New Adaptive Non _ communication TL Protection Scheme with Three Phase Auto_Reclosing

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Abstract

In This paper a new adaptive non-communication method offers 100% Over Head Transmission Line fault clearance instantaneously, is presented. This Adaptive scheme adjusts distance Measuring Protection covering full TL in First zone with out waiting the communication inter-tripping signals, with high percentage successful three phase Auto_ Reclosing rate. This has been achieved by arrangement of three instantaneous, fundamental frequency, rms Under voltage Supervisory Relays controlling Auto_Reclosing command applied to the Circuit Breaker. The researchers presented a new philosophy to restore Over Head TL in more reliable and dependable method than the common existing one. The method utilizes a three phase monitoring Voltage Relay at each end of the OHTL which control the Reclosing Command. This new method is applicable approximately to all types of TL protection Relays (conventional or Modern Numerical Relays).

Key-Words: Non communication TL protection, Adaptive Auto_Reclosing Relays, Distance Measuring Protection.

طريقة تضبيط جديدة لحماية خط النقل من العطب بدون إتصالات مع إستخدام إعادة غلق الأطوار الثلاثة ذاتيا

د. مأمون فاضل الكبابجي **د. ناظم شيت رسول**

الخلاصة

تم تقديم طريقة تضبيط جديدة لاتعتمد على انتقال المعلومات بين الأطراف وتعمل على إزالة العطل لخطوط النقل بصورة آنية وبتغطية ١٠٠% ، وهذه التغطية للحيز الأول تعمل بدون انتظار الإشارة من الطرف الآخر على إعادة الغلق للأطوار الثلاثة ويتم العمل بواسطة مرحلات آنية تتحسس انخفاض فولتية (جذر معدل التربيع) لمركبة التردد الأساسي.

تم استعراض فلسفة جديدة (لاعادة غلق الأطوار الثلاثة ذاتيا)، تخفل ى المتوفرة وستخدم الطريقة ثلاثة مرحلات تتحسس انخفاض الفولتية عند نهاية كل خط نقل, للسيطرة على إعادة الإغلاق ويمكن استخدام هذه الفلسفة مع كل أنواع مرحلات الحماية القديمة والحديثة.

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1. Introduction

" The Adaptive Protection is believed to be one of the important concepts in modern power system protection. Various techniques based on the concept have greatly improved the performance of protection relays and its potential for even greater contribution will let it to play an increasingly important role in future of power system protection" [1].

Auto Reclose is of vital importance in power transmission system [2, 3]; hence most of the faults (on OHTL s) are transients in nature. So A/R affects stability and improves reliability of the transmission system [4].

High speed Auto-Reclose relays were applied to all high voltage Over Head Transmission Lines (OHTL) in the Iraqi Interconnected National Grid Networks. Auto_Reclosing is very important in restoring HV TL after transient fault which are almost 85% of the over all faults on OHTL [5]. Restoration of High Voltage TL is very important for better stability, continuity, reliability and dependability of the system; especially Tie Lines.

Non communication TL protection have been attracted many researchers allover the world[6]. Zhiqian Q. presented in Ref [7-9] new algorithms of TL protection, non_communication in three different schemes. These proposed new techniques in power line protection, based on the symmetric components to detect and identify the balance condition of the system during the fault. The speed of the relay could be relatively slow for some particular system and fault conditions. This may not be acceptable for applications where very high speed operation is required.

This paper presents new method in TL protection based on the combination of the concept of adaptive Auto_reclosing and non-communication protection. The paper presents the adaptive non-communication protection techniques, the protective relay makes instant tripping and reclosures operation decision adapting to the system and fault condition. Practical considerations are introduced and the performance of the technique under different conditions is discussed.

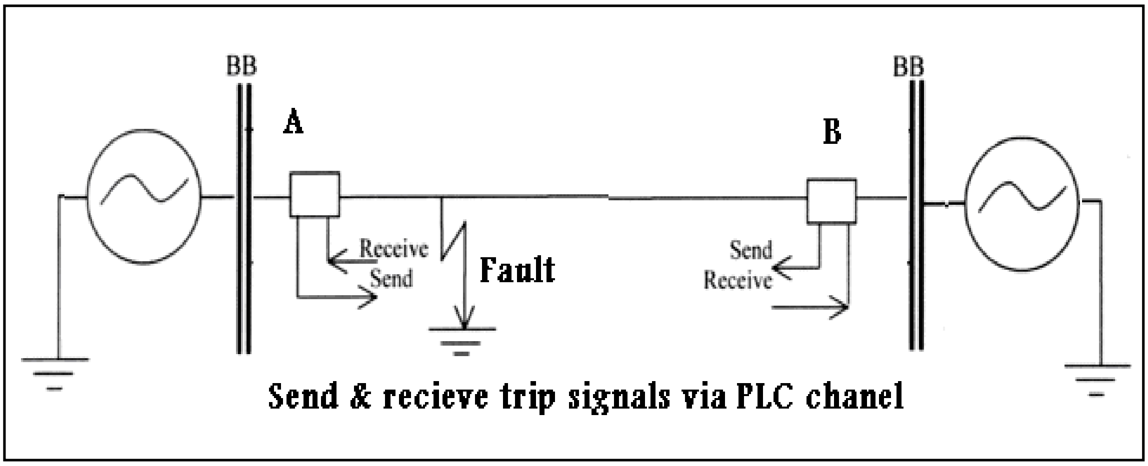

Fig. (1) the existing scheme of TL protection with inter-tripping.

2. Existing Protection Scheme

Iraqi High Voltage Networks 132 Kv utilize DMP Distance Measuring Protection with inter tripping scheme. The signals between the protection Relays at both ends of the TL transfer using Power Line Carrier (PLC) channels. As seen in Figure (1), any faults in the first zone will initiate CB trip at A with Sending trip to the protection relays at B via PLC, following that Auto_Reclosing command release. Received signal at B will initiate CB trip with A/R even if the fault seen at B-side is at 2nd zone (Under Reach accelerating scheme).

2.1 High Speed Auto_Reclosing

High-speed Auto_Reclosing relays are utilized on the high voltage Transmission system [10]. Auto-reclose schemes are employed to carry out this duty automatically: they have been the cause of a substantial improvement in continuity of supply [11]. Further benefit particularly to Extra High Voltage (EHV) system is the system stability and synchronism [12]. Refer to figure (1) the existing scheme of TL protection with PLC under reach accelerating trip signal which is used in all High Voltage (132 Kv) Iraqi Network.

The existing scheme suffers from difficulties in restoration of the TLs after transient faults due to the following reasons:-

1. Power Line Carrier scheme failures, so the fault will be continuously fed from the other 2nd line's end (B) and C.B at (A) will reclose on fault which will shock the system & the equipment of control and protection.
2. Protection at B in this case will trip at 2nd zone with time delay about 0.5 sec.
3. Sustained fault, which also will cause both ends of the T.L trip & Reclose on the fault which will also cause shocks to the system and apparatus.

3. Novel Adaptive Three Phase Auto Reclosing (ATPAR) Scheme

All the existing Auto_Reclosing relays applied to the system have followed the philosophy of ***'reclose to restore the system'***, but a progression from this philosophy to ***'reclose only if safe to do so'*** can now be made using the new adaptive conventional approach. The performance of A/R can be greatly improved by applying three Voltage Monitoring Relays which will be fed directly from the Capacitive Voltage Transformers (CVT s) of the protected TL. Each voltage relay of the three phases will give an indication of healthy phase voltage (normally closed contact), while open contact will indicate Dead/ or phase Undervoltage.

For any network or protection configuration The circuit shown in figure (2), can be successfully used. The circuit will be inserted between the

Auto_Reclosing Relay which initiates Auto_Reclosing command and the Circuit Breaker closing control device and as can be seen in figure (3).

Reclosing command from the A/R relay will either pass through three healthy phase voltage path, which will result in definitely successful Reclosing, or through the dead three-phase voltage path, which will use the philosophy of Live Bus Dead Line (LBDL)[3], which also will surly led to successful Reclosing.

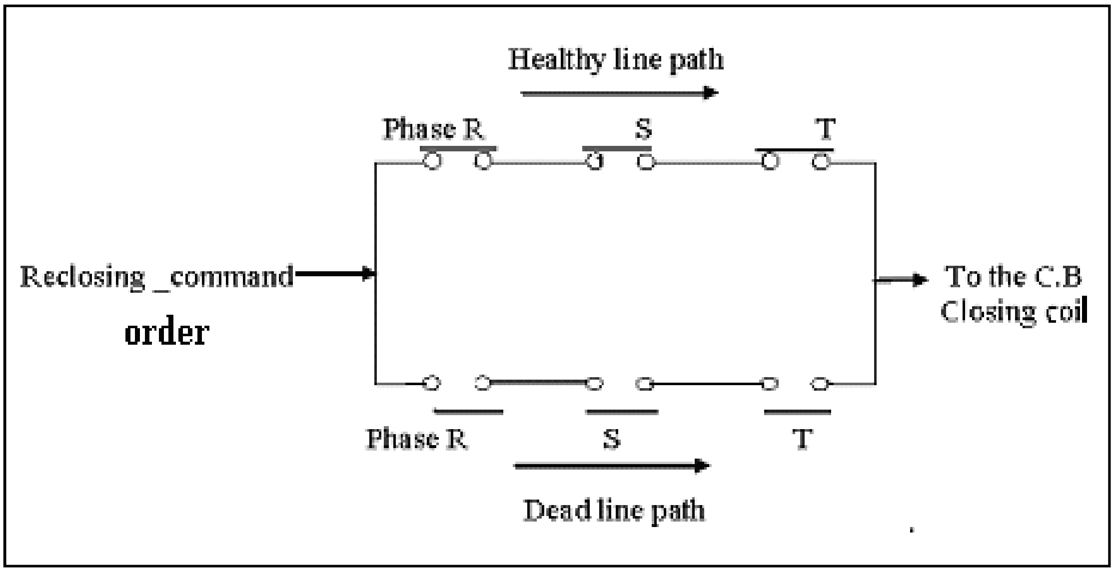

Fig. (2): Reclosing command paths diagram

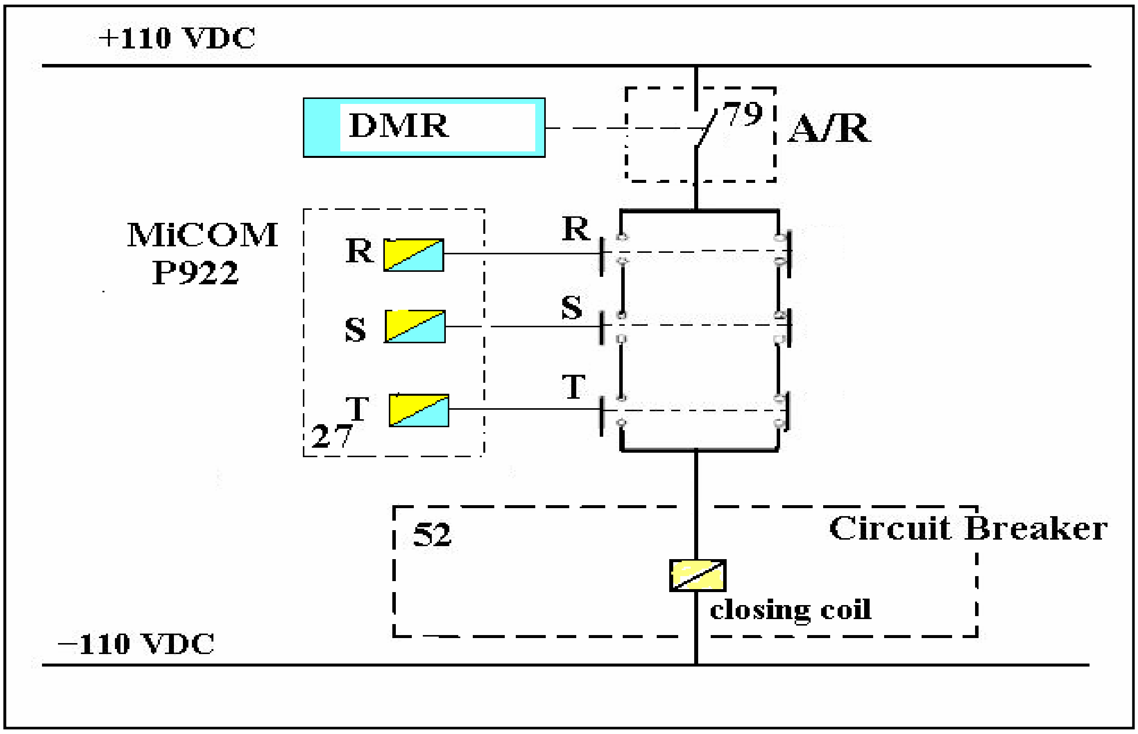

Fig.(3): CB control circuit diagram with the Adaptive Three Phase A/R

Other wise if any phase situation was different (incase of fault) from the other phases then the two paths will be interrupted and there will be no Reclosing; hence avoiding Reclosing on to faulty T.L.

4. Adaptive Non_communication full line Protection

All Hv Transmission Lines are normally equipped with a combination of the Distance Relay protection with a communication links (PLC) to provide full line coverage [1, 8]. In the schemes as shown in Fig. (4), the distance protection relays are installed at both ends of the protected line and they are arranged to instantly trip for a fault within Zone 1 (~80%) of the line length from their locations, for example at point “F1” in Fig.(4).

Under reach accelerating or inter-tripping scheme on HV 132 KV transmission lines are commonly used [3, 4]. In this scheme PLC signaling is used in connection with distance relays to speed up fault clearance, falling in delayed second zone, from both ends. The delay inherent in the second zone may be overcome by transmitting a trip instruction to the delay at the remote terminal via a carrier channel. For a fault occurring near one end of the protected zone within the Zone 2 reach of the end "A " relay, for example at point "F2 ", the end "B " relay near the fault location will trip instantly and at the same time send the information about the fault condition to the end " A" relay through a communication link. Signal transmission is being initiated by local first zone relay operation. The carrier facility thereby allows simultaneous and fast tripping at both ends of the tie line and permits application of Auto_Reclosing schemes. In this scheme, the requirement for the communication link will surely increase the cost and decrease the reliability of the scheme due to the expected errore in PLC system. *"In the latter case, not only the delay of the tripping is unacceptable, but also the tripping could occur for fault outside the protected zone"* [1].

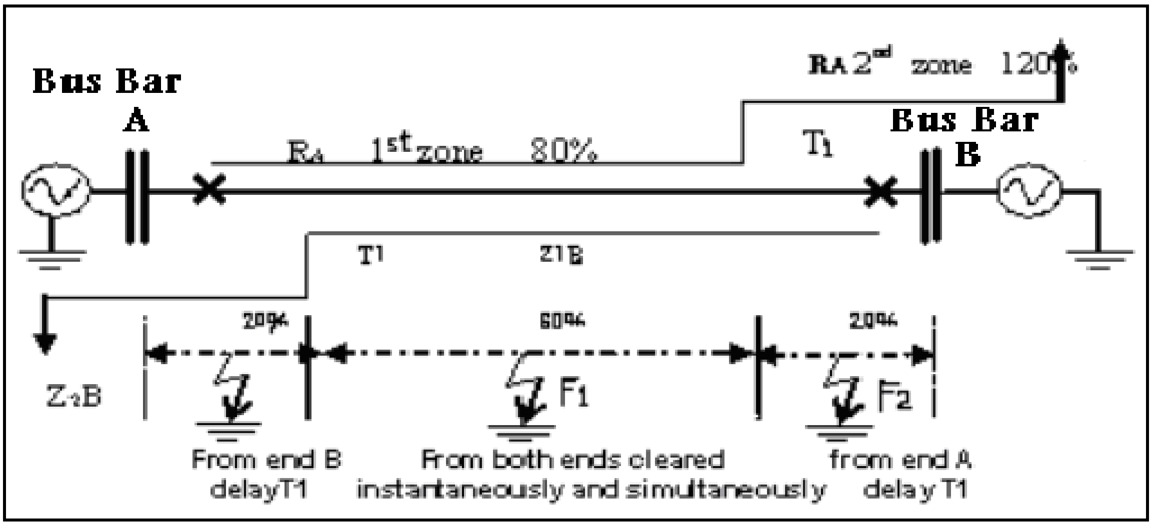

Fig. (4): TL Distance protection zones coverage.

As shown in figure (5), a new protection zone which covers the entire line section "AB" is introduced to be used in the new technique.

By this method any fault along the hall TL (100%) will be covered by the 1st zone and instantaneously cleared from both TL ends with Auto_ Reclosing operation. The ATPAR operation (as illustrated before in section 3), will control the reclosures after the Dead Time delay elapse, allowing the secondary arc extinction and the fault path rehealment (if it is transient fault). So the restoration of any HV OHTL will be very fast with the following timing: -

3 cycles = 60 msec. protection time before trip signal release after fault inception.

2 cycles = 40 msec. for TL's CB opening time.

Typical dead times for 132 Kv TL are calculated by the relationship given by the following [3]:

$$t = 10.5 + \frac{Kv}{34.5} \text{ cycles} \qquad \text{----------} \ (1)$$

where Kv here is : Line_Line system voltage in Kv.

For HV 132 Kv TL system:-

$$\text{Dead Time} = 10.5 + \frac{132}{34.5} \text{ cycles}$$

$$= 14.3 \text{ cycles}$$

14 cycles = 14x 20 = 280 msec. Dead Time (de_ ionization time) DT.

4-6 cycles = 80 ~ 120 msec. CB reclosing time (this depends on the site test of the associated Breaker).

0.46 ~ 0.5 sec. Total System interruption time.

4.1 The New suggested Method

Non-Communication instant full TL Protection can be achieved by the following arrangement steps:

Step 1: setting first zone DMP to 100% TL impedance, instead of 80~90% which are common practice all over the world [2-4] & [10].

Step 2: Utilizing the three phase Under Voltage supervisory Relays arrangement as highlighted in previous section 3.

If the fault is at the boundary of 1st zone (100%), of course with expected minimum error ± 3% (collected from CTs and CVTs, phase & magnitude errors and DMP plus man error). Man error: from the calculation and setting of TL impedance [5].

DMP may overreach and the coverage of the protection Relays will extend to the front BB and to the next TL (that is BC) in the forward direction. Let us explore the scenario of such fault with protection reactions to the fault (F1) shown in Figure (5):

For **R1** due to the above mentioned errors, it is 1st zone fault; so trip with A/R.

Also for **R3**, it is close 1st zone fault; so trip with A/R.

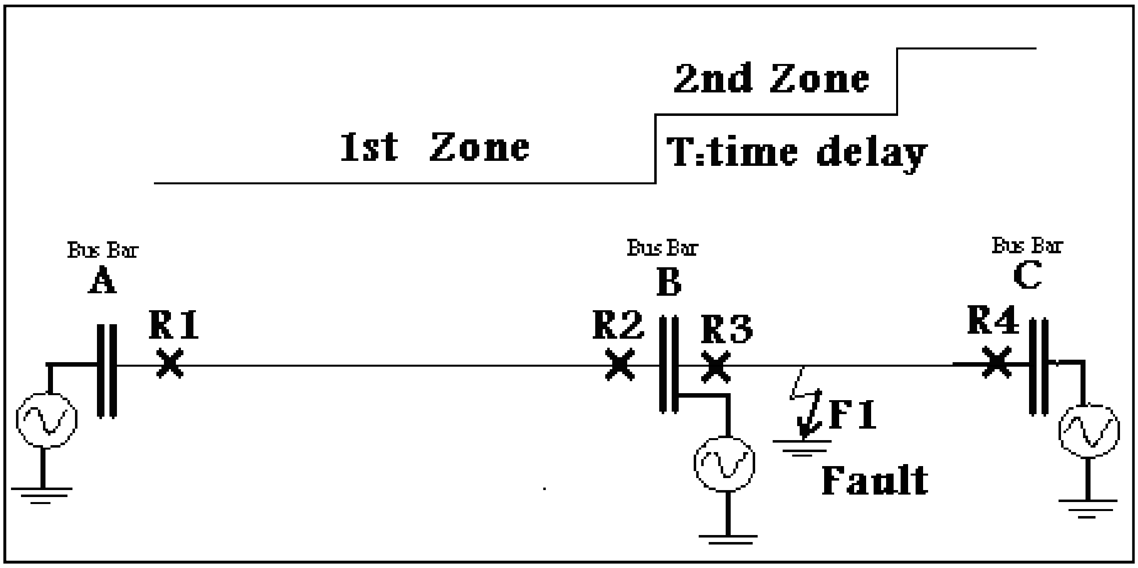

Figure (5) fault at the next TL with double end feed.

For **R2** it is a reverse fault; that is starting DMP, 4th Zone fault (2 seconds delayed trip) with out Auto_reclosing operation.

R1 & R3 after about 0.5 sec will Reclose connected CBs, if the ***fault*** was ***transient***, both TLS will be restored instantaneously and successfully. Otherwise, if it is a ***permanent fault***:

In this case **R3** re-closing will be prevented by the Adaptive Three phase Auto_ Reclosing arrangements (ATPAR).

But **R1** will be Reclosed successfully because there is no fault on its TL. In this case the faulty line was not Reclosed while the healthy TL restored immediately.

5. Results

The new suggested configuration of the voltage monitoring relays performed successfully by programming the MiCOM P 922 Voltage Relay in the laboratories of AREVA T&D UK Ltd-EAI, Stafford, UK. The Relay's parameters and configuration are given in the appendix.

This Novel Adaptive Three Phase Auto_Reclosing scheme can operate without any time delay waiting to the Power Line Carrier PLC signal; hence the setting of the instantaneous protection zone1 of the Distance Measuring Relays at the two ends can be extended to cover the entire TL with no risk, together with coordinating the dead time of the reclosing relays at the tow ends of the TL. Thus ATPAR scheme can provide full line trip immediately in succession. This Method can be applied to both HV 132kv, and EHV 400kv transmission systems.

6. Conclusions

The ATPAR scheme is simple in nature and easy in implementation; since it is using the existing hybrid relays (conventional and/or Modern Numerical Relays), which are already in service. However the AI Methods in this field are still in experimental and under academics study stages.

The main incentive for the scheme is to avoid Circuit Breaker Reclosing upon permanent fault, as this leads to an extremely shock loading to the Generator's shaft, system stability and time consuming system restoration process. Furthermore, the scheme is intended to be a robust and adaptive corrective arrangement enhancing Auto_Reclosing operation.

The advantageous of this practical and new applicable method are:

1. No Reclosing onto permanent faults.

2. Faster reclosures after transient fault clearance; by integrating fault clearance of the 2^{nd} zone portion of the TL (which is about 40% of the TL, 20% from each ends).

3. Higher percentage of successful reclosures increased by 33%.

4. Better system stability and less shock loading (due to avoiding reclosures upon permanent fault).

5. Longer circuit breaker in service life.

6. Reduction in number of recurring faults.

7. Full line trip immediately in succession without PLC inter tripping signal.

8. Improvements in quality of supply.

7. Appendix

MiCOM P922 relays are able to provide effective voltage protection; due to the three independent phase overvoltage and phase undervoltage thresholds.

The configurable detection logic (AND, OR) can also indicate the absence of voltage, when the undervoltage protection is used [13]. Figure (6) declares the connection diagram of the P9xx series. The 3 zero-sequence under voltage thresholds can be applied: The following functions are available in MiCOM P922 relay: • 3 independent phase overvoltage thresholds (instantaneous and time-delayed - ANSI 59 code). • 3 independent phase undervoltage thresholds (instantaneous and time-delayed - ANSI 27 code). • Settable Hysteresis thresholds for Undervoltage and Overvoltage functions. • 3 independent zero-sequence overvoltage thresholds. (Instantaneous and time-delayed

- ANSI 59N code). • 2 programmable logic equations). • Programmable I/O Relay latching (ANSI 86 code). • Display of true RMS values •

An RS485 rear port compatible with one of the following protocols: MODBUS™, Courier, IEC 60870-3-105. Threshold value for Undervoltage relay adjusted to 0.8 Per Unit, indicating voltage Dip. associated with fault occurrence.

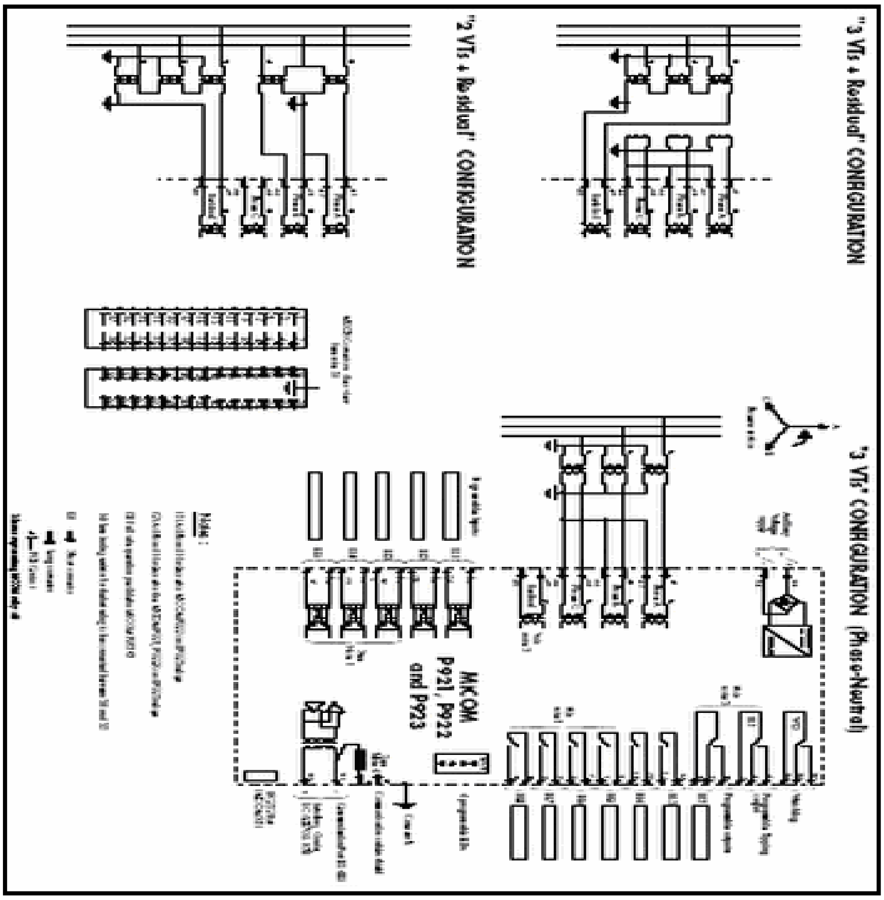

Figure (6): MiCOM P922 connection diagram [13].

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10. Biographies

Nathim Sheyt Rasool, International Protection Engineers Association (IPEA) member, was borne in Mosul 1959, obtained his B.Sc. in Electronics & communication 1981, M.Sc. 1995, Ph.D. 2006 in Power & Machine from Mosul University, Iraq. Since 1987, he has been with INRG, Iraqi North Regional Grids, working as Protection & Maintenance Engineer. Currently Mr. Rasool is the Manager of Planning & Development dept. in INRG.

Al_Kababjie, Maamoon (M'77) was born in Mosul, Iraq, on June 21, 1947. He received the B.Sc. degree from the College of Engineering University of Mosul, Iraq, in 1968, the M.Sc. degree from Middle East Technical University, Ankara, Turkey, in 1976 and Ph.D. degree from Bradford University, England in 1982, all in electrical Engineering. Since graduation he is with Electrical Engineering Dept. Mosul University. He was promoted to Assistant Prof. in 1985. He supervised many M.Sc. and Ph.D theses.

The work was carried out at the college of Engg. University of Mosul