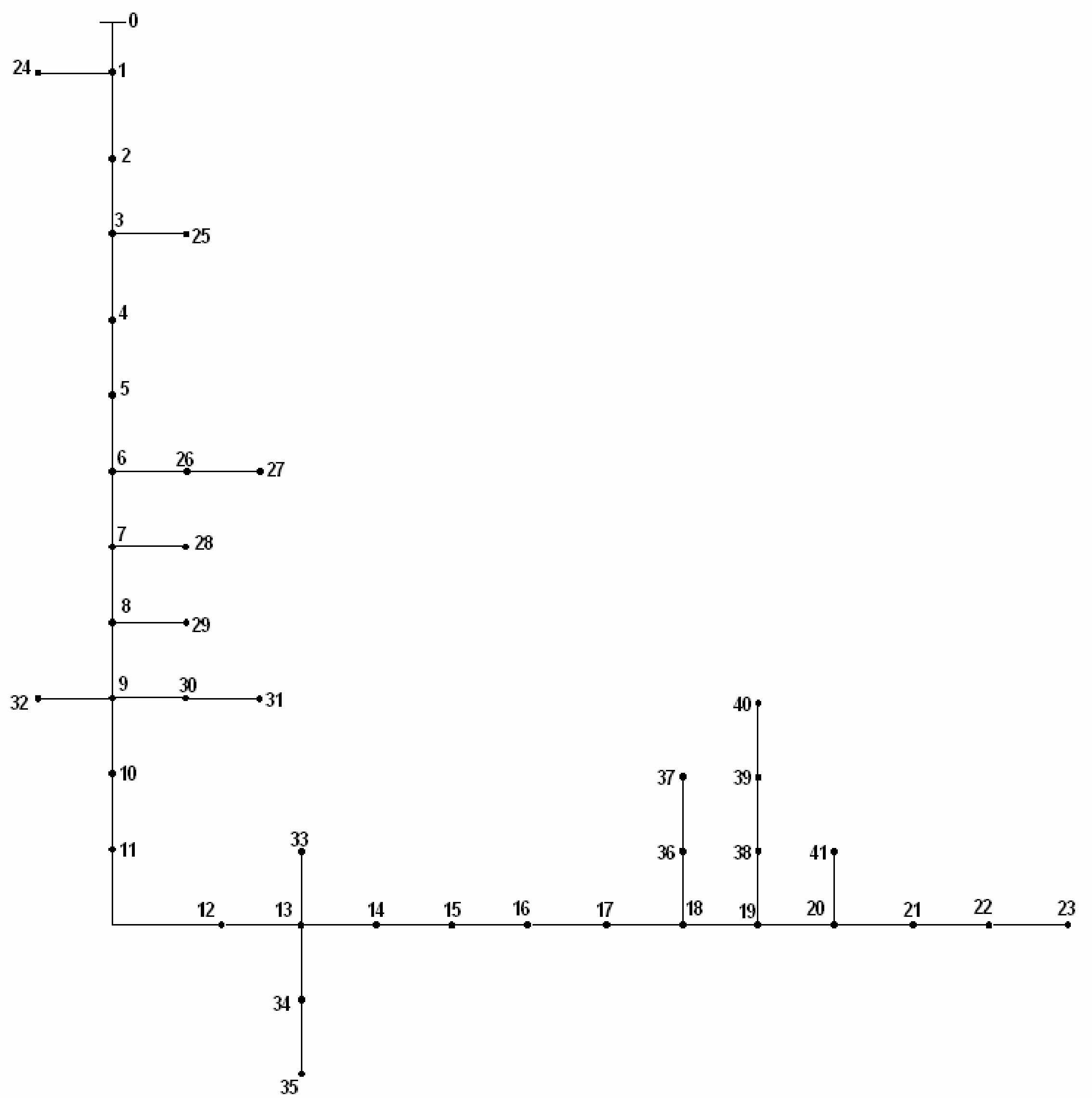
## 2. CALCULATION EXAMPLE AND RESULTS ANALYZE

Calculation results are shown for 10 kV distributive network in Kosovska Mitrovica. Voltage of this voltage knob varies in range of 0,9$U_n$ up to 1,0$U_n$, while coefficients of self regulation $k_p$, i.e. $k_q$ are in range of 0 to 2. It is adopted that all consumers are the same and that coefficients $k_p$, and $k_q$ are equal. At the beginning of power calulation of individual loads are suitable to nominal voltage.

An analyze has been carried out of these named parameters on following certain values:

- electricity of the most burdened network branch
- minimal voltage in the network,
- losses of active power in network and
- losses of reactive power in the network.

On picture no. 1 configuration of analyzed distributive radial feeder Zupce which supply from TS 35 /10 kV GAZIVODE.




Picture no.1. Configuration of radial 10 kV distributive feeder Zupce

In calculation load are firstly treated as load of constant power, than as load of constant current and in the end as load of constant impedance. In electro-distributions the load of constant impedance are the most frequent.

First, we will do the analyze of influence of supply knob on mentioned characteristics values for three basic types of loads. The results of calculations for the voltage values ( $U_0 = 0{,}9U_n$ and $U_0 = 1{,}1U_n$ ) are shown in the table 1.

Table 1. Calculation results for 10 kV distributive feeder Zupce

| $\frac{U_0}{U_n}$ | $k_{pi}, k_{qi}$ | $\frac{U_{min}}{U_0}$ | $I_{max}$ $[A]$ | $\Delta P$ $[kW]$ | $\Delta Q$ $[kVAr]$ |
|---|---|---|---|---|---|
| 0,9 | 0 | 0,615 | 400,85 | 1581,17 | 1035,886 |
| 0,9 | 1 | 0,764 | 253,53 | 586,195 | 390,027 |
| 0,9 | 2 | 0,82 | 197,56 | 346,094 | 231,365 |
| srednja vrednost | | **0,733** | **283,98** | **837,819** | **552,426** |
| odstupanje rezult. | | **16,098%** | **41,154 %** | **88,72 %** | **87,515 %** |
| 1 | 0 | 0,722 | 320,19 | 980,73 | 649,653 |
| 1 | 1 | 0,788 | 253,56 | 586,318 | 390,815 |
| 1 | 2 | 0,82 | 219,51 | 427,276 | 285,636 |
| srednja vrednost | | **0,776** | **264,42** | **664,774** | **442,034** |
| odstupanje rezult. | | **6,958 %** | **21,09 %** | **47,52 %** | **46,968 %** |
| 1,05 | 0 | 0,757 | 295,01 | 826,432 | 549,103 |
| 1,05 | 1 | 0,798 | 253,57 | 586,374 | 390,151 |
| 1,05 | 2 | 0,82 | 230,49 | 471,072 | 314,914 |
| srednja vrednost | | **0,7916** | **259,69** | **627,959** | **418,389** |
| odstupanje rezult. | | **4,37 %** | **13,6 %** | **31,6 %** | **31,24 %** |
| 1,1 | 0 | 0,785 | 274,57 | 711,91 | 474,106 |
| 1,1 | 1 | 0,806 | 253,58 | 586,426 | 390,454 |
| 1,1 | 2 | 0,82 | 241,47 | 517,004 | 345,62 |
| srednja vrednost | | **0,8036** | **256,54** | **605,113** | **403,393** |
| odstupanje rezult. | | **2,31 %** | **7,028 %** | **17,649 %** | **17,529 %** |

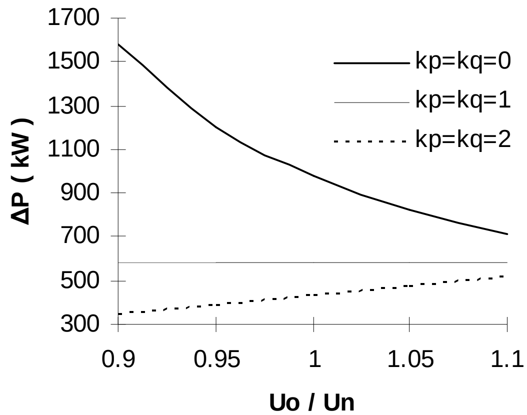
Due to great overloading ( $P_{max}$ = 4300 kW ) analyzed in 10 kV network, significant voltage deviations have been spotted within the knobs and that in relation to voltage in voltage-knob..

First we analyze the distributive network when voltage in voltage-knob is decreased and has value of 9 kV. In winter period the dispatcher is applying this measure since it is practically impossible to transmit the power when the voltage of voltage – knob is equal to nominal voltage of 10 kV. The curent in the first branch of network is the biggest and for the type of constant power load its value is 400,85 A, while for the type constant impedance load its value is 197,56 A. So,total change of current 116,87 A, which in percentage is 41,154 % out of medium curent value. Regarding losses for the same operational conditions, these losses are changing on following way. Total active losses of power are change in range of 88,72 %, while total reactive losses are changed in range of 87,515 %. For minimal voltage we have the following situation in the network. For load of constant power the minimal voltage in relative units has value 0,615 pu, while within load of constant impedance it has values of 0,82 pu, which means it changes for 16,098 %. The most critical values in the network are reached when load are of constant power ones.

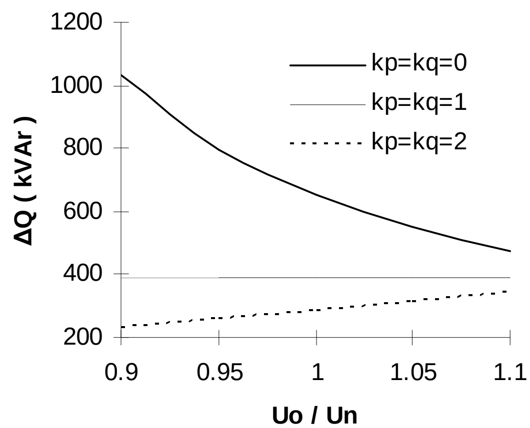
The best situation in network can be reached when load are of constant impedance ones. In practice this circumstance is used in winter period when dispatcher decreases the voltage in order to avoid unwanted breakdowns, due to overloading of certain elements in distributive network ( transformers and distributive radial feeder ).

In case dispatcher lifts up the voltage of voltage – knob on 10,5 kV , in all knobs of this distributive network voltage will become higher. However due to huge lenght of network and due overloading of certain branches of the network, voltage depreciations are still huge.Situation in the network is little more stable. Voltages are little higher, while current in first and in other branches are significantly decreased for load of constant power type. For load of constant power we have same results as in case of voltage values 9 kV. In case of having load of constant impedance, due to increasing of voltage value in knobs we have little increasing of power in knobs.

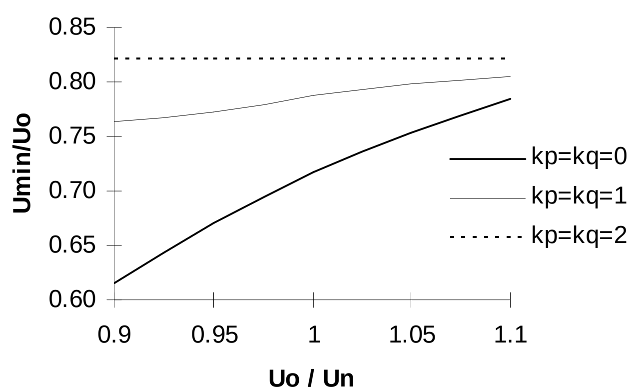
Graphic scheme changes of charasteristic 2,3,4 and 5.



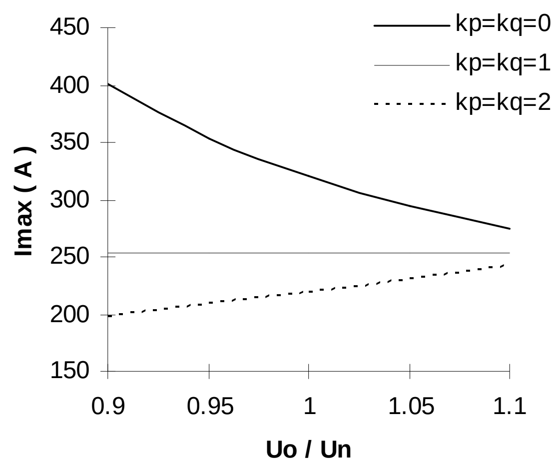

Picture 2. Losses of active power depending of voltage in voltage knob




Picture 3. Losses of reactive power depending on voltage in voltage knob




Picture 4. Minimal voltage in network depending on voltage in voltage knob




Picture 5. Maximal current depending on voltage in voltage knob

Analyzing and comapison of characteristic values for the same load models in discussed network can certify the following:

- Change of voltage value of voltage knob do not influence on total current and total losses i distributive network if all are constant power load,
- If power voltage increases for **10 %** in relation to results reached for nominal voltage **10 kV,** current in first branch increased for **14,247 %** and total losses of power for **27,41 %** in case there all constant power load,
- if power voltage increases for **10 %** in relation to results raeched for nominal voltage **10 kV,** current in first branch increases for **9,09 %,** and total power losses **17,35 %** in case there are all constant impedance load,
- decreasing of power of voltage-knob for **10 %** in relation to results reached for nominal voltage **10 kV,** causes increasing of maximal current in first branch for **20,12 %** and total losses of power for **37,974 %** in case there are all constant power load,
- decreasing of power of voltage-knob for **10 %** in relation to results reached for nominal voltage **10 kV,** causes decreasing of maximal power for **10 %** and total losses for **19 %** in case there are all constant impedance load.

Following was concluded for the discussed network:

- due to huge lenght of long distance feeder (42 km.) and overloading ( $P_{max}$ = 4300 kW ) voltagesare critical in all knobs, except in first and twenty fourth knob, where power falls smaller then **5 %** are allowed. This implies for case when all loads are of constant power and constant impedance, and power of voltage-knob is 10 kV.
- When all loads are of constant power and power of voltage-knob is also of 10 kV, and then results regarding voltage are even more critical. Only voltage in knob 1 and 4 are not critical. For this case we are getting critical current values, i.e. current is overcoming values of allowed current in branches 1, 2, 3, 4 i 18. So, maximum of overloading is surpassed considering the allowed power of overloading lines.
- It is necessary out of discussed distributive network to form two new radial feeder of which one would be feed out of TS 35/10 kV GAZIVODE, while second feeder would be feed from TS 35/10 kV SIMPO. Cutting of existing wire would be performed between knobs 11 and 12.

For two newly formed distributive feeders a new calculation is done and results reached are presented i tables no.1 and no . 2.

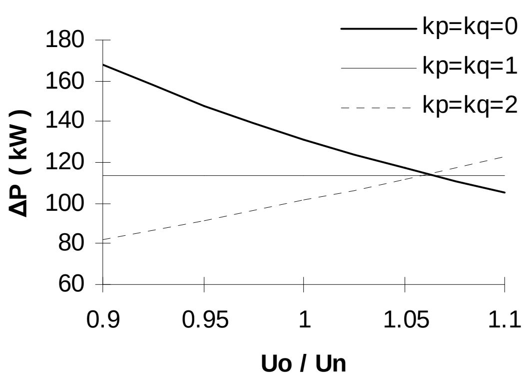
Table no.2. Calculation results for new-formed distributive feeder no.1 from TS 35/10 GAZIVODE

| $\frac{U_0}{U_n}$ | $k_{pi}, k_{qi}$ | $\frac{U_{\min}}{U_0}$ | $I_{\max}$ $[A]$ | $\Delta P$ $[kW]$ | $\Delta Q$ $[kVAr]$ |
|---|---|---|---|---|---|
| 0,9 | 0 | 0,9 | 160,7 | 167,652 | 111,52 |
| 0,9 | 1 | 0,917 | 133,27 | 114,296 | 76,142 |
| 0,9 | 2 | 0,93 | 113,37 | 82,198 | 54,815 |
| srednja vrednost | | **0,9156** | **135,78** | **121,382** | **80,825** |
| odstupanje rezult. | | **1,7 %** | **18,35 %** | **38,12 %** | **37,97 %** |
| 1,1 | 0 | 0,935 | 127,68 | 105,486 | 70,325 |
| 1,1 | 1 | 0.933 | 133,28 | 114,306 | 76,215 |
| 1,1 | 2 | 0,931 | 138,57 | 122,789 | 81,884 |
| srednja vrednost | | **0,933** | **133,176** | **114,193** | **76,141** |
| odstupanje rezult. | | **0,214%** | **4,126 %** | **7,62 %** | **7,638 %** |

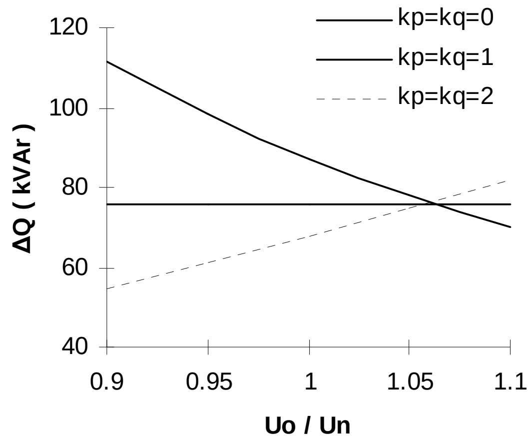
Table no. 3. Calculation results for new-formed distributive feeder no.2 from TS 35/10 SIMPO

| $\frac{U_0}{U_n}$ | $k_{pi}, k_{qi}$ | $\frac{U_{\min}}{U_0}$ | $I_{\max}$ $[A]$ | $\Delta P$ $[kW]$ | $\Delta Q$ $[kVAr]$ |
|---|---|---|---|---|---|
| 0,9 | 0 | 0,947 | 138,88 | 64,842 | 41,773 |
| 0,9 | 1 | 0,955 | 120,61 | 48,071 | 30,997 |
| 0,9 | 2 | 0,961 | 105,72 | 36,456 | 23,524 |
| srednja vrednost | | **0,954** | **121,736** | **49,789** | **32,098** |
| odstupanje rezult. | | **0,73 %** | **14,08 %** | **30,23 %** | **30,14 %** |
| 1,1 | 0 | 0,965 | 112,25 | 42,103 | 27,153 |
| 1,1 | 1 | 0,963 | 120,62 | 48,074 | 31,011 |
| 1,1 | 2 | 0,961 | 129,22 | 54,46 | 35,141 |
| srednja vrednost | | **0,963** | **120,696** | **48,212** | **31,101** |
| odstupanje rezult. | | **0,207 %** | **7 %** | **12,67 %** | **12,7 %** |

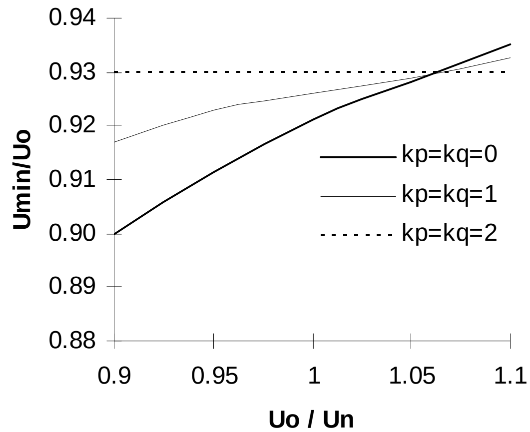
Graphic scheme of results reached for distributive feeder 1 are presented on pictures 6, 7, 8, and 9.



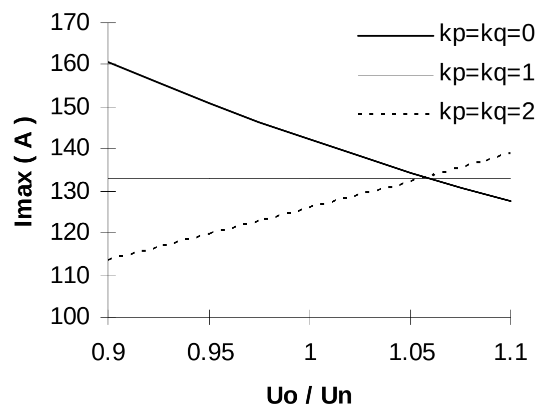

Picture 6. Losses of active power depending on power of voltage-knob




Picture 7. Losses of reactive power depending on power of voltage-knob




picture 8. Minimal voltage in the network depending on power of voltage - knob




Picture 9. Maximal current depending on power of voltage-knob

## 4. CONCLUSION

Calculation determines the maximum of perspective overloading, considering the allowed current of lines overloading of this perspective network. It is established that reconfiguration of the discussed network is needed with respecting of mimimal losses criteria. So, it is needed to divide the discussed network on two ditstributive radial feeders where overloading could be equally shared.

Calculation results show that the different load models significantly influences on degree of overloading and voltage circumstances in the network.Based on results for currents, losses of active and reactive powers and minimal voltages we can conlude that elements of newly formed distributive feeders are regularly dimensioned. Program packet can also serve in future planning and development of distributive 10 kV as well as in selection of elements for construction of new distributive network. Adapted program PDM $KM_{p,q}$ is perfect tool for engineers in electro-distributions who are dealing with problems of energetic and development of distributive 10 kV networks.

LITERATURE

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