Study of a system of automatic transfer of load through reclosers in the distribution system of Emelnorte.

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Abstract - The main objective of this work is to conduct an electrical study for the automatic transfer of load, through reclosers throughout the Emelnorte distribution system.
The first chapter presents the background, describing the existing problems, and raises the justification for the completion of this degree work. In the second chapter we analyze the concepts of electrical power systems, distribution system, elements that make it up and its classification according to the topology; It describes the types of faults that can occur in the distribution networks and the consequences that can bring them, so it is also analyzed the quality of the electrical service and the regulation No. CONELEC 004/01, that must comply the companies Power distributors
Chapter three mentions the research methodologies applied in this thesis work. The fourth chapter presents the development of the technical proposal in which the Emelnorte distribution system is disclosed and the procedure that has been carried out to determine the feeders where they will be located from the reclosers to perform the automatic transfer of loads

I. INTRODUCTION

The electric energy has become part of the essential raw material to move the economic and social development of the countries. It is indisputable to imagine the lack of this supply, since it moves the commerce, it makes possible the operation of the production at industrial level and most important it improves comfortably the daily life of the human being.

In a high-quality distribution system, the use of reclosers for automatic transfer of loads, which are located in strategic areas of the system, is paramount in order to restore the electric service in the shortest possible time and reduce the number of subscribers without Supply of power in the event of grid failure.

An automatic energy transfer system is a set of elements that gives the possibility of feeding the load from two or more different sources. The transfer systems provide greater reliability to the systems of power supply of electricity, because if there were a failure in any of them would not cause the total loss of power in the load.

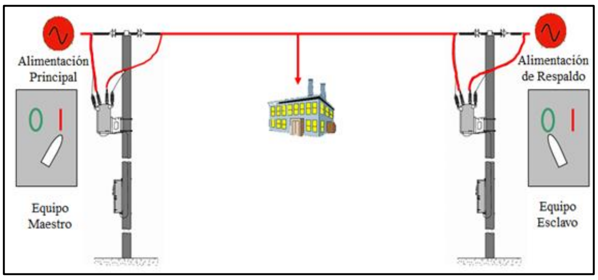

Figure 1. Principle of operation for automatic transfer of load
Source: Schneider Electric outlet.

In order for a load transfer to meet the objective, which is to maintain a greater number of users in service in the event of a failure in one of the power supplies, it must comply with certain conditions, to transfer the load of a Safe and reliable way for both the distribution company and the user.Los criterios a considerar son:

The feeders must have the same voltage level and the substations a same sequence of phases.

- Feeders having a point of interconnection between them, preferably from a three-phase network.
- The feeders can be from different substations, as this would ensure the availability of the service in the event of a failure in one of the sources.
- At least one of the feeders must comply with the voltage levels of ± 10% established in the CONELEC 004/01 regulation.

Emelnorte, is a leading company in distribution and commercialization of electric energy in the north of the country. The company currently has 16 substations and 66 distribution feeders, which have a voltage level of 6.3 kV in the feeder C3 of the Ajaví substation and with 13.8 kV in the rest of the feeders, the System of distribution with which it counts is purely radial, which implies eater affectation of the system in case of failures.

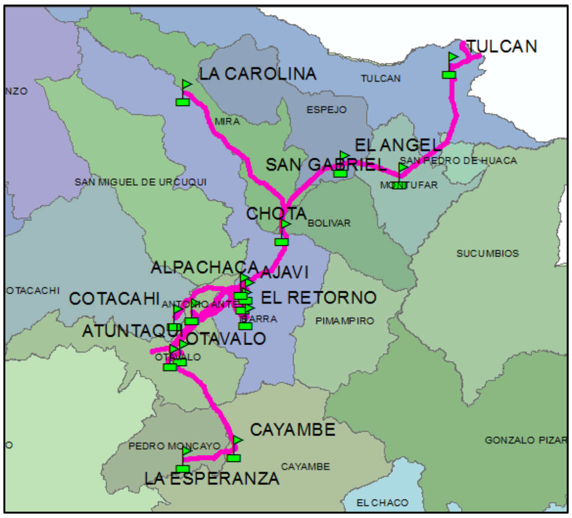

Figure 2. Emelnorte Distribution System.
Source: Taken from Emelnorte.

II. MATERIALS AND METHODS

A. Methods

For this type of research, it can be stated that the following methods were used:

1) Collection of information

The collection of information is carried out through the plans and measurements of each of the feeders, which allow to know the distribution system of Emelnorte

2) Analytical-synthetic method

Through the analysis of the information collected in each process for the automatic transfer of load and through a systematization of the information was obtained the feeders in which if feasible the location of reclosers.

3) Inductive-deductive method

By means of the previous knowledge acquired and the development of this work of degree, the different technical solutions were proposed, which are supported by each result obtained and that were analyzed in each stage or section of this work.

B. Techniques and instruments

1) Modification of plans

Plan modifications are made in the feeders of Alpachaca, Ajaví, San Agustín, El Retorno, Cayambe, Cotacachi, San Vicente and Otavalo; Which meet the conditions to be able to carry out the load transfers between them, the location of the reclosers is determined.

2) Measurements

Based on information from the database maintained by Emelnorte, the measurements of the demand (kW), the voltage per unit, the current (A) and the power factor of the three phases are taken into account. Times in which the reclosers will act, this data will be entered in the software used in this study.

3) Simulation

Through the simulation in the CYMDIST software of CIME International T & D Inc., it was possible to test the ideal operation in which the reclosers operate.

III. DEVELOPMENT OF THE TECHNICAL PROPOSAL

Taking into account the criteria described above, the proposal for the transfer of cargo in the distribution system

A. Determination of feeders for automatic transfer of load

The criteria for selecting the feeders in which the automatic transfer of load will be carried out by the use of reclosers is described, so it is stated that the distribution system of Emelnorte in its 65 feeders have a voltage level of 13, 8 kV, and the transformers have the substations have a DyN1 connection.

B. Interconnected feeders

Another of the considered criteria is that the feeders considered for the study must have a point that interconnects them, but at the same time they must be of different substations, in order to guarantee the continuity of the service in the event of a failure in the electrical system .

In order to be able to fulfill this condition a visual inspection is realized, through the help of planes in the program ArcGIS. Figure 3 shows an example of how the feeders of different substations can interconnect.

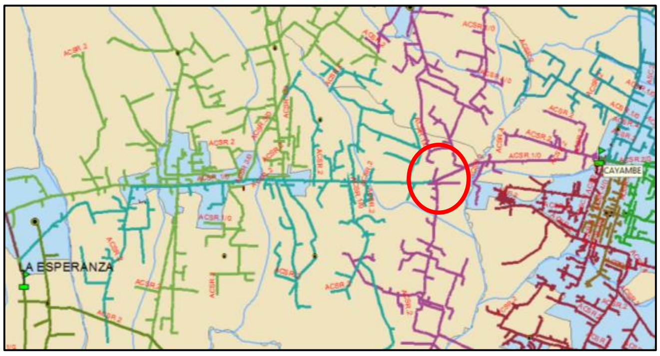

Figure 3. Feed Interconnection
Source: Taken from Emelnorte.

It was determined that 36 feeders throughout the Emelnorte distribution system have an interconnection point. The following table describes the substations and feeders with which they have interconnection for a load transfer, in case of system failure.

TABLE I
LIST OF INTERCONNECTED FEEDERS

Subestation 1	Feeder 1	Feeder 2	Subestation 2
La Esperanza	C1	C3	Cayambe
	C3	C3	
	C4	C2	
Cayambe	C5	C2	El Retorno
Otavalo	C2	C1	San Vicente
	C2	C4	
	C4	C3	
San Vicente	C2	C3	Atuntaqui
	C3	C3	Cotacachi
Atuntaqui	C1	C2	Alpachaca
	C1	C4	Cotacachi
El Retorno	C1	C2	Alpachaca
	C1	C5	San Agustín
	C4	C1	Ajaví
	C4	C2	San Agustín
	C5	C1	
San Agustín	C2	C1	Ajaví
	C3	C2	
	C4	C2	
	C4	C4	
	C5	C4	
La Carolina	C1	C1	Chota
	C4	C4	Tulcán
El Chota	C1	C3	El Ángel
Ajaví	C1	C2	San Agustín
	C2	C4	
	C2	C3	
	C4	C1	Alpachaca
	C4	C2	
	C4	C5	San Agustín
	C5	C1	Alpachaca
	C5	C6	
Alpachaca	C2	C1	Atuntaqui
	C2	C1	El Retorno
El Ángel	C1	C5	San Gabriel
San Gabriel	C1	C3	Tulcán

C. Voltage Levels

With data from the database maintained by Emelnorte, the data of each feeder were obtained as: demand (kW), voltage per unit, current (A) and power factor in the three phases. It is necessary to acquire this data, since with them the load flow of each feeder will be realized to verify its current state of operation and to be able to determine the feeders in which the transfer of load can be made.

Through the software CYMDIST of CIME International T & D Inc., load distribution is performed to determine the conditions of the feeders, which must comply with a ± 10% voltage drop according to the CONELEC 004/01 regulation.

After having made the load flows of the 36 pre-selected feeders, these are simplified to 9 cases, in which at least one of the feeders meets ± 10% of voltage drops.

TABLE II
LOAD DISTRIBUTION

Subestation 1	Feeder 1	V less 1	Subestation 2	feeder 2	V less 2
Cayambe	C5	79,90 %	El Retorno	C2	90,43 %
Otavalo	C2	79,90 %	San Vicente	C1	93,69 %
San Vicente	C3	66,05 %	Cotacachi	C3	96,45 %
El Retorno	C5	88,99 %	San Agustín	C1	94,67 %
San Agustín	C3	91,89 %	Ajaví	C2	82,93 %
	C4	90,27 %	Ajaví	C2	82,93 %
La Carolina	C4	84,47 %	Tulcán	C4	90,73 %
Ajaví	C4	77,52 %	Alpachaca	C1	96,20 %
	C5	56,07 %	Alpachaca	C6	90,89 %

D. Prior transfer to adapt to the distribution system.

This transfer is performed to balance the load between the 9 interconnected feeders, in which it is determined by the simulation that the amount of load is automatically transferable, verifying that there are no voltage drops or currents.

For this, the current demand of the feeders, such as the load, current and capacity of each transformer, must be known.

To begin with this process an analysis is performed between the feeders, so it was determined that the transformer of the substation El Retorno is of a capacity of 10 MVA, but for the moment is overloaded with a value of 10.91MVA, Which leads to a retrospective analysis of the other feeders as shown in the table, in order to make the download of The Return is considerable.

When adapting the feeders to be able to perform automatic transfers of load, the point of attachment is modified, where the recloser called Tie will be located, which, when entering operation, will allow the transfer of the amount of load determined in this study.

TABLE III
RETROSPECTIVE ANALYSIS OF THE FEEDERS

Subestation	Cayambe	El Retorno	San Agustín	Ajaví	Alpachaca
Current demand (kVA)	13557,71	10908,54	7298,67	7959,41	7140,26
	C5 →	C2			
		C5 →	C1		
			C3 →	C2	
			C4 →	C2	
				C4 →	C1
				C5 →	C6

An example of a feeder before and after the load transfer is described below.

- *El Retorno C5- San Agustín C1*

Currently in the table, it is evident the values with which the transformer of the El Retorno substation is overloaded with more than 900 kVA, being able to generate problems since they are not transformers in good condition, whereas the load of the San Agustín C1 feeder is very Small, so the goal is to transfer load to this feeder.

TABLE IV
FEEDERS THE RETURN C5-SAN AGUSTIN C1

Subestation	Feeder	Load (kW)	Current (A)	Trafo (kVA)
El Retorno	C5	3237,27	147,39	10908,55
San Agustín	C1	288,35	16,07	6238,98

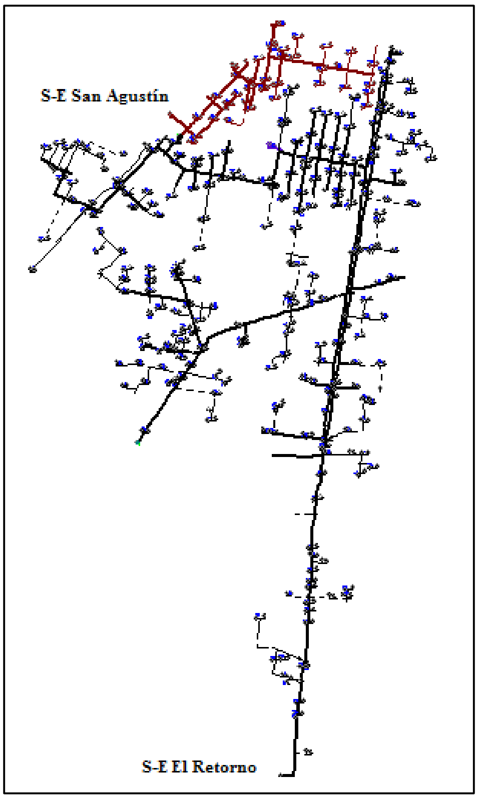

Figure 4. Feeders The Return C5 - San Agustín C1
Source: Taken from Emelnorte.

The transfer is made from the feeder The Return C5 to the feeder San Agustín C1, obtaining in this way a considerable discharge of 2221 kVA of the feeder of the Return C5, as described in the table.

TABLE V
TRANSFER OF THE FEEDERS THE RETURN C5-SAN AGUSTIN C1

Subestation	Transfer (kVA)	Load (kW)	Current (A)	Trafo (kVA)	Reser
El Retorno C5	2221,65	1015,61	67,61	8686,89	1313,11
San Agustín C1	2221,65	2510	93,21	8460,63	1539,37

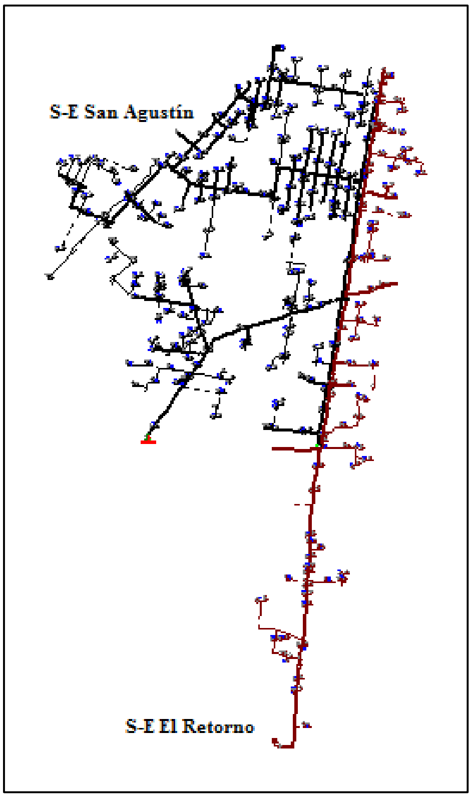

Figure 5. Feeders The Return C5 - San Agustín C1
Source: Taken from Emelnorte.

E. Location of reclosers for automatic transfer of load..

After the previous transfer, where the location of the first TIE device has already been determined, the mid-points are located, which according to their location determines the amount of load to be transferred. For this purpose cases are defined, in which the different possibilities of location of the reclosers will be determined and the amount of load to be transferred in the event of a failure.

Three ways of configuring the reclosers were described, the Feeder Recloser is the recloser that is placed closer to the substation, which for this study is not used since Emelnorte's electrical system does not have automatic reclosing switches in the Headers of the substations.

One of the advantages of configuring these devices is that the logic associated with each recloser operates in this scheme without the need for communications or operator intervention, using the integrated voltage detection of the Nu-Lec reclosers and according to the programmed times, As shown in Figure 6.

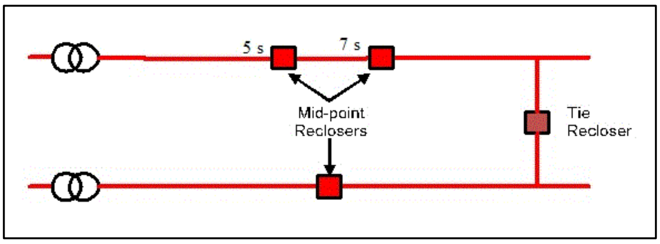

Figure 6. Device configuration.
Source: Schneider Electric outlet.El Retorno C5- San Agustín C1

a) CASE 1:

TABLE VI
CASE 1- ALIMNETADORES RETURN C5-SAN AGUSTIN C1

CasE 1	Transfer		
Recloser	Load (kW)	Current (A)	Load (kVA)
Mid-point El Retorno 1	748	65,21	781
Tie			
Mid-point San Agustín 1	1832,39	72,31	1873

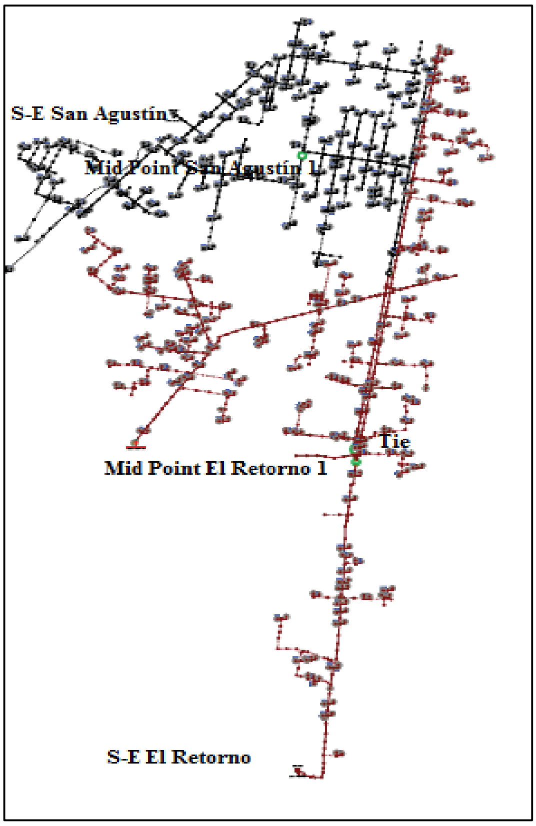

Figure 7. Case 1 feeders The Return C5- San Agustín C1
Source: Taken from Emelnorte.

• *Mid-point Return1*: a load of 781 kVA is transferred, being considerable from the feeder The Return-C5 to San Agustín-C1, the transformers are left with adequate loads, reason why it is considered that it is feasible.

• *Mid-point St. Augustine 1*: when transferring load from the San Agustín C1 feeder to Return C5, the transformer of the El Retorno substation is overloaded with more than 1 MVA, therefore the transfer is not feasible.

b) CASE 2:

TABLE VII
CASE 2 - FEEDER EL RETORNO C5-SAN AGUSTIN C1

CasE 2	Transfer		
Recloser	Load (kW)	Load(kVA)	Trafo (kVA)
Mid-point El Retorno 2	22	23	8286,25
Tie			
Mid-point San Agustín 2	3254	3353	11616,25

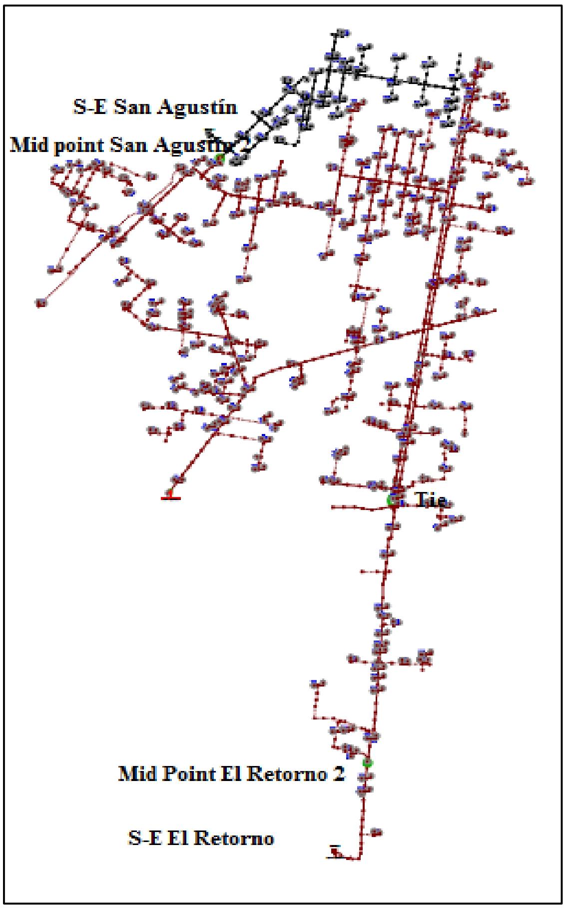

Figure 8. Case 2 feeders The Return C5- San Agustín C1
Source: Taken from Emelnorte.

• *Mid-point Return 2*: a load of 1036 kVA is transferred, most from the feeder The Return-C5 to San Agustín-C1, so it is not recommended, as it is unlikely to cause a fault in That portion of the feeder, the location of a recloser at that point is unnecessary.

• *Mid-point San Agustín 2:* When transferring a 2294 kVA load from the San Agustin-C1 feeder to the feeder The Return-C5, the transformer of the El Retorno substation is overloaded with more than 1 MVA, the transferred load exceeds Capacity of the transformer, which discards this option.

c) CASE 3:

TABL VII
CASE 3 - FEEDER EL RETORNO C5-SAN AGUSTIN C1

Caso 3	Transfer		
Recloser	Load (kW)	Current (A)	Load (kVA)
Mid-point El Retorno 1	748	65,41	781
Tie			
Mid-point San Agustín 3	1086	27,61	1100

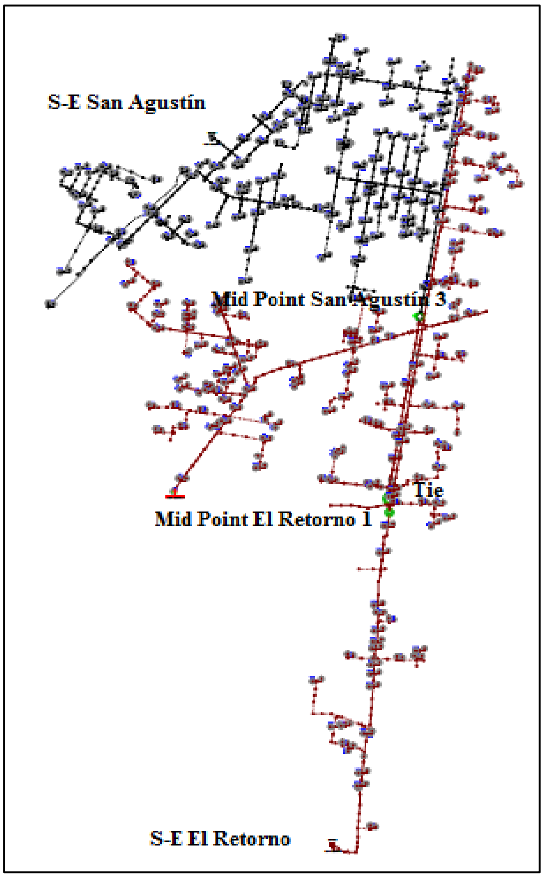

Figure 9. Case 3 feeders The Return C5- San Agustín C1

Source: Taken from Emelnorte.

• *Mid-point Return 1*: As already analyzed in the first case the location of the mid point Return 1, is the most feasible, since in case of failure a considerable load of 781 kVA can be transferred, taking into account That the feeder of St. Augustine C1 will operate without any inconvenience.

• *Mid-point San Agustín 3:* For the transfer of the San Agustín-C1 feeder to the Return-C5, the transferred load is taken into account, this being more than 1 MVA, so it is considerable although the transformer of El Return is still overloaded, if it can withstand that overload as it is only in case a fault occurs. So, this case if you apply it.

In summary, the following are the transfers that can be executed in the study:

Two-Way Transfers:

- Alpachaca C6- Ajaví C5 with Case 1
- Alpachaca C1- Ajaví C4 with Case 2
- Ajaví C2- San Agustín C3 with Case 3
- El Retorno C5- San Agustín C1 with Case 3
- El Retorno C2- Cayambe C5 with Case 1.

Unidirectional transfers:

- Ajaví C2- San Agustín C4 with *Mid-point* Ajaví 1,
- Cotacachi C3- San Vicente C3 with *Mid-point* San Vicente 1
- Otavalo C2- San Vicente C1 with *Mid-point* Otavalo 1

IV. CONCLUSIONS

With the present study, it was concluded that the recloser, besides operating as a protection device, also acts as an element that allows automatic transfers of load, allowing in this way to maintain a greater number of users with service, in case of a Failure in the distribution system.

It was determined that, of the 66 feeders that make up the Emelnorte distribution system, it is possible to proceed with the automatic transfer of load through Schneider Nu-Lec reclosers in 8 feeders which have the necessary technical conditions for the selection.

Using the CYMDIST simulator, it was determined that it was necessary to make a previous transfer to improve the feeder loadability, and thus to have optimum conditions to proceed to the location of the reclosers called mid-points, which according to their location is determined The amount of charge to be transferred.

With the strategic location of the reclosers, it was possible to determine the load to be transferred, taking into account the capacity of the transformers of the substations and was able to maintain in service about half of the load, in case of a system failure electric.

It was concluded that Emelnorte have sections of the single-phase network distribution system, so it can not perform the automatic transfer of load, since the study is applied only for three-phase networks.

V. REFERENCES

Alexis Zhungur Procel, E. C. (2014). *Diseño de esquemas de control integrado de tensión y potencia reactiva del sistema de distribución de la empresa eléctrica regional CENTRO SUR C.A.* Cuenca.

Allen Wood, B. W. (1996). *Power generation, Operation and Control.*

Chumbi, R., & Verdugo, T. (2013). *Integración con CYMDIST de las redes de media tensión y subtransmisión del sistema de CENTROSUR.* Cuenca.

D. Miraglia, J. M. (2015). Aplicación de Loop Automation en una red de distribucion aérea de media tensión. *INGE@UAN*, 17.

Escobar Corona, R. (2004). *Metodología para la solución del problema de flujos de potencia convencional mediante el metodo desacoplado rapido incluyendo el compensador avanzado serie para el control del flujo de potencia.* Morelia.

Ganoa, J. L. (2009). *Aspectos para la planeación de redes de distribución.* Mexico D.F.

Juárez, J. (2006). *Sistemas de distribución de energía eléctrica.* Mexico D.F: Sans Serif Editores.

Rivas, C. (2013). *Manual de operación, programación y pruebas eléctricas del reconectador automático trifásico.* Camurí Grande.

Schneider Electric. (2002). *Reconectador Trifásico automático.*

Schneider Electric. (2009). *Automatización de redes.*

Schneider Electric. (2010). *Recloser Solution- Descripción Tecnica General.*

Schneider Electric. (2014). *Descripción Técnica General.*

Schneider Electric. (2014). *Distribución Aérea y Automatización de Redes.*

Schneider Electric. (2015). *Loop Automation.*

Soto, R. (2002). *Power System Protection and Switchgear.* Sao Paulo, Brazil: Limusa.

Torres, O. (2012). *Protecciones de los sistemas eléctricos de distribución.*

CELEC S.A. (14 de Febrero de 2011). *Sistema eléctrico ecuatoriano*. Obtenido de https://www.celec.gob.ec/transelectric/images/stories/baners_home/ley/terminologia.pdf

CONELEC. (23 de Mayo de 2001). *Calidad de servicio eléctrico de distribución.* Obtenido de http://www.regulacionelectrica.gob.ec/wpcontent/uploads/downloads/2015/12/CONELEC-CalidadDeServicio.pdf

Constructor Eléctrico. (12 de Enero de 2016). *Sistemas de Transferencia*. Obtenido de https://constructorelectrico.com/sistemas-de-transferencia/

EATON Powering Business Worldwide. (Noviembre de 2014). *CYME International T&D*. Obtenido de http://www.cyme.com/es/

Gonzalez, F. (2007). *Anormalidades en sistemas de potencia.* Obtenido de http://fglongatt.org/OLD/Archivos/Archivos/SP_I/Capitulo4,SP1-2007.pdf

Ordoñez, J. (02 de 2010). *Mantenimiento de sistemas eléctricos de distribución.* Obtenido de http://dspace.ups.edu.ec/bitstream/123456789/2119/15/UPS-GT000156.pdf

Ptolomeo. (2008). *Sistemas de Distribución.* Obtenido de http://www.ptolomeo.unam.mx:8080/xmlui/bitstream/handle/132.248.52.100/784/A4%20SISTEMAS%20DE%20DISTRIBUCION.pdf?sequence=4

Sistemamid. (23 de Septiembre de 2014). *Sistema de distribución de energía eléctrica.* Obtenido de http://sistemamid.com/panel/uploads/biblioteca/2014-09-23_12-57-35110593.pdf

Vásquez, P. (Abril de 2013). *Parametrización, control, determinación y reducción de perdidas de energía en base a la optimización en el montaje de estaciones de transformación en la provincia de Morona Santiago.* Obtenido de http://dspace.ucuenca.edu.ec/bitstream/123456789/423/1/Tesis.pdf

VI. BIOGRAPHY

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