EPCG AD NIKŠIĆ

FU DISTRIBUTION
SECTOR FOR DEVELOPMENT

AN OPTIMAL TECHNICAL SOLUTION STUDY FOR CONNECTION

OF

sHPP "BISTRICA" AND "KALUDERSKA"

PODGORICA, 25/06/2013

STUDY

Of possibilities, terms and conditions for connection of sHPP "Bistrica" and "Kaluderska"

For small hydropower plants "Bistrica" Bijelo Polje and "Kaluderska" Berane, for which the Ministry of economy intends to announce a public tender for granting a concession for exploitation of waterstreams, Sector for Development at FU Distribution has developed a feasibility study on possibilities and conditions for the connection of these small hydropower plants to the distribution network.

For the purpose of expressing an opinion on the possibility of connection to the electric power grid for the above mentioned sHPP, it is necessary to analyze the possibility of optimal technical connection solution, taking into account the following: the state of the network, the parameters of waters, the connection strength of small power plant, max and min load of feeders, as well as the parameters of the power supply of TS110/35 and TS 35/10kV Ribarevina and TS 110/35/10kV Rudeš.

An optimal technical solution for power plant connection has to reconcile demands of the distribution system Operator and the network users, and it has to be mutually acceptable. A technical solution for connection is considered acceptable for the Operator if it fulfills the following conditions: a) stability of facility and availability of the network are not undermined by the connection of the power plant; b) the parameters and conditions in the network are within the permitted limits; c) a technical solution of connection is in line with the development plans of the network, and d) the technical solution minimizes negative impacts of the power plant connection to the distribution network, if the power plant does not diminish the acquired rights to the other network users. For network users, a technical solution for connection is considered acceptable if a user achieves the minimum connection costs with a maximum network availability, which enables his unhindered and uninterrupted supply of produced electrical energy within the network for a specific connection capacity.

PARAMETERS WHICH DETERMINE TECHNICAL SOLUTION FOR POWER PLANT CONNECTION

Technical solution for power plant connection to the electricity distribution network includes a technical solution of connection and a technical solution of creating conditions in the network. A technical solution of power plant connection implies that a power plant meets the requirements of appropriate parallel mode operation with the network (the electric power quality, reactive power production within tolerable limits (cos Phi), safety, etc.).

Technical solution of power plant connection depends on a number of factors. The main factors are the parameters of the plant itself, and the most significant among these are the following :

- connection capacity of small hydro power plant,
- power plant location,
- type of power plant,
- the number of billing meter points BMP on location.

Connection capacity of small hydro power plant, along with its location, has the greatest influence on the technical solution of power plant connection. Another important factor that power plant connection depends on, is the exhisting electrical power network, to which a small hydro power plant could be connected.

- network configuration close to the power plant,
- distribution and connection capacity of existing plants in the local network,
- network distance from the planned power plant location,
- network load (the daily load diagram),
- reserves in voltage substation with automatic voltage regulation (solid line),
- development plan,
- connections in the process of implementation.

Relevant importance of the local network is defined by comparison of the load in the existing network with a connection capacity, which determines the intensity of the power plant impact to the network. It is important to consider whether there is a power plant in the network under consideration for the connection, or whether there is a plan for conducting power plant connection, because in that case, the analysis and criteria for the adoption of technical solution become rather complex. If terms and conditions for connection have already been issued, the operator is required to keep reserves in the network, which, according to the terms and technical solution of the connection given in terms and conditions, belongs to the power plant, over the validity period of 1 year.

Therefore, the power plants with the applicable terms and conditions are treated as existing producers.

STUDY OF OPTIMAL TECHNICAL SOLUTION FOR CONNECTION (SOTSC)

Apart from the local network power flows (the network taken into consideration is the one influenced by the power plant), the scope of the network considered by the SOTSC depends on the electric power substation (TS) superior to the closest power plant with the possibility of voltage regulation, i.e. maintainability of approximately static voltage, with respect to the highest voltage drop alongside waterstreams at the most vulnerable feeder of the substation area (at the maximum load without production of the power plants, but with minimum load and maximum production of the power plants), thus limiting the available scope of voltage regulation of energy transformer in the superior electric power substation.

The scope of calculation is defined by the study task for developing SOTSC and includes, inter alia, the short circuit calculation, power flows calculation and analysis, analysis of power system voltage circumstances of the selected network at current and future condition (including all the power plants with deemed connections (they have SOTSC) and their connection points in the network are included in this (SOTSC) for normal operation status and situations with single outages, criterion N-1, for each selected possible connection version, in the following cases:

a) maximum power plant load, without production during the period of maximum load
b) maximum production, without load during the period of minimum load
c) sudden interruption of production (power plant outage at maximum production) during the period of maximum load

CRITERIA FOR SELECTION OF OPTIMAL TECHNICAL SOLUTION

A variant of the technical solution for connection includes a selection of connection point, as well as the location and configuration of connection facility, and it is considered possible if under selected circumstances the network meets the following conditions:

a) permanent operation status of power plant-network user (supplier/buyer) is possible, i.e. supplying/transmission of electric power, according to requested connection capacity of the network user (in either direction), in the normal switching network status and with the ability to meet criterion n-1 (exceptionally).
b) power system-voltage conditions at all points in the observed network are kept within the permitted values, according to the Grid Code (the values of voltage, cos phi), and there is no overloading of the network elements.

Criteria for the selection of optimal connection type:
Positive (or less negative) impact of the power plant to voltage conditions
Minimal losses in the network (in the normal operation status)
Retention of the acquired rights of existing network users
The possibility of meeting criteria n-1
Minimum connection costs (the connection and creating conditions in the network)
Minimum connection implementation timeframe (connection realization timeframe, as well as realization of network requirements)
Other relevant technological, economic, legal and property criteria which are conditional for connection feasibility

Analysis and Studies on possibilities and conditions for connection sHPP "Bistrica" Ljubovida river and "Kaluderska" Kaludra river have been made on the basis of clearly established criteria and determined methodology for connection of small power plants to distribution network.
Analysis have been carried out on the basis of defined methodological process which consists of four sections:
-preparation of the network model
-determination of the parameters at the production unit's connection point
-analysis of technical possibilities for distributed production units' connection to the network and
-economic analysis
The network model is a key element for reliability and correctness of network analyses and it should present the real physical network situation. It is formed by applying the suitable program applications that enables the execution of analyses in the transmission and distribution network
The model is made on the basis of topological and attributive data of electric power elements.

For the analysis of distributed generation units, it is enough to model the medium-voltage distribution networks with a part of 110kV transmission network. Any change of voltage in medium-voltage network causes voltage change in low-voltage network, which most of the users are connected to. Therefore the model, regardless of the planned voltage level of DI connection, has to encompass also the low-voltage network, at least to the level of TS 10/0.4kV, including the associated distribution transformers and load. It is necessary to determine an appropriate branch of regulation for distribution transformers. Proper adjustment of branch is the key element in determining the real voltage in low-voltage distribution networks. If the voltage is unknown, it should be determined by simulations with the average loads and by simulating automatic regulation of distribution transformers in an appropriate "load flow" application.
When analyzing the DI impact on distribution network operation, even before performing the analysis, a question can be made on what the impact of the source generally is, with its rated power Sdi, to voltage change. In the network node, where the voltage changes minimally due

to the drive of DI, its effect can be neglected. In other words, the above mentioned point represents a solid line for DI, with substitutional impedance Zkm = 0Ω. For the electrically distant points, which are topologically behind the point of solid line, Di has less impact and causes minor fluctuations anyway. Permitted change limit is determined by the criterion of the maximum allowed voltage changes ΔUtm due to DI operation at the point of solid line . Permitted voltage change ΔUtm, at point TM, due to DI operation ΔUtm = 0.005. On the basis of specific point of the solid line and designed minimal distribution network model, the possibility of DI connection to the power network is defined. DI can be connected to the network, if the operation reliability and quality of electric power supply to end customers are not impeded. It means the following:

DI should not cause clogging in the network.

DI should not significantly impede load conditions at consumers' points in the network.

As consumers are connected to 0.4kV low-voltage network, voltage criterion restrics the voltage in low-voltage network. The voltage change which does not exceed the voltage criterion in low-voltage network, defined and circulating within permitted limits $0.40 \leq U \leq 0.42$ is allowed in medium-voltage network.

Analysis for connection of small power plants "Bistrica" Ljubovida river and "Kaluderska" Kaludra river have been made on the basis of methodology for analysis of possibilities and conditions for connection to electrical distribution network, which was presented in the Study of connection and operation of DI energy in the electric power energy system of Montenegro, and which was carried out for the purposes of the Ministry by the Institute "Milan Vidmar" from Slovenia. The points of the solid network were determined and models of minimal network were made for the sites where the future investors intend to construct small power plants, for the purpose of the analysis. Network modeling was performed based on data received from electric distribution centers Berane and Bijelo Polje.

Analysis of possibilities and connection conditions have been performed in the programme package SINCAL. Connection of small power plants have been analyzed for the most unfavourable situations: max load-min production; min load-max production.

Based on completed analysis and their results, the following can be noted:

- sHPP "Bistrica" S = 1.9MVA

In ZTS 10/0.4kV Ravna Rijeka, it is possible to connect sHPP capacity of 0.300MVA, for parallel operation with distribution network, to the existing 10kV network, with given network parameters.

sHPP capacity of S=1.9MVA is possible to be connected through new 10kV outflow at TS 35/10kV Ribarevina, by newly constructed air transmission line with conductors AlFe 3x70/12mm2, length approx. 5.5km.

For connection of small power plants of full capacity, it is necessary to extend the facility and do the reconstruction of TS 35/10kV Ribarevina, installing an outflow and a measuring unit- approx. € 50,000.00.

Construction of new transmission line with conductors AlFe3x70/12mm2, length approx. 5.5km, approx. € 270.000,00.

- sHPP "Kaluderska" S=0.9MVA

It is possible to connect a small power plant capacity 0.1MVA, to the existing 10kV network with given parameters.

For connection of sHPP capacity S=0.9MVA for the parallel operation with electrical distribution network a reconstruction of TS 35/10kV Rudeš is needed, as well as installation of an outflow and a measuring 10kV unit approx. € 50.000,00

Construction of new 10kV transmission line with conductors AlFe3x70/12mm2, sHPP "Kaluderska" - TS 35/10kV Rudeš, length approx. 12km approx. € 576.000,00

The Studies include technical solution for construction of the above mentioned small power plants to distribution system, with approximate length of connection lines and approximate prices for connection of these small power plants.

Please note that it is necessary to initiate the procedures for amendments of Spatial plans at the local governments, in order to provide the corridor for connection lines.

Attachements: Analysis carried out in program package SINCAL for various DI connection points and different DI capacities, with different lines' parameters.

Based on the results obtained through the program, connection points and voltage levels of connection for those small power plants have been determined.

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Head of the Sector
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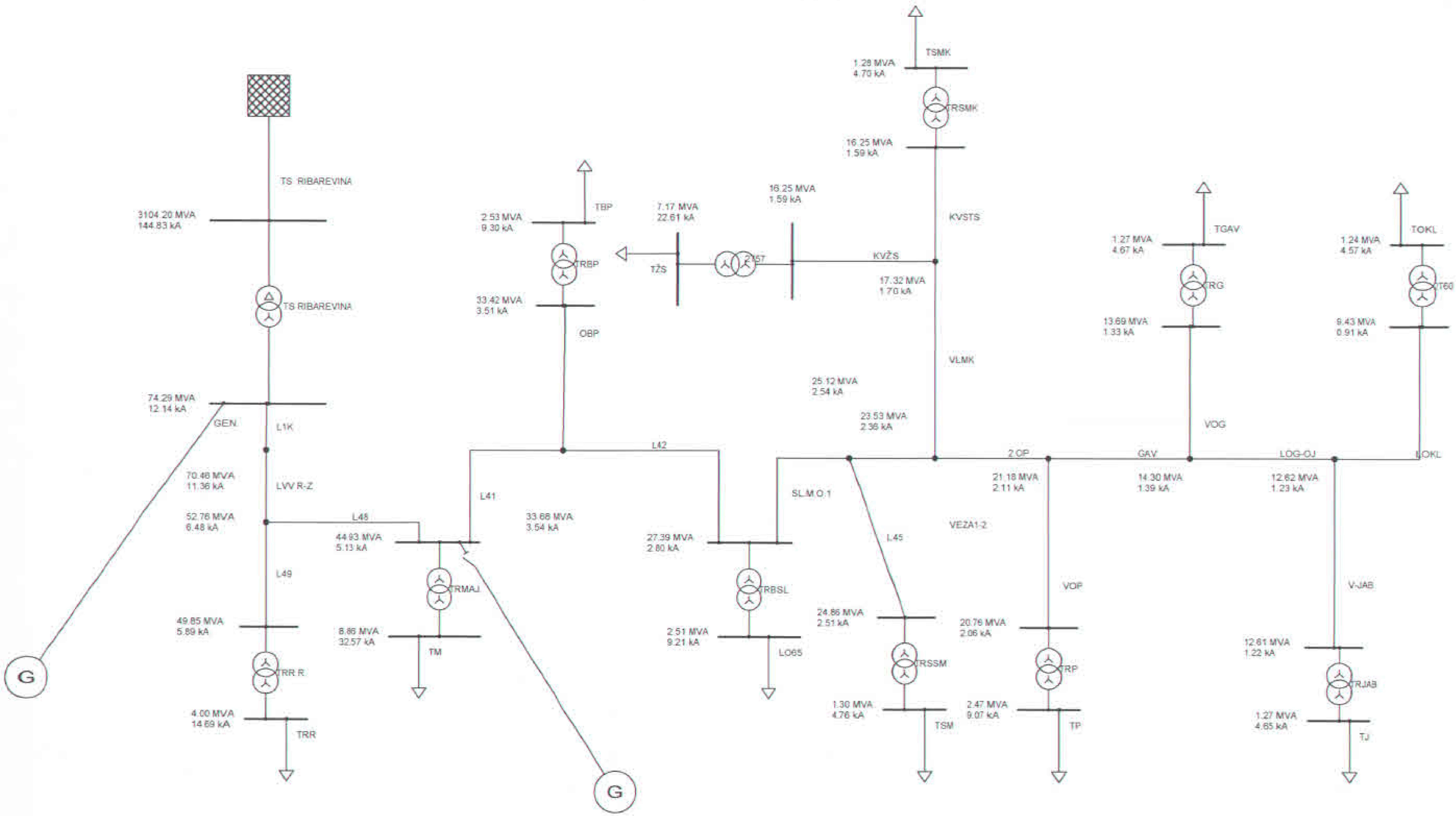
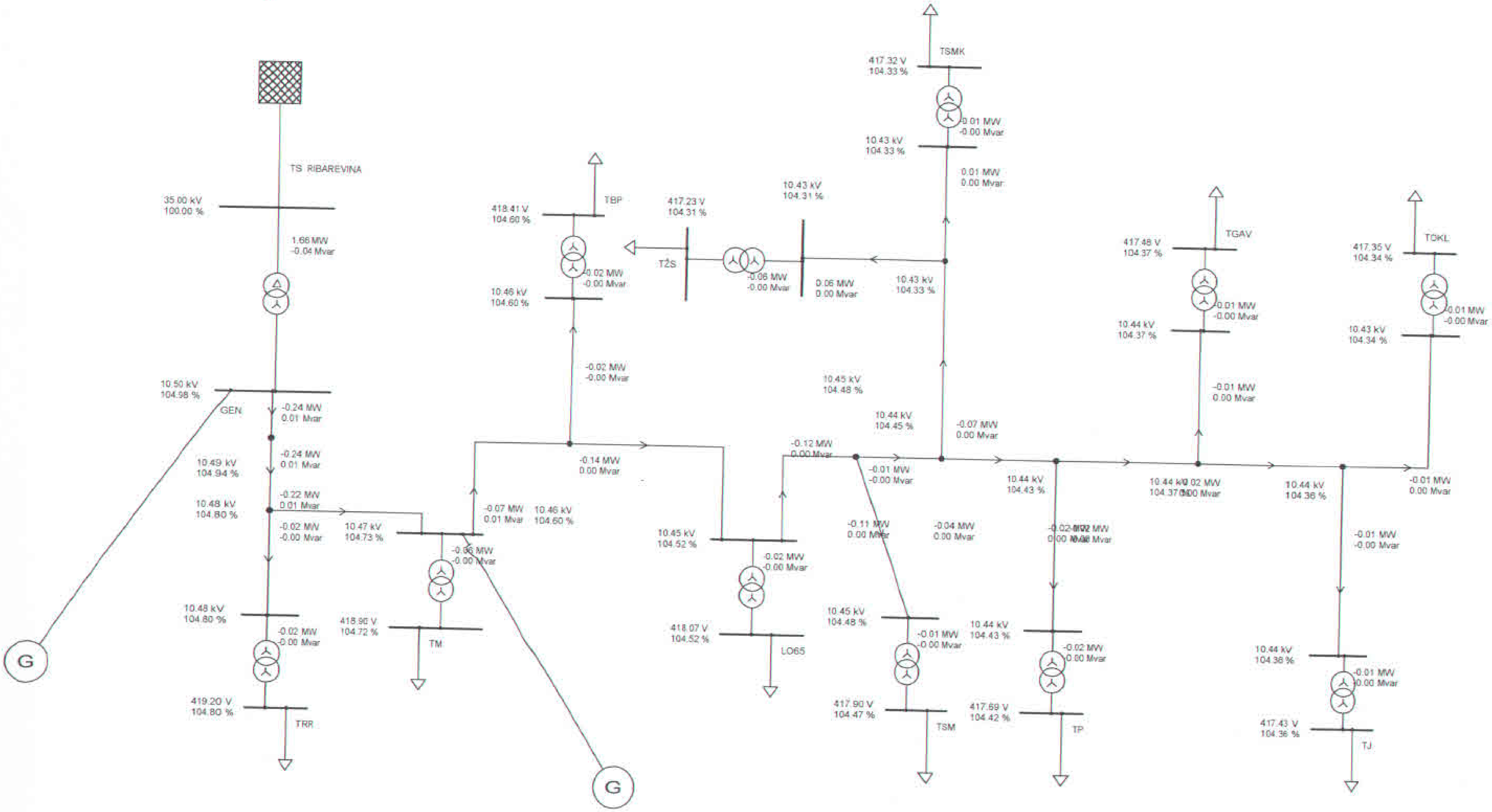
mHE"BISTRICA 1.9 MVA-SNAGA KS . PRIKLJ.NA 10 kV U TS RIBAREVINA 35/10 kV



mHE"BISTRICA 1.9 MVA-NAPONSKE PRILIKE PRIKLJ.NA 10 kV U TS RIBAREVINA 35/10 kV



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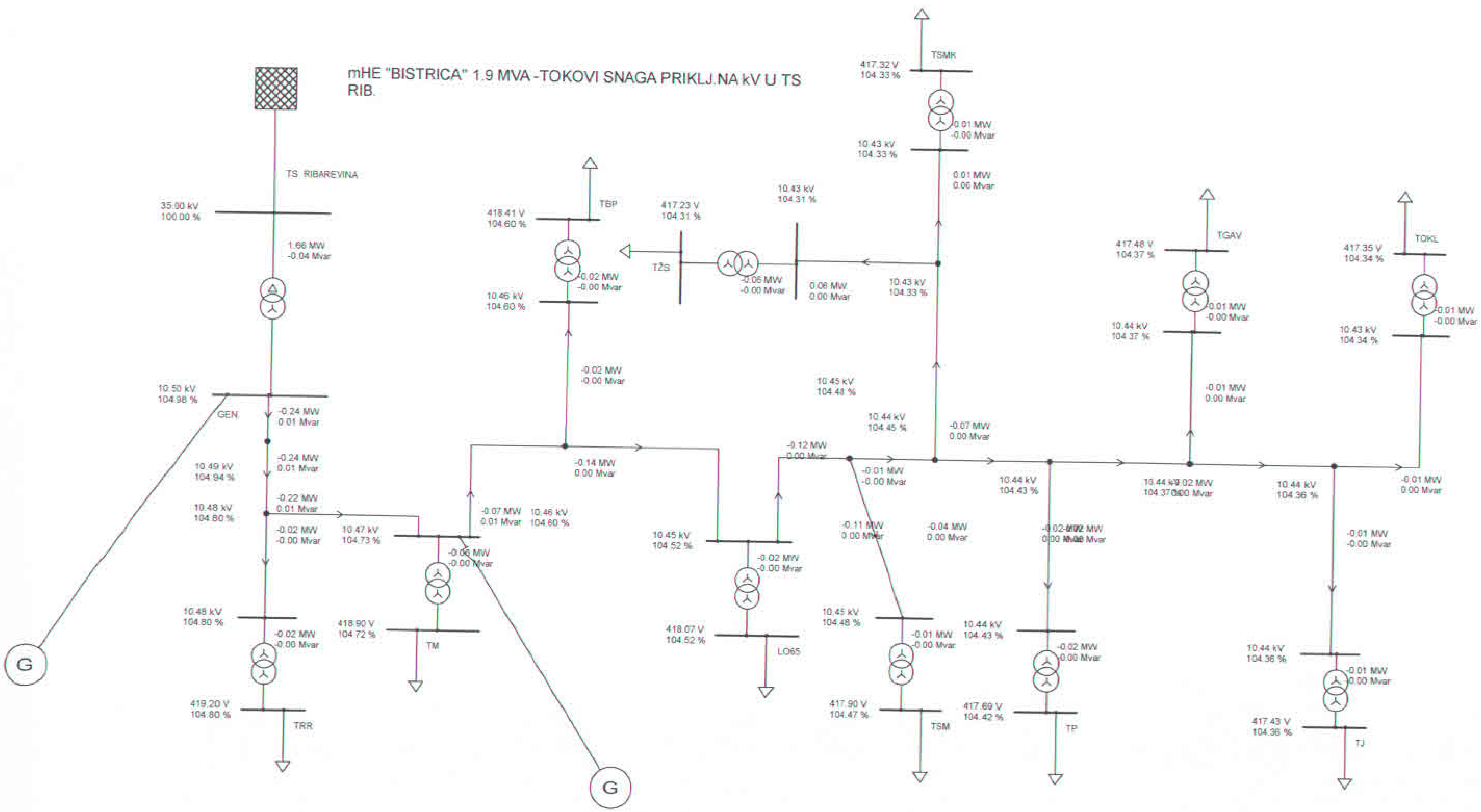

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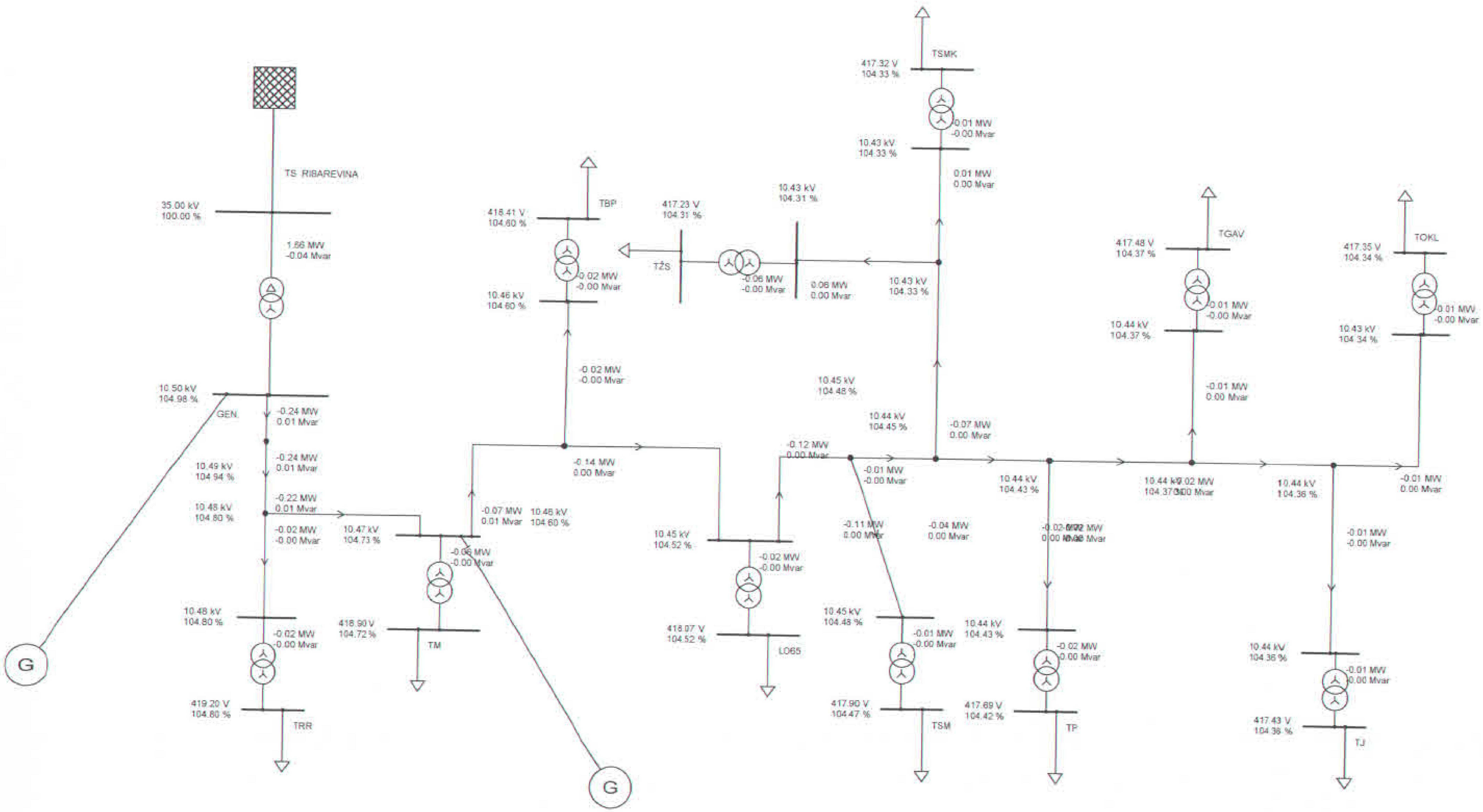
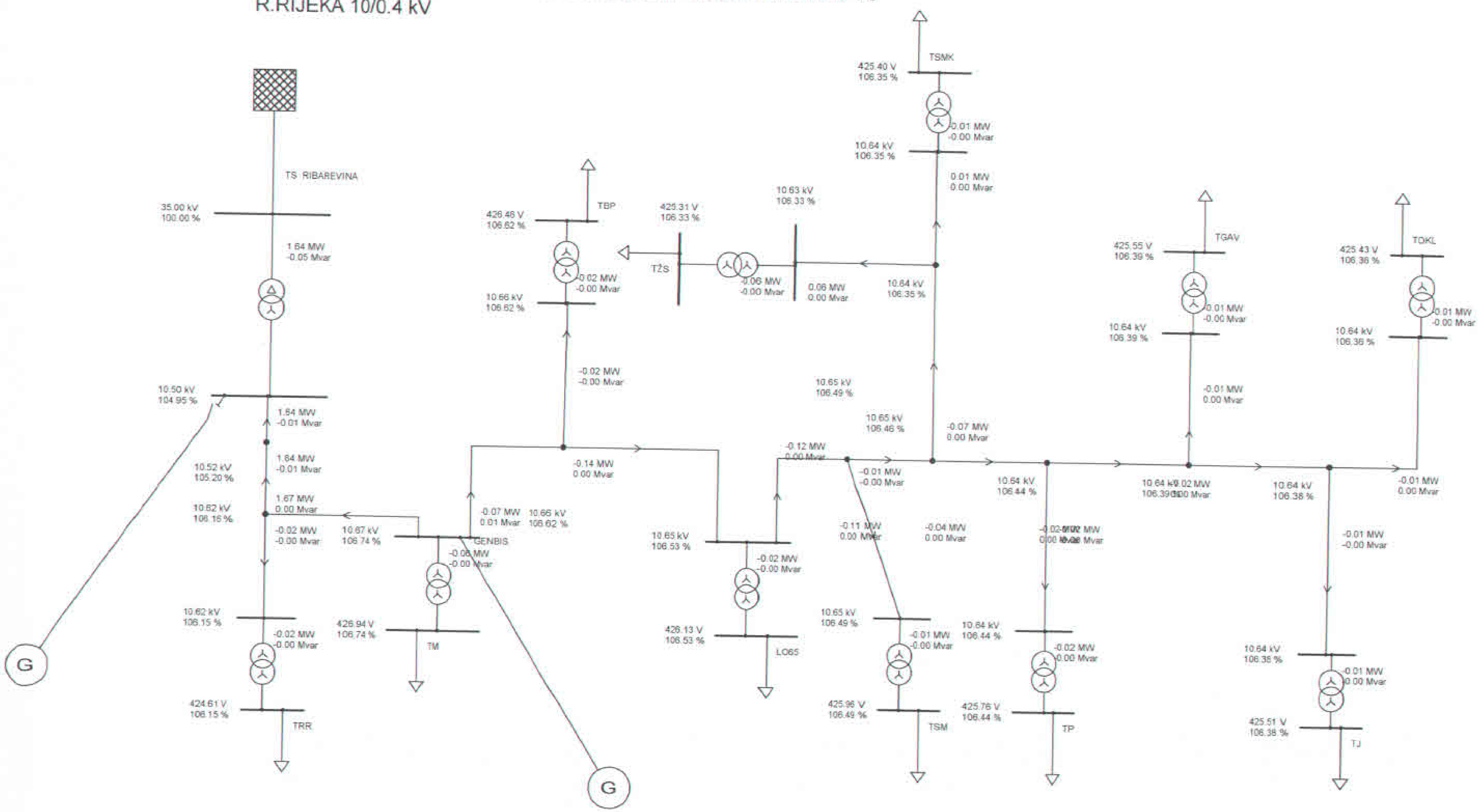


mHE"BISTRICA 1.9 MVA-NAONSKE PRILIKE . PRIKLJ.NA 10 kV U TS R.RIJEKA 10/0.4 kV



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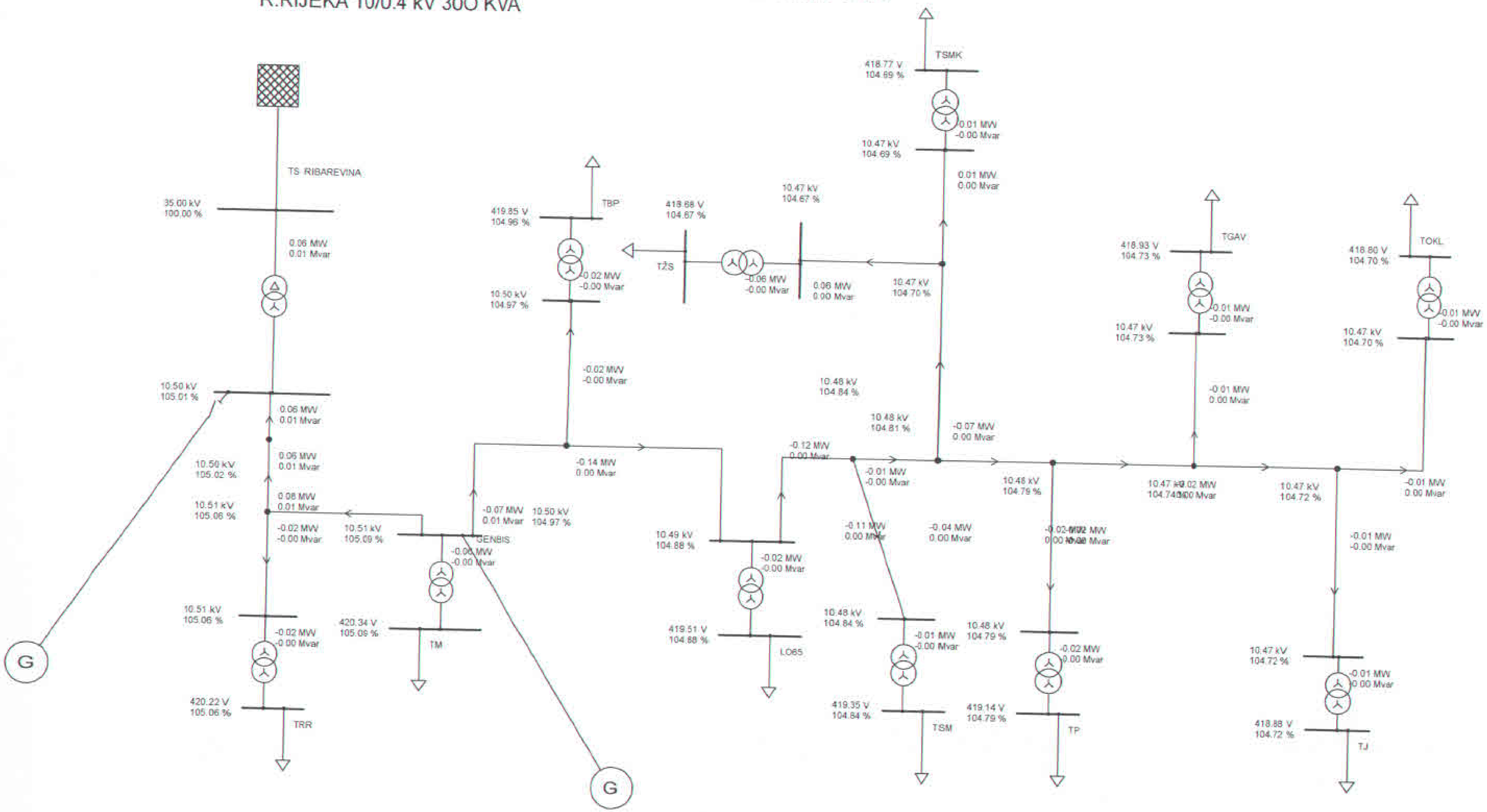
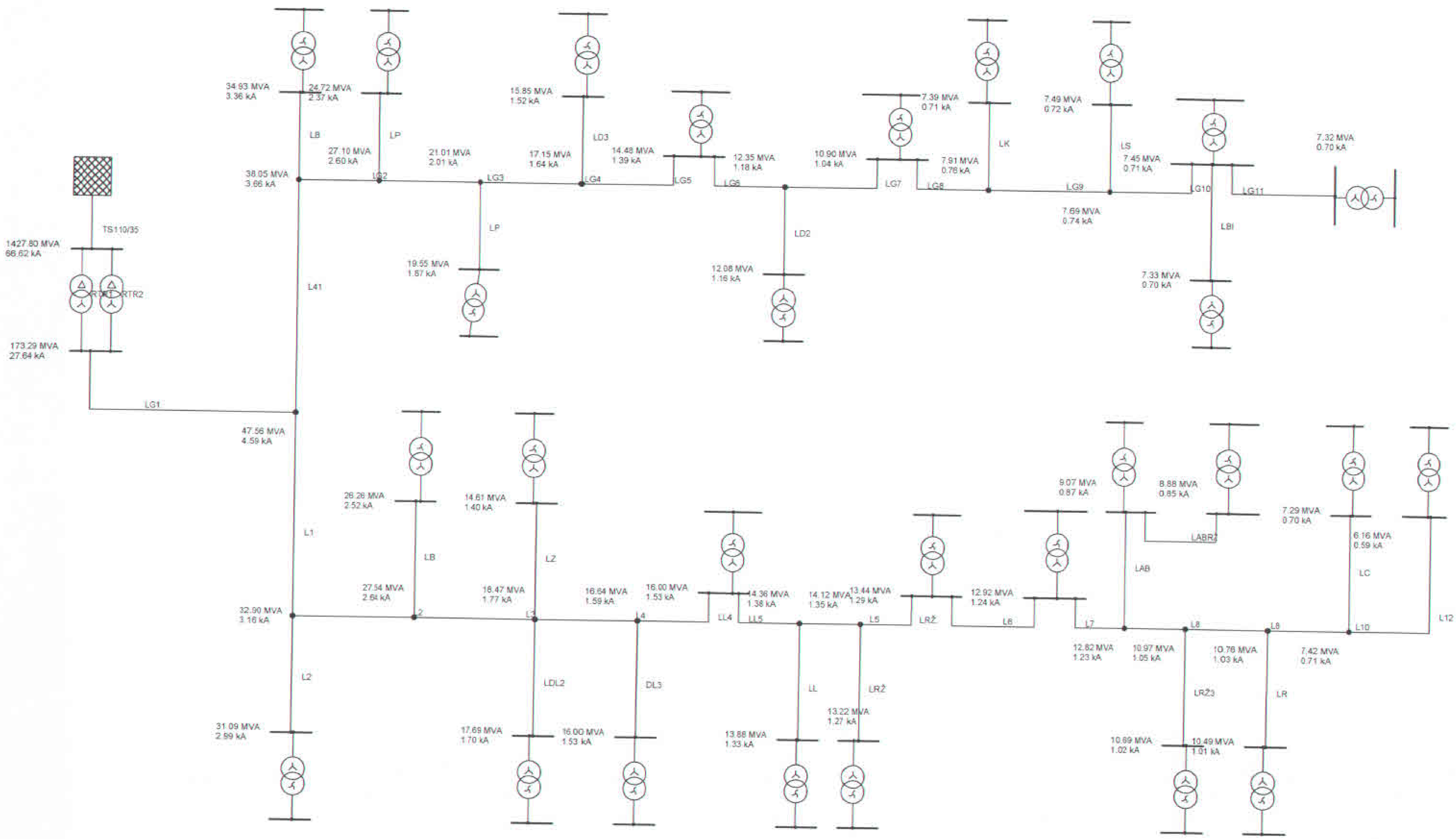
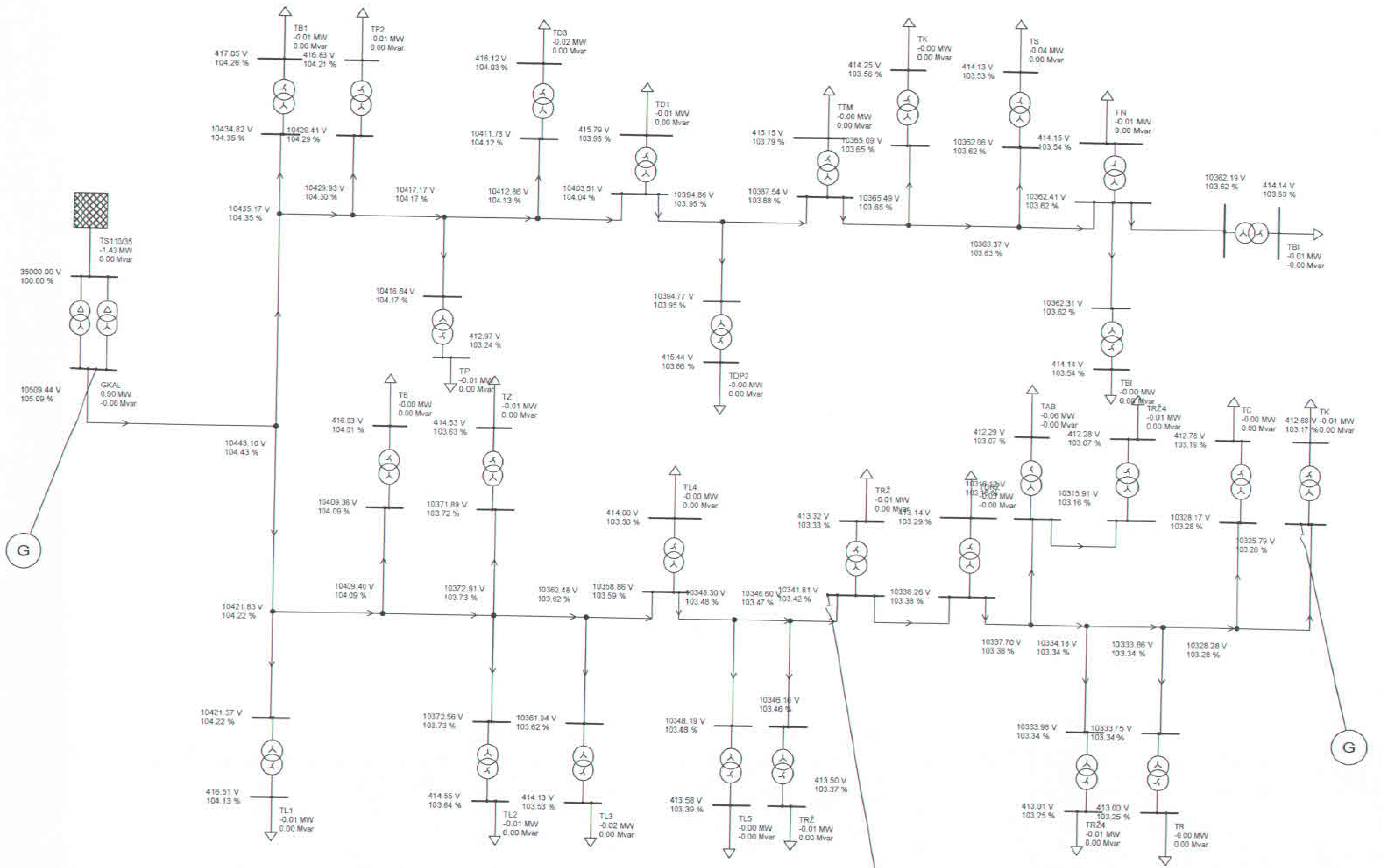
R.RIJEKA 10/0.4 kV 30O KVA



mHE KALUDERSKA SNAGA KS U MVA



mHE "KALUDERSKA" NAPONSKE PRILIKE PRIKLJUČENJE U TS RUDEŠ



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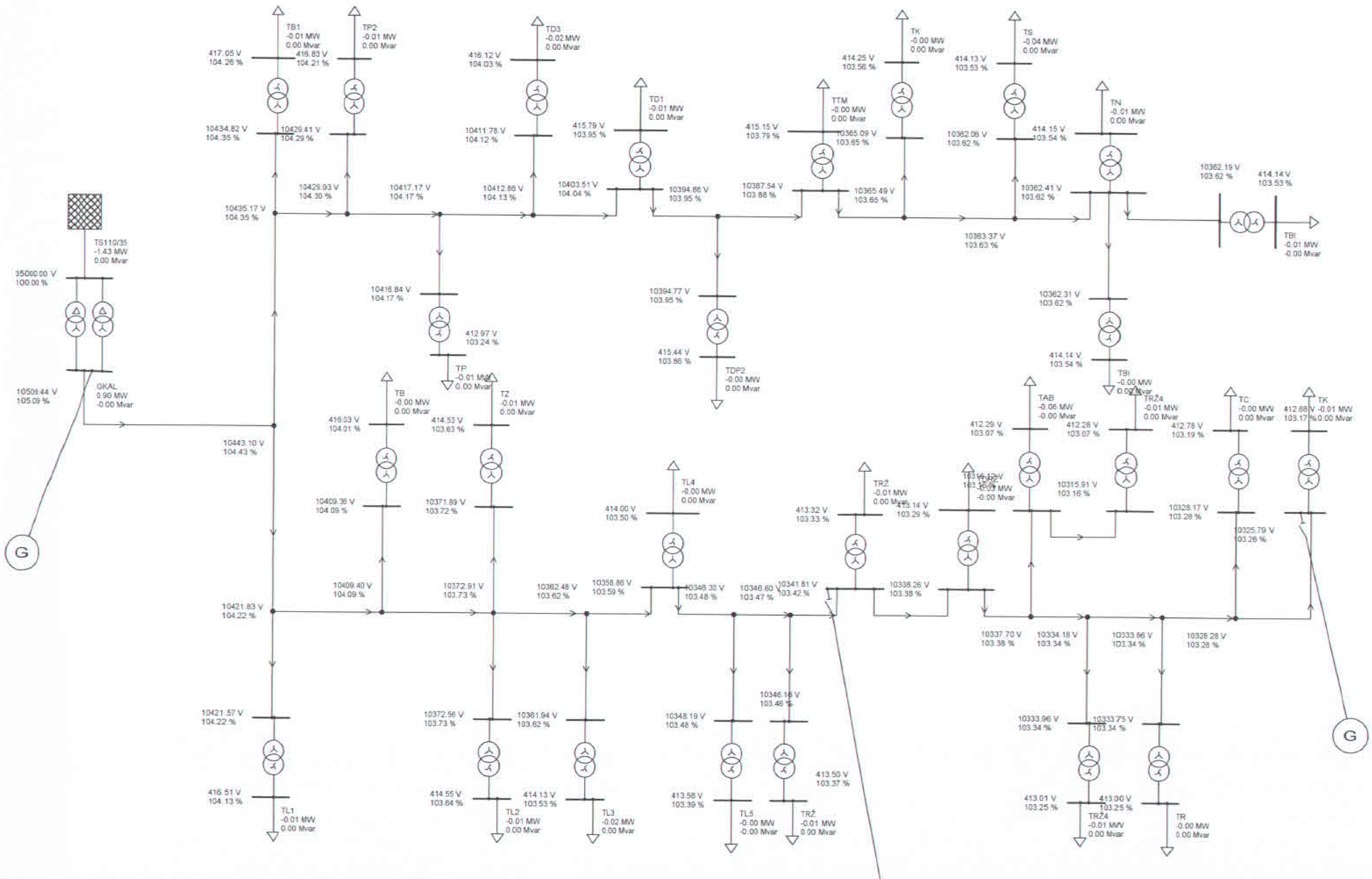
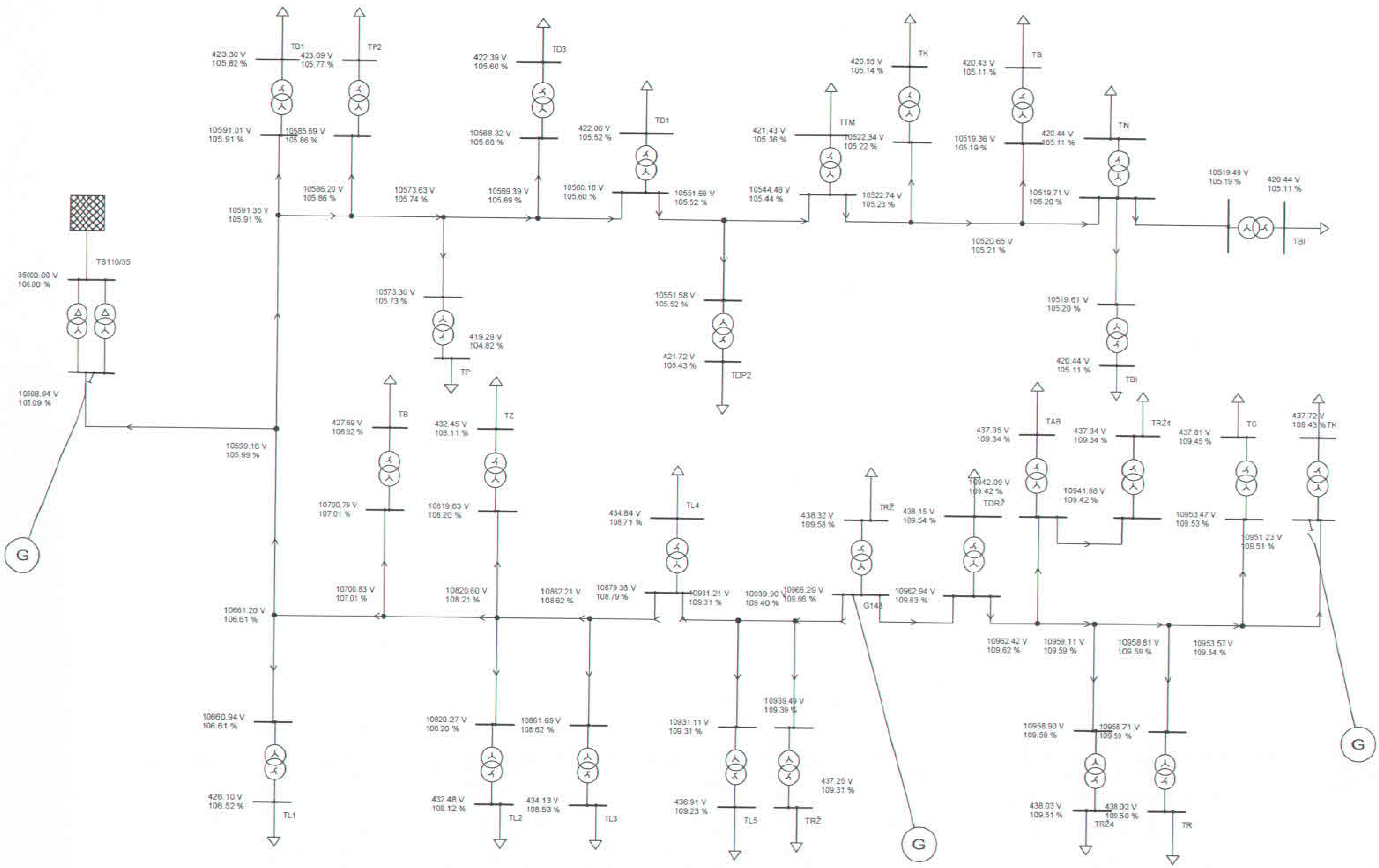
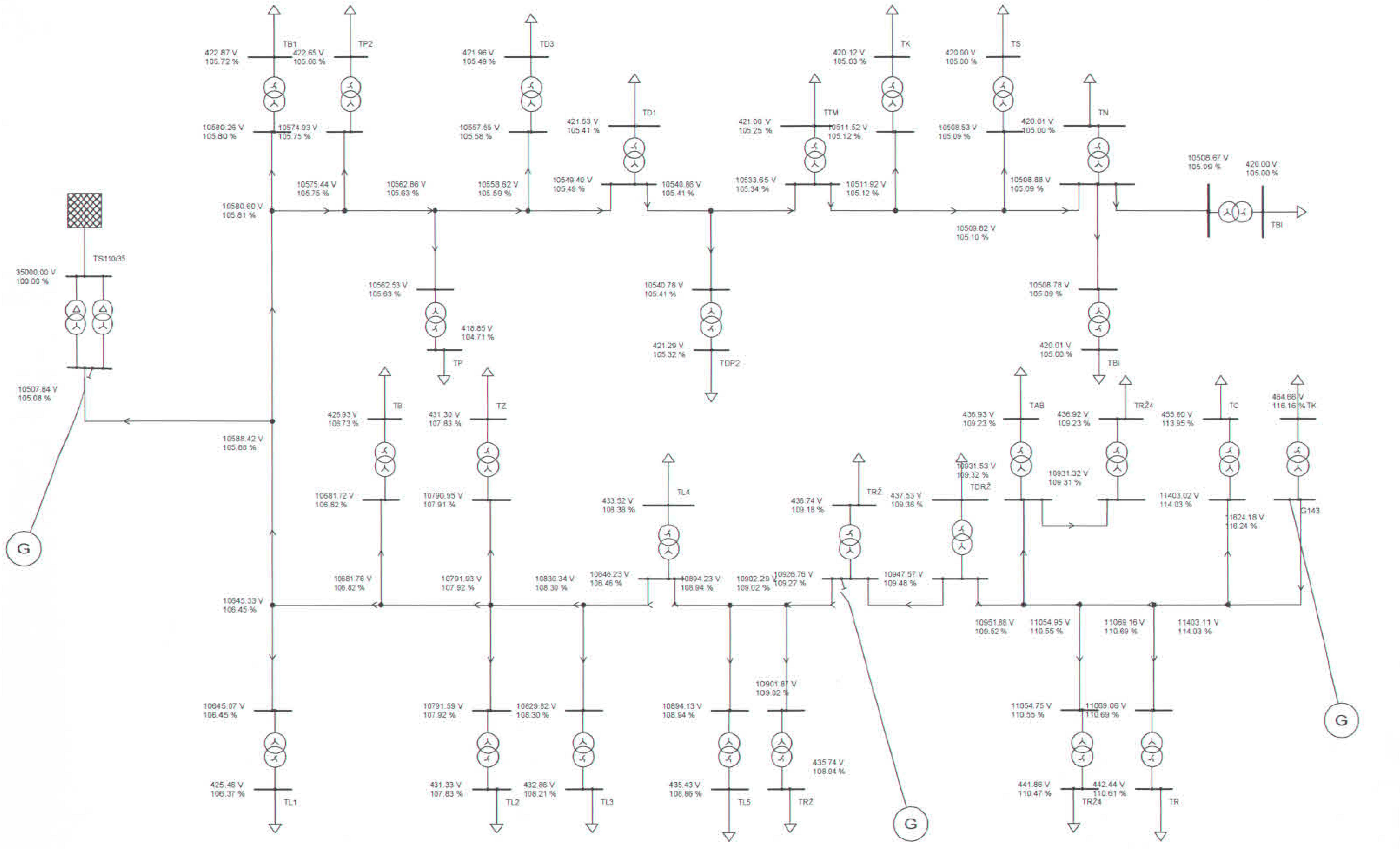


m HE "KALUDERSKA" NAPONSKE PRILIKE PRIKLJ. U TS RŽ 2



mHE "KALUDERSKA" NAPONSKE PRILIKE PRIKLJ.U TS KALUDRA



Legend:
Pg. 7 :sHPP "BISTRICA" 1.9MVA – POWER – CONNECT. To 10kV at TS Ribarevina 35/10kV

Pg 8: shPP"BISTRICA" 1.9MVA – VOLTAGE CIRCUMSTANCES of CONNECT. To 10kV at TS Ribarevina 35/10kV

Pg 9: shPP"BISTRICA" 1.9MVA – POWER FLOWS OF CONNECT. To kV at TS

Pg 10.: shPP"BISTRICA" – POWER FLOWS OF CONNECT. To 10kV at TS Ribarevina 35/10kV

Pg 11: shPP"BISTRICA" 1.9MVA- VOLTAGE CIRCUMSTANCES of CONNECT. To 10kV at TS R. Rijeka 10/0.4kV

Pg 12: shPP"BISTRICA" 1.9MVA- VOLTAGE CIRCUMSTANCES of CONNECT. To 10kV at TS R. Rijeka 10/0.4kV 300KVA

Pg 13: sHPP "KALUDERSKA" POWER AT MVA

Pg 14: sHPP "KALUDERSKA-" VOLTAGE CIRCUMSTANCES of CONNECT.at TS RUDEŠ

Pg 15: sHPP "KALUDERSKA- POWER FLOWS

Pg 16: sHPP "KALUDERSKA-" VOLTAGE CIRCUMSTANCES of CONNECT at TS RŽ.2

Pg 17: sHPP "KALUDERSKA" - VOLTAGE CIRCUMSTANCES of CONNECT at TS KALUDRA