OPTIMAL LOCATION OF A CAPACITOR BANK, BASED ON FUZZY LOGIC ALGORITHMS.

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Abstract - This paper compiled the information of some works in which it is tried to identify the methodology to find the optimal location of a bank of capacitors a Long a feeder of an electrical distribution system, in function of minimizing the costs Operations and investment. To reach the proposed objective, we took indicators such as loss reduction and reduction of voltage drops found in a load flow, which will be used as input logic variables to the fuzzy logic tool, to find the most suitable node In which a bank of capacitors can be installed.

Index of terms - algorithm, voltage drop, capacitor, fuzzy logic, optimum node, loss reduction.

I. INTRODUCCIÓN

Every enterprise needs to maximize economic benefits, so it is generally assigned to engineers and technicians to investigate the problems and causes in which economic losses are incurred, looking for methods or processes that minimize the effect of losses. In the case of electricity distribution companies, voltage drops and energy losses are quantified and graded by means of indices to measure the efficiency and quality of service that the distributors must comply with according to the regulation of national regulation determined by the Agency of National Electricity Regulation ARCONEL, these indices reflect a cost of benefit for the company and the users.

Ecuadorian regulation considers technical product quality indexes based on the ARCONEL 004-10 and 0003-99 regulations, which is why the distribution companies seek to improve these indices, and the improvement of these indices corresponds directly to the optimization of resources To the distributors, for

Many distribution systems used in practice have a single main feeder circuit and are known as radial distribution systems. Radial systems are popular because of their simple design and low overall price (Mekhamer, 2002).

Many solutions have been suggested such as problem identification and decision-making techniques, large-scale complex problem-solving techniques, non-linear mixed-integer programming techniques, among others. The analytical techniques (Bae, 1978), programming (Graiger, 1982),

heuristics (SF, 2002), mathematical programming (Chiang, 1993) and a number of other methods have been developed to solve the problem.

Among these techniques evolutionary computer methods such as Genetic Algorithm (Gringer, 1981) and ant colony optimization (Wadhwa, 2006) have been shown to produce superior results. Simulated annealing and Tabu searches have also been very successful. However, a common drawback of these techniques lies in the enormous computational task involved in obtaining the solution; on the other hand, the efforts of system engineers have not always been enough to avoid complex solution applications with intensive calculation processes. For this reason, the use of simple, physically understandable logic to solve the problems is sought, although such simplified solutions from time to time cannot find the best approach in fuzzy logic, they imply a lower computational load

II. DESCRIPTION OF DISTRIBUTION SYSTEMS

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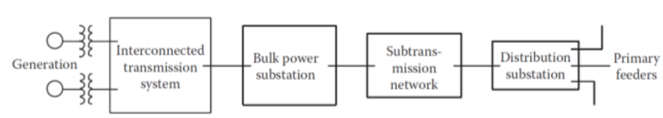


a) 2.6.1 RADIAL FEEDERS

They are characterized by having a single path from the source that is the distribution substation to each client or consumer. A typical system consists of one or more distribution substations with one or more feeders, the components of the feeders consist of:

Main three-phase primary feeder.

Single-phase, two-phase and three-phase side feeders.
Step-type voltage regulators.
Transformers Online.
Parallel capacitor banks.
Distribution transformers.
Secondary feeders.
Single-phase, two-phase and three-phase loads.

The structures are physically arranged as shown in Figure 11

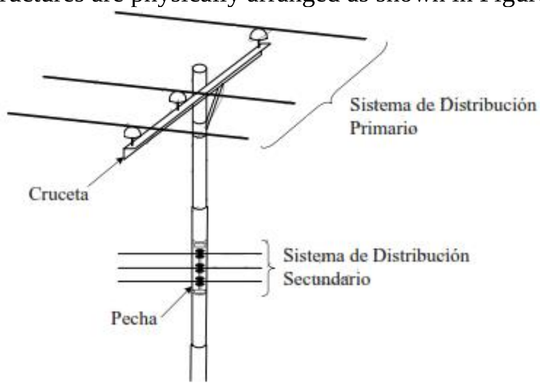
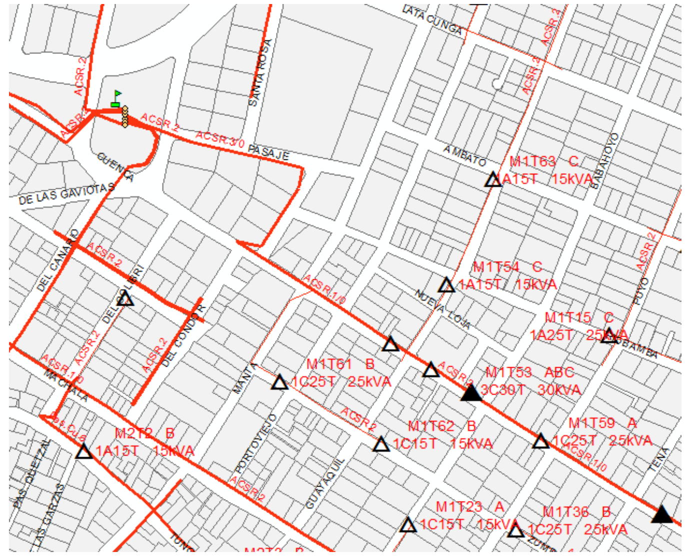


Figura 1. Estructura Física de un Sistema de Distribución Aéreo Típico (Gonzales, 2007).

The nominal voltages existing in the different components of the distribution system in feeders or primary distribution networks are: 6.3kV, 22.8kV GRDY / 13.2kV, 13.2kV GRDY / 7.6kV. At this level, special consumers such as industries and others can be fed. The primary distribution circuits are characterized because they are connected to a single point or distribution substation (Radial Systems) and it is very little seen in special cases only the connection to more than one substation (Multiple Ring System).

The secondary ones correspond to the lower levels of power and voltage. They are closer to the residential consumer. In Ecuador, the voltage levels at the secondary distribution level are those that operate at voltages below 600V. The nominal voltages existing in the different components of the three-phase secondary circuits system are: 220V / 127V and 210V / 121V, for single-phase secondary circuits are: 240V / 120V.

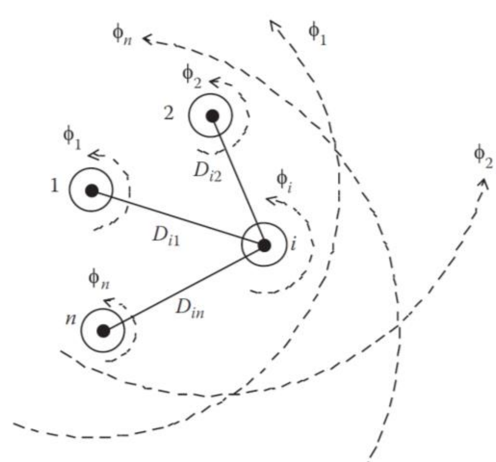


B. PROBLEMS IN MAIN FEEDERS

A distribution feeder provides unbalanced 3-phase, biphasic and single-phase loads on non-transposed 3-phase, biphasic and single-phase line segments. This combination leads to three-phase line currents and line voltages being unbalanced. In order to analyze these conditions as accurately as possible, it will be necessary to model the three phases of the feeder as accurately as possible, however, often only a ball park estimate response is required for the analysis. When this is the case, some approximate methods of modeling and analysis may be employed.

C. LINE IMPEDANCES.

The series impedance of a single-phase, biphasic or three-phase distribution line consists of the resistance of the conductors and the inductive and mutual inductive reactance's resulting from the magnetic fields surrounding the conductors



$$I_1 + I_2 + \cdots \ldots \ldots + I_i + \cdots \ldots \ldots + I_n = 0$$

The total concatenated flux in conductor i is mathematically given by the equation:

$$\lambda_i = N.\Phi = 2.10^{-7}.\left(I_1.\ln\frac{1}{D_{i1}} + I_2.\ln\frac{1}{D_{i2}} + \cdots + I_i.\ln\frac{1}{GMR_i} + \cdots + I_n.\ln\frac{1}{D_{in}}\right)$$

Where:
N: Number of times the flow lines embrace the itch operator.
D_{in} : Distance between the itch conductor and the nth conductor in inches.
GMR_i : Geometric mean radius of the itch conductor

a) 2.7.2 VOLTAGE DROPS

In a distribution system, the equivalent circuit of a three-phase segment serving a three-phase load is shown in Figure 14 in which the Kirchoff voltage law "LVK" and its phasor diagram have been applied in Figure 15 in which We observe the phasor of the voltage drop that occurs in the line resistance (IR), in phase with the current phasor, and the voltage drop phasor in the reactance (jlx) having an annulus of 90 ° with respect to the current

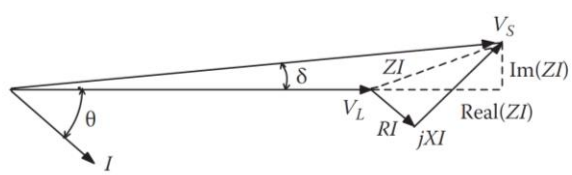


Figure 2 Line impedance components

$$Vdrop \cong Real\ (Z.I)$$

b) 2.7.4 LOSSES

Like voltage drops, the importance of analyzing losses from an "S" source, to the "n" node in a feeder is critical, losses must be accounted for by the distributor, losses are divided into technical losses And non-technical or commercial (often called black losses) energy losses is the difference between the energy delivered by a feeder minus the energy billed to the consumer, for this reason the distribution companies are obliged to buy additional energy To meet the demand of users in its concession area, which increases the costs of managing the same, reducing losses increases the volume of energy actually sold. The two types of losses are detailed below:

(1) 2.7.4.1 NON-TECHNICAL LOSSES.

The energy produced is not invoiced in its entirety, within the non-technical losses we have three large groups of losses, the same as indicated below:

A) Accidents, are caused by unintentional faults in connections misuse or operation of electrical service elements and equipment.

B) Administrative, are errors produced by the administration of the distribution company, among them are errors in taking readings, users without meters (excluding from this group users with contraband in their facilities), occasional services (errors in the estimation of Energy), past due portfolio, lack of measurement equipment in the facilities of the distribution company itself, etc.

C) Fraudulent, referring to the energy not counted that certain consumers with the desire to avoid charges for energy consumed by the distributing company, manipulate the measuring devices, connect directly to the electrical network without the prior authorization of the distributor company and without signing any contract with the same. These types of cases are commonly known as contraband and often occur in certain sectors already identified and conflicting, there are several methods today to avoid this type of eventualities, the most used in our country is the use of pre-assembled cable or also known as anti-theft driver.

(2) 2.7.4.2TECHNICAL LOSSES

These constitute the portion of energy that is not supplied to the user, but is required for its operation, this is lost in the equipment, networks and other elements that make up the distribution system, these serve to drive and transform energy (transformers), These methods are measurable and estimable, the measurement is made in the field with the specialized tool and designated for that purpose, the estimation is done with computer tools that the distributor company disposes for the case of EMELNORTE uses the CYME tool. This type of losses to be caused by the transmission of energy is normal in any power distributor and cannot be eliminated in its entirety can only be reduced through the topological improvement of the network.

In order to achieve an adequate control plan and reduction of technical losses, the following parameters must be taken into account:

- Diagnosis of the current state of the system,
- Projection of load expansion,
- Studies of load flows,
- Analyze the optimal location of transformers and networks,
- Perform reconfiguration studies of primary feeders.

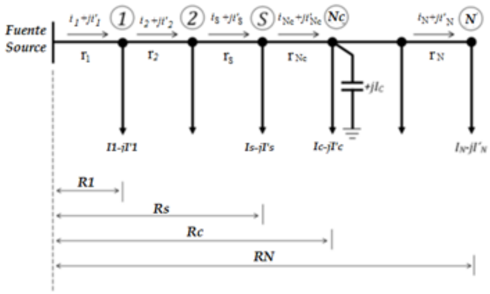


Fig. 1. Feeder with N nodes and evenly distributed loads including the installation of a capacitor.

III. CAPACITOR BANKS

The pole-mounted capacitive system (Qpole) is an economical solution to compensate for reactive power in an air feeder, according to ABB's technical specifications the systems offer benefits as (ABB, 2010):

- Correction of the power factor close to the loads (consumers)
- Voltage stability
  Increase in network capacity
  Cost savings through reduction of losses.

The banks can be installed as fixed or switched systems, depending on the voltage profile in the feeder, in addition they can be installed in groups called banks, when it is known that the load is almost constant, fixed systems are used, in changes the switches are more Used in networks with variable load. Fixed banks can be assembled by grouping single-phase and star-rated capacitors with floating neutral to the system voltage.

The average unit powers in the medium are 33.3, 50, 83.3, 100, 167, 200, 250, 300 and 400 KVAR, so that three-phase banks of 100, 150, 250, 300, 500, 600, 750, 900 and 1200 KVAR, or multiples of these powers. Its installation on overhead lines is easy and only need a fuse and a surge arrester for protection, few accessories for its connection.

Conventionally in Emelnorte these banks are roughly based on the experience of their older technicians, which achieves a significant reduction of losses and voltage drops, and a consequent improvement in the quality of service provided to all customers (Leyden). Pole banks in half voltage allow a high concentration of power, achieving low-cost three-phase equipment by KVAR.

In the country, the distribution companies installed capacitor banks to improve the electrical system, as in the case of CNEL EP and the El Oro business unit, installed 9 capacitor banks to supply reagents to the distribution system, benefiting more than 45,000 inhabitants. The cantons Machala, Santa Rosa, Pinas, Portovelo, Pasaje, Atahualpa, balao and Ponce Enríquez according to the publication of the ministry of energy and electricity (EP, 2017).

Therefore, the present work seeks to optimize the economic resources in an electric power distribution company, depending on the optimal location of capacitors in the course of a main feeder.

IV. FUZZY LOGIC

Fuzzy logic is a method that provides a simplified conclusion from inaccurate, ambiguous, incomplete, or noisy inputs (also called fuzzy logic) that generally mimics a person's decisions based on things seen from a position Relative It allows to work with information with a high degree of imprecision, which makes the difference with the conventional logic that always needs well defined and precise information. This logic has many intermediate values within the classic logic range that come true / false, hot / cold, on / off, open / closed, etc.

It is necessary to understand that it is a fuzzy set to infer in the values of the logic, if we call U to the set of several values, which are in a range and within a space of n dimensions, then to U is called Universe of Discourse, which contains one or more diffuse subsets of Values called F, which is characterized by a membership function uf such that uf: U -> [0,1], Where the function uf(u) Represents the degree of belonging that one u belongs to U in the diffuse subset F.

The fuzzy sets theory also defines the operations of union, intersection, difference, negation or complement, and other operations on sets, on which this logic is based.

Fuzzy logic is used when the complexity of the process in question is very high and there are no precise mathematical models for highly nonlinear processes and when definitions and knowledge are not strictly defined (imprecise or subjective). On the other hand, it is not a good idea to use it when some mathematical model already solves the problem efficiently, when the problems are linear or when there is no solution.

V. DETERMINATION OF THE LOCATION

In order to determine the suitability of capacitor placement at a particular node, a set of multiple background diffuse rules has been established. The inputs to the rules are the voltage indexes and the loss of power which can also be integrated into energy losses, and the resulting output is the suitability of the capacitor positioning.

CONSIDERATIONS FOR SIMPLIFICATION OF THE PROBLEM

Capacitors or fixed capacitors. - Installation of capacitors in parallel (shunt) as points of injection of reactive power in the nodes that require it.

- Strictly radial feeder. - For each simulation, the voltage can be in per unit (pu) between a value of 0.95 and a maximum of 1.05.

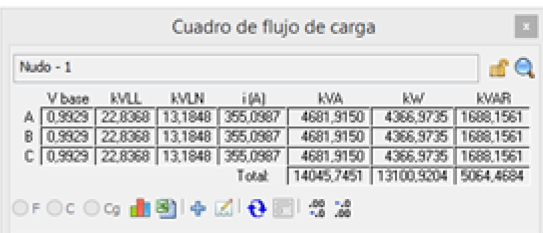
- The largest reduction of losses was assigned to the '1' and the remaining reduction of losses of energy will be placed on the basis of the greater reduction of losses.

- Analysis in the trunk, without considering the branch circuits. - Power flow analysis in the study feeder to find the parameters of observation, for this item will be used the computer tool of CYME used in real feeders.

To experience the functions studied in the applications developed for this work we have the system of a radial feeder with a voltage level of 13800 Volts, frequency of 60 Hz and is understood as infinite bar for analysis, in which loads have been distributed Specified in Table 1.

The variables of the analysis are defined as, voltage drops, power or power losses, and the suitability of a node to be located in a capacitor bank, following the methods investigated, many authors consider measurement indices for these variables which will be used as inputs Logical to the fuzzy logic tool, as will be explained below.

The load flow is in agreement with the found in the CYMDIST simulation:



Cuadro de flujo de carga

Nudo - 1

	V base	kVLL	kVLN	i (A)	kVA	kW	kVAR
A	0,9929	22,8368	13,1848	355,0987	4681,9150	4366,9735	1688,1561
B	0,9929	22,8368	13,1848	355,0987	4681,9150	4366,9735	1688,1561
C	0,9929	22,8368	13,1848	355,0987	4681,9150	4366,9735	1688,1561
				Total:	14045,7451	13100,9204	5064,4684

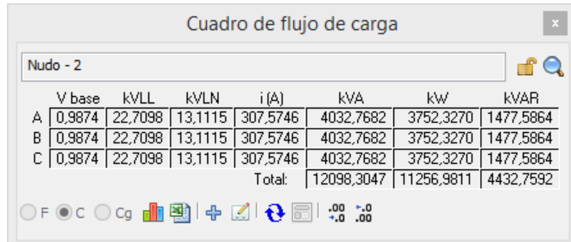
Figure 3. Load flow at node 1

TABLE I
INFORMATION ON LOADS ON EACH NODE

Barra o nodo	Potencia activa [kW]	Potencia Reactiva [kVAR]
1	1840	460
2	980	340
3	1790	446
4	1598	1840
5	1610	600
6	780	110
7	1150	60
8	980	130
9	1640	200

TABLE 2
LINES INFORMATION ON EACH LINE

Tramo	Impedancia R [ohmio]	Impedancia X [ohmio]
0-1	***0,1233***	***0,4127***
1-2	***0,0140***	***0,6051***
2-3	***0,7463***	***1,2050***
3-4	***0,6984***	***0,6084***
4-5	***1,9831***	***1,7276***
5-6	***0,9053***	***0,7886***
6-7	***2,0552***	***1,1640***
7-8	***4,7953***	***2,7160***
8-9	***5,3434***	***3,0264***

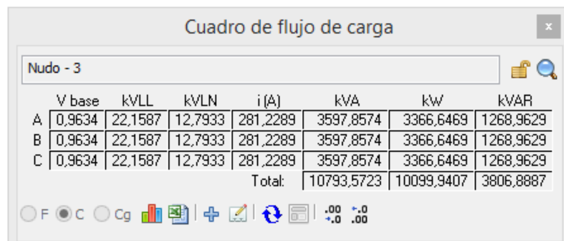


Cuadro de flujo de carga

Nudo - 2

	V base	kVLL	kVLN	i (A)	kVA	kW	kVAR
A	0,9874	22,7098	13,1115	307,5746	4032,7682	3752,3270	1477,5864
B	0,9874	22,7098	13,1115	307,5746	4032,7682	3752,3270	1477,5864
C	0,9874	22,7098	13,1115	307,5746	4032,7682	3752,3270	1477,5864
				Total:	12098,3047	11256,9811	4432,7592

Figure 4. Load flow at node 2

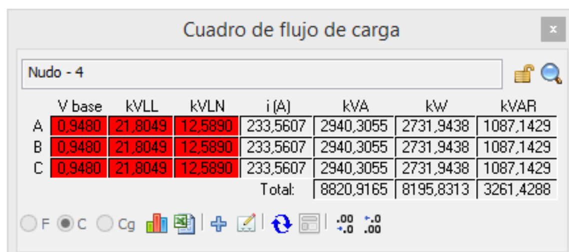


Cuadro de flujo de carga

Nudo - 3

	V base	kVLL	kVLN	i (A)	kVA	kW	kVAR
A	0,9634	22,1587	12,7933	281,2289	3597,8574	3366,6469	1268,9629
B	0,9634	22,1587	12,7933	281,2289	3597,8574	3366,6469	1268,9629
C	0,9634	22,1587	12,7933	281,2289	3597,8574	3366,6469	1268,9629
				Total:	10793,5723	10099,9407	3806,8887

Figure 5. Load flow at node 3

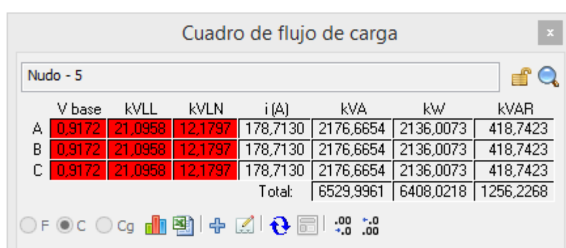


Cuadro de flujo de carga

Nudo - 4

	V base	kVLL	kVLN	i (A)	kVA	kW	kVAR
A	0,9480	21,8049	12,5890	233,5607	2940,3055	2731,9438	1087,1429
B	0,9480	21,8049	12,5890	233,5607	2940,3055	2731,9438	1087,1429
C	0,9480	21,8049	12,5890	233,5607	2940,3055	2731,9438	1087,1429
				Total:	8820,9165	8195,8313	3261,4288

Figure 6. Load flow at node 4

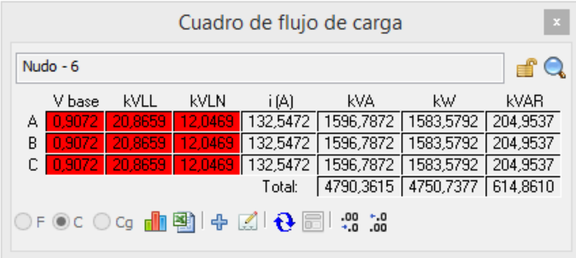


Cuadro de flujo de carga

Nudo - 5

	V base	kVLL	kVLN	i (A)	kVA	kW	kVAR
A	0,9172	21,0958	12,1797	178,7130	2176,6654	2136,0073	418,7423
B	0,9172	21,0958	12,1797	178,7130	2176,6654	2136,0073	418,7423
C	0,9172	21,0958	12,1797	178,7130	2176,6654	2136,0073	418,7423
				Total:	6529,9961	6408,0218	1256,2268

Figure 7. Load flow at node 5

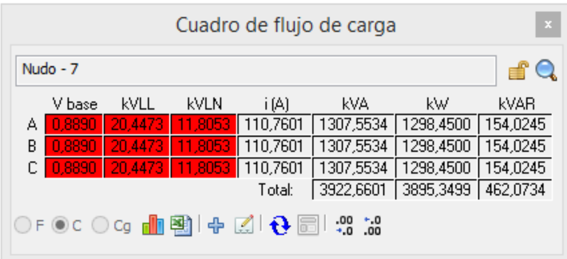


Cuadro de flujo de carga

Nudo - 6

	V base	kVLL	kVLN	i (A)	kVA	kW	kVAR
A	0,9072	20,8659	12,0469	132,5472	1596,7872	1583,5792	204,9537
B	0,9072	20,8659	12,0469	132,5472	1596,7872	1583,5792	204,9537
C	0,9072	20,8659	12,0469	132,5472	1596,7872	1583,5792	204,9537
				Total:	4790,3615	4750,7377	614,8610

Figure 8. Load flow at node 6

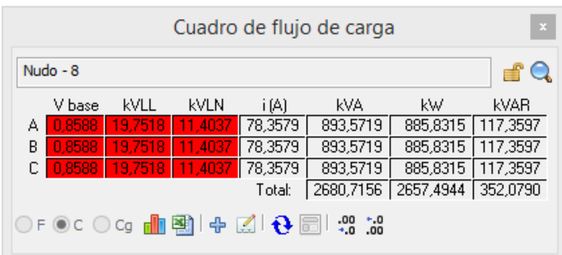


Cuadro de flujo de carga

Nudo - 7

	V base	kVLL	kVLN	i (A)	kVA	kW	kVAR
A	0,8890	20,4473	11,8053	110,7601	1307,5534	1298,4500	154,0245
B	0,8890	20,4473	11,8053	110,7601	1307,5534	1298,4500	154,0245
C	0,8890	20,4473	11,8053	110,7601	1307,5534	1298,4500	154,0245
				Total:	3922,6601	3895,3499	462,0734

Figure 9. Load flow at node 7

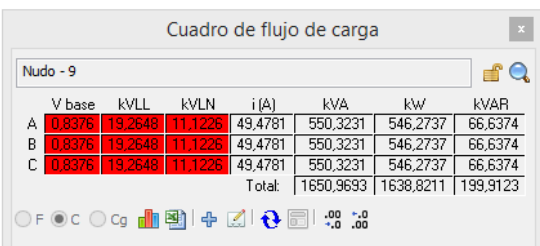


Cuadro de flujo de carga

Nudo - 8

	V base	kVLL	kVLN	i (A)	kVA	kW	kVAR
A	0,8588	19,7518	11,4037	78,3579	893,5719	885,8315	117,3597
B	0,8588	19,7518	11,4037	78,3579	893,5719	885,8315	117,3597
C	0,8588	19,7518	11,4037	78,3579	893,5719	885,8315	117,3597
				Total:	2680,7156	2657,4944	352,0790

Figure 10. Load flow at node 8



Cuadro de flujo de carga

Nudo - 9

	V base	kVLL	kVLN	i (A)	kVA	kW	kVAR
A	0,8376	19,2648	11,1226	49,4781	550,3231	546,2737	66,6374
B	0,8376	19,2648	11,1226	49,4781	550,3231	546,2737	66,6374
C	0,8376	19,2648	11,1226	49,4781	550,3231	546,2737	66,6374
				Total:	1650,9693	1638,8211	199,9123

Figure 11. Load flow at node 9

The membership functions for the power loss reduction indexes (IRPP) or energy loss reduction index (IRPE), voltage reduction index (IV), and capacitance bank location suitability index (IIUC) , Were created to provide a classification. Therefore, the partitions of the membership functions for the power, voltage and suitability indices are equally spaced.

Diffuse variables are:

- Energy Loss Reduction Index (IRPE)
- Reduction of voltage falls (VI)
- Optimal condenser location (CI)

They are described by the fuzzy terms of:

- Alto (High)
- Medio-Alto (High Medium)
- Medio/Normal (Medium)
- Medio-Bajo (Low Medium)
- Bajo. (Low)

TABLE 2
INFORMATION OF THE LOSSES OF POWER AND VOLTAGE IN EACH PATH

Tramo	Perdida de potencia [kW]	Caída de voltaje Vl [V]
0-1	-	***13.200,000***
1-2	***46,6432***	***13.106,280***
2-3	***1.840,9200***	***13.033,680***
3-4	***3,0188***	***12.716,880***
4-5	***1.157,0405***	***12.513,600***
5-6	***1.904,1093***	***12.107,040***
6-7	***1.787,8096***	***11.975,040***
7-8	***1.657,2840***	***11.734,800***
8-9	***855,3879***	***11.336,160***
9-10	***1.237,8555***	***11.056,320***

Once the terms and diffuse variables are indicated, the variables are identified or fuzzified as follows:

TABLE 3
INFORMATION ON PU POWER AND VOLTAGE LOSSES PU

Tramo	Perdida de potencia [pu]	Caída de voltaje [pu]
0-1	-	***1***
1-2	***0,0245***	***0,9929***
2-3	***0,9668***	***0,9874***
3-4	***0,0016***	***0,9634***
4-5	***0,6077***	***0,9480***
5-6	***1,0000***	***0,9172***
6-7	***0,9389***	***0,9072***
7-8	***0,8704***	***0,8890***
8-9	***0,4492***	***0,8588***
9-10	***0,6501***	***0,8376***

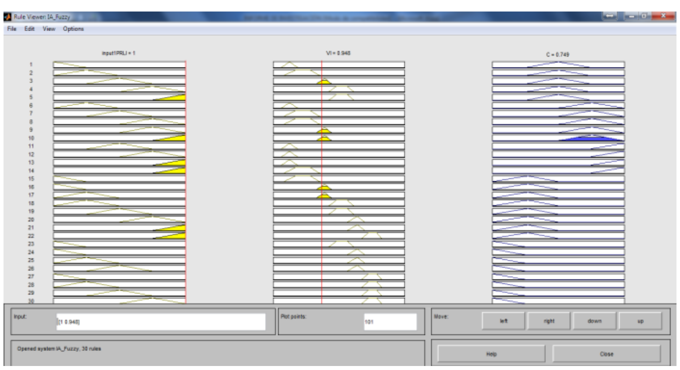
IRPE:
L = 0.00
LM = 0.25
M = 0.50
HM = 0.75
H = 1.00

VI:
VL = 0.95
L = 0.975
LN = 0.987
N = 1.00
HN = 1.025
H = 1.05

Now we have the elaboration of the logic of belonging, as follows:

yes (IRPE is L) y (VI es VL) so (IC es M)
yes (IRPE is L) y (VI es L) so (IC es LM)
yes (IRPE is L) y (VI es LN) so (IC es LM)
yes (IRPE is L) y (VI es N) so (IC es L)
yes (IRPE is L) y (VI es HN) so (IC es L)
yes (IRPE is L) y (VI es H) so (IC es L)
yes (IRPE is LM) y (VI es VL) so (IC es HM)
yes (IRPE is LM) y (VI es L) so (IC es M)
yes (IRPE is LM) y (VI es LN) so (IC es LM)
yes (IRPE is LM) y (VI es N) so (IC es LM)
yes (IRPE is LM) y (VI es HN) so (IC es L)
yes (IRPE is LM) y (VI es H) so (IC es L)
yes (IRPE is M) y (VI es VL) so (IC es H)
yes (IRPE is M) y (VI es L) so (IC es HM)
yes (IRPE is M) y (VI es LN) so (IC es M)
yes (IRPE is M) y (VI es N) so (IC es LM)
yes (IRPE is M) y (VI es HN) so (IC es L)
yes (IRPE is M) y (VI es H) so (IC es L)
yes (IRPE is HM) y (VI es VL) so (IC es H)
yes (IRPE is HM) y (VI es L) so (IC es HM)
yes (IRPE is HM) y (VI es LN) so (IC es HM)
yes (IRPE is HM) y (VI es N) so (IC es M)
yes (IRPE is HM) y (VI es HN) so (IC es LM)
yes (IRPE is HM) y (VI es H) so (IC es L)
yes (IRPE is H) y (VI es VL) so (IC es H)
yes (IRPE is H) y (VI es L) so (IC es H)
yes (IRPE is H) y (VI es LN) so (IC es HM)
yes (IRPE is H) y (VI es N) so (IC es M)
yes (IRPE is H) y (VI es HN) so (IC es LM)
yes (IRPE is H) y (VI es H) so (IC es LM)

After obtaining the indexes and membership functions in fuzzy logic, we use the fuzzy logic (Matlab) tool to determine the suitability of the best qualified node to be installed in the capacitor bank:



This exercise is performed for all nodes and the result table of the location index of IC capacitors is obtained as follows:

The bar that needs an equilibrium will give a maximum IC, the bars that are already balanced will give smaller values. The higher IC values are considered first for the placement of the capacitor, therefore, the value of capacitor to be placed is decided. According to Table 9, the bar 5 has a higher IC, so the location has also been selected to install the condenser.

According to these values we can find the savings according to the following equations and constants:

$$S = K_P \Delta P + K_E \Delta E - K_C C$$

K_P = Cost of one kilowatt lost per year ($ / KW)
K_E = Cost of one kilowatt-hour lost per year ($ / kWh)
K_C = Cost of installing capacitor bank ($ / KVAR)
ΔP = Reduction of peak energy losses(KW)
ΔE = Reduction of energy losses (kWh)
C = Capacitor Size (KVAR)
S = Saving money per year ($/año)

TABLE 3
INFORMATION ON THE LOSSES OF POWER AND VOLTAGE IN PU

Tramo	Perdida de potencia [pu]	Caída de voltaje [pu]	Ubicación de Capacitor [nodo]
0-1	*-*	*1*	
1-2	*0,0245*	*0,9929*	*0,0983*
2-3	*0,9668*	*0,9874*	*0,6726*
3-4	*0,0016*	*0,9634*	*0,0534*
4-5	*0,6077*	*0,9480*	*0,5424*
5-6	*1,0000*	*0,9172*	*0,7595*
6-7	*0,9389*	*0,9072*	*0,7323*
7-8	*0,8704*	*0,8890*	*0,7035*
8-9	*0,4492*	*0,8588*	*0,6962*
9-10	*0,6501*	*0,8376*	*0,7232*

VI. Conclusion

• When performing calculations and simulations in feeders with a small number of nodes, the results are more accurate, which shows that the factors that alter the optimal location of a capacitor bank are the number of nodes or the complexity of the distribution system in which it is desired to investigate.

• Voltage profiles in the feeder are compensated, complying with the restriction given and with a considerable loss percentage, when presenting quality indices.

• In the calculation of loss reduction index, it can be automated according to the sensitivity of each node for its load and its components of the section.

• The problem It can be further complicated in reality, if you consider the derivation capacitances in the PI model of the feeder line, everything will depend on the level of voltage with which you are working, because at higher voltage capacitances Can increase and be representative for the analysis, which may be an additional topic for research.

• Voltage stabilization. - There is a considerable improvement in the voltage profile after system compensation, conditions and restrictions if they can meet the voltage constraint.

• Loss of power and energy results in the placement of compensated reactive power capacitor as a power factor, resulting in an improvement of the system. The data are obtained from the load flow program in CYME.

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