Abu Dhabi University

EEN 399 - Internship

Internship Report

Summer 2013 - 2014 Internship at Sawa Lake Electromechanical

Name of Internee:
Muhammad Obaidullah
1030313
B.Sc. Electrical Engineering
Abu Dhabi University, U.A.E.
Communication Major

Supervisor:
Dr. Muhammad Akmal

August 10, 2014

بسم الله الرحمن الرحيم

In The Name of Allah, The Most Beneficent, The Most Merciful.

Contents

List of Figures

1 Internship Information

Name of Internee: Muhammad Obaidullah
Internship Start Date: 15th June 2014
Internship End Date: 24th July 2014
Number of Internship days: 30
Type of Internship: Development
Company Name: Sawa Lake Electromechanical

Dr. Muhammad Akmal	Muhammad Obaidullah

2 Description of the Company

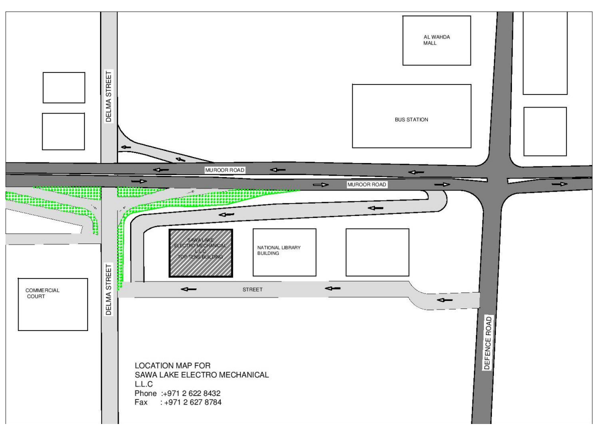
2.1 Basic Information about Company

Sawa Lake Electro Mechanical L.L.C. is engaged in Electro-mechanical works and maintenance services since 1999, and is located in Abu Dhabi, U.A.E. Sawa Lake is no just any other contracting company, it is a team of dedicated engineers and professionals striving to bring growth to the community and provide the finest professional electro mechanical services to meet the client's needs.

The company is approved by several governmental entities such as Abu Dhabi Water & Electricity Authority and Federal Electricity & Water Authority.

Sawa Lake Electro Mechanical L.L.C. بحيرة ساوة للأعمال الكهربائية والميكانيكية ذ.م.م.

Company: Sawa Lake Electro Mechanical
Phone: +971 2 6228432
Mobile: +971 50 3873307
Fax: +971 2 6278784
Email: info@sawalake.ae, sawalake@gmail.com
Address: Delma St. Below Murror Bridge Abu Dhabi UAE
Website: http://www.sawalake.ae/



2.2 Type of Business Structure

Sawa Lake is a Limited Liability Company (LLC). In other words, the loss and profit is shared between the owners according to the investment into the business.

Sawa Lake has two main managers. A Project Manager, Engineer Alaa, who is responsible for handling all the on-going projects and assign all the engineers and technicians to their appropriate jobs. A General Manager, Engineer Hassan, overlooks the organization's operations and keeps track of all the profits, losses, and clients.

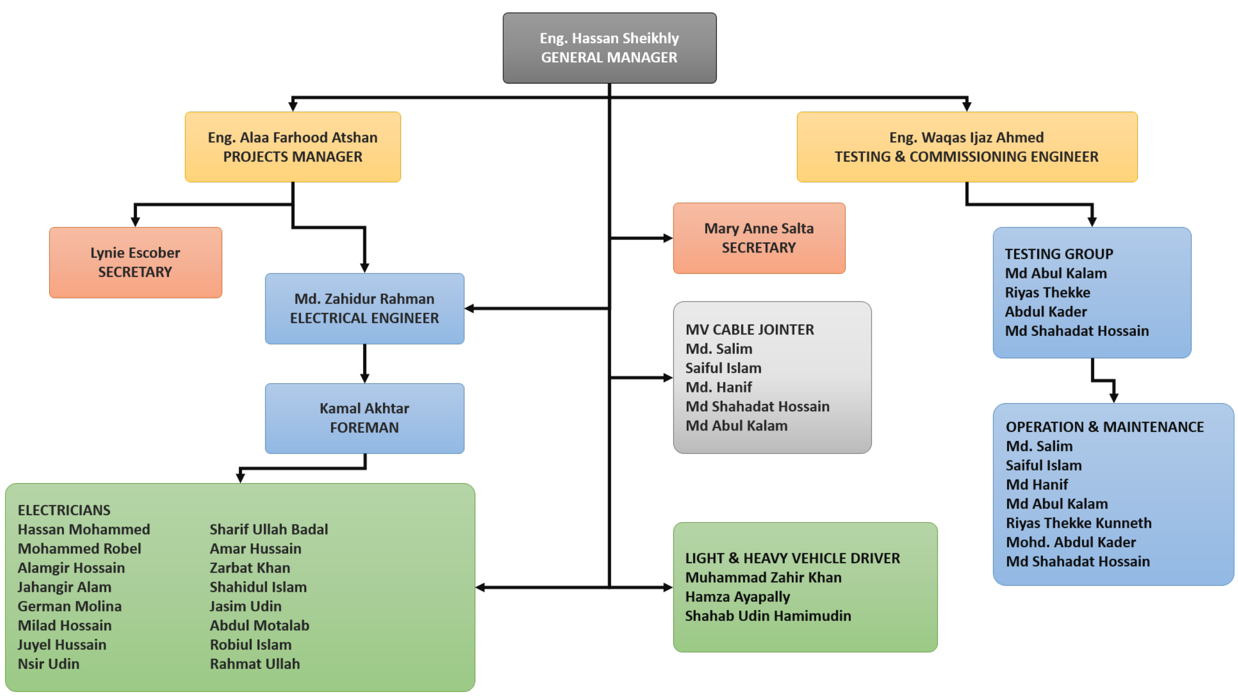
2.3 Sector of Service

The company operates in testing and installation of Electrical and Mechanical aspects of a construction work. Basic consumers are the companies and contractors who have the contract to build a villa, a building, or an office. Sawa Lake binds in contract with these companies to handle testing and installation of electrical and mechanical equipment inside the building or villa. Installation and testing of Ring Main Units (RMUs), Remote Terminal Units (RTUs), Switch gears etc. is handled by the company for many major construction and automation companies.

2.4 Customers & Clients

The major customers are private companies who provide contract for laying Low voltage cables, testing and commissioning. Major customers include companies like Tabreed, AutoChim, Cityscape, ADDC and many more. The company has tender for laying low voltage cable lines for Tabreed after getting approval from ADDC. As far as AutoChim and other companies are concerned, the company performs commissioning, testing and replacement of electrical equipment according to the ADDC regulations and prior approval.

2.5 Organization Chart



2.6 Duties of Electrical Engineers in the Organization

The following tasks and duties are performed by the electrical engineers in the company:

- Install and Test different units including Tri Ring Main (TRM) and Quad Ring Main (QRM) and commission them for quality assurance.
- Studying and Analyzing the parameters for the relays.
- Cable jointing and termination for transformers, Package Units, QRM and TRM's.
- Supply, Installation, Testing and Commissioning of Switchgears, ATS Panels, DMS Interface Cubicle.
- CT, VT, Ammeter, Voltmeter, Breakers and Isolator Works.
- Energization and Clearance with Authorities like ADDC, AADC.
- Complete Jointing and Termination Works.
- New and Old relays of make such as Schneider Electric, ABB, Areva, Alstom, Siemens, Micom are optimized for maximum protection and efficiency points of operation. Intense and critical calculations are performed to assure all the equipment falls under ADDC rules and regulations.
- Supply, Installation, Jointing, Testing and Commissioning of high voltage cables.
- Operation and Maintenance of all substations including high and low voltage.
- Additional accessories which accompany Main Distribution Boxes, Sub Main Distribution Boxes, Control Boxes such as Light Fittings, Light Poles are also installed and maintained by the electrical engineers.

3 Internship Activities

3.1 Researching on Remote Terminal Units (RTUs)

RTU is Remote Terminal Units based on microprocessors which are used to control and monitor power systems. RTU can provide the server with all the critical sub-station analog and digital parameters and information such as transformer oil temperature, pressure, and level.

Each substation is equipped with a SEL Axion Node that communicate with the relays and sensors using the company's own Protocol. IN this case SEL Protocol. Each substation node can be interconnected by either Ethernet cable, WiFi, Fiber Optic, or GSM.

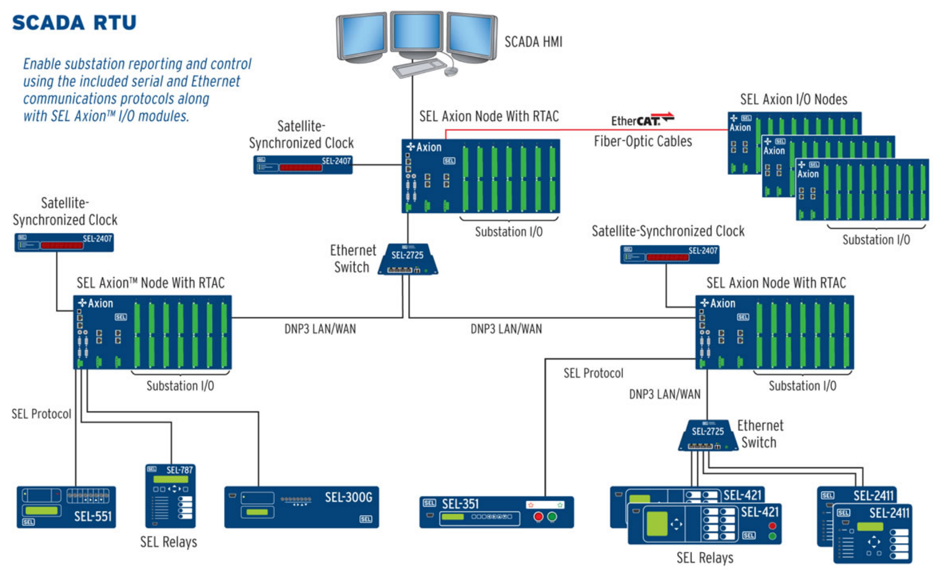


Figure 1: The figure explains how the SCADA RTU system works by using the SEL protocol. [1]

3.2 Researching on Ring Main Units (RMUs)

Ring main units are combination of switches, circuit breakers and transformers which act as a node in the ring. The objective of ring main unit is to supply consumer units with un-interrupted power supply while stepping down the voltage. If there is a fault or breakdown in one of the ring main units, then that unit can be isolated and the power flows through the other side of the ring. This ensures that there is continuous supply of power even when there is fault or any maintenance work needs to be done. There are basically two types of ring main units:-

3.2.1 TRM

TRM stands for Triangular Ring Main Unit. There are two incomers and one outgoing. The outgoing cable is connected to one transformer and is used to create a node in the ring.

3.2.2 QRM

QRM stands for Quad Ring Main Unit. There are two incomers and two outgoing for two transformers. He outgoing are connected to two transformers and can be used to create another ring.

UAE uses ring main units because of its un-interrupted power supply. When a new unit is to be added to the ring, or in other words a new substation is to be installed in the ring, the following steps are taken.

1. Calculation of load current and the capacity of the ring to support the additional load.
2. Prior approval from ADDC mentioning the isolation point and the total time for installation.
3. All work should be completed within the appointed hours by ADDC and supply should be put back within time limit.

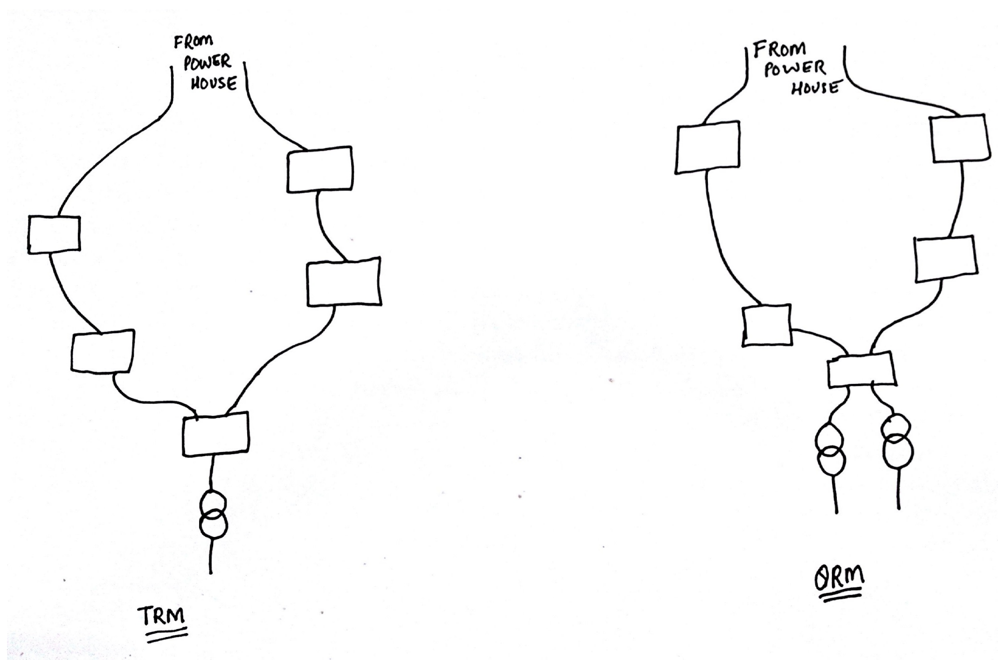


Figure 2: The figure shows two different ring main units. TRM on the left has two incomers and one outgoing while the QRM has two incomers and two outgoings.

4. All entities and consumers are informed if there is any shutdown. Normally because of the ring network, while interruption, the supply is provided from the other side of the ring.
5. If the engineers are installing the TRM, only one transformer is needed.
6. If engineers are installing the QRM, two transformers are needed. Another ring of consumers can be created from the QRM as two outgoign cables are present.

3.3 Analysis of Street Lamp Power Supply & Control Circuits - Khalidiya Area

At the end of the first week of internship, we were allowed to visit one of the sites in the Abu Dhabi city center, sector W-10 in the Khalidiyah area to be precise. The operation being done there was the removal of old street lamps and the installation of new ones. The entire network of the street lamps was commissioned, tested and changed by Sawa Lake and their engineers.

Since by the time we reached, the operation of installation was in its concluding stages and therefore a detailed insight of all the equipment used in the said operation. We were introduced to many things that we were not aware of during this site visit. We were accompanied by engineer Naseer, a professional engineer who was managing and overlooking the on-site operation. He explained in detail most of the electrical equipment installed in the control cabinet and inside each of the street lamps. The lamps are using LEDs since LEDs are power efficient and green. All the electrical equipment like the fuse and AC-DC converter are installed in the cavity underneath each lamp. All the lamps are then connected to the main control cabinet from where each sector of lamps is abstracted and lumped using the parallel connection and fed into a single MCB (Miniature Circuit Breaker). In the control cabinet there are several key components:-

1. Photo resistor.

2. Miniature Circuit Breakers (MCBs) for each sector.

3. Electric Power Meter.

4. Current Transformers (CTs) for measuring and metering purposes.

5. Mechanical Timer.

6. Several Busbars for each phase and neutral.

There are four busbars inside the control cabinet. The red, yellow, green, and neutral busbars. The neutral busbar is thinner than the phase busbars because in normal mode of operation it has to carry back only the reactive power component of the electricity.

Figure 3: The figure shows the inside of the control cabinet where the switches for each sector of street lamps are installed and can be controlled either manually, by using a timer, or by photo diode. The two current transformers in blue can be clearly seen which are used for sensing the amount of current consumed by street lamps and display it on the meter.

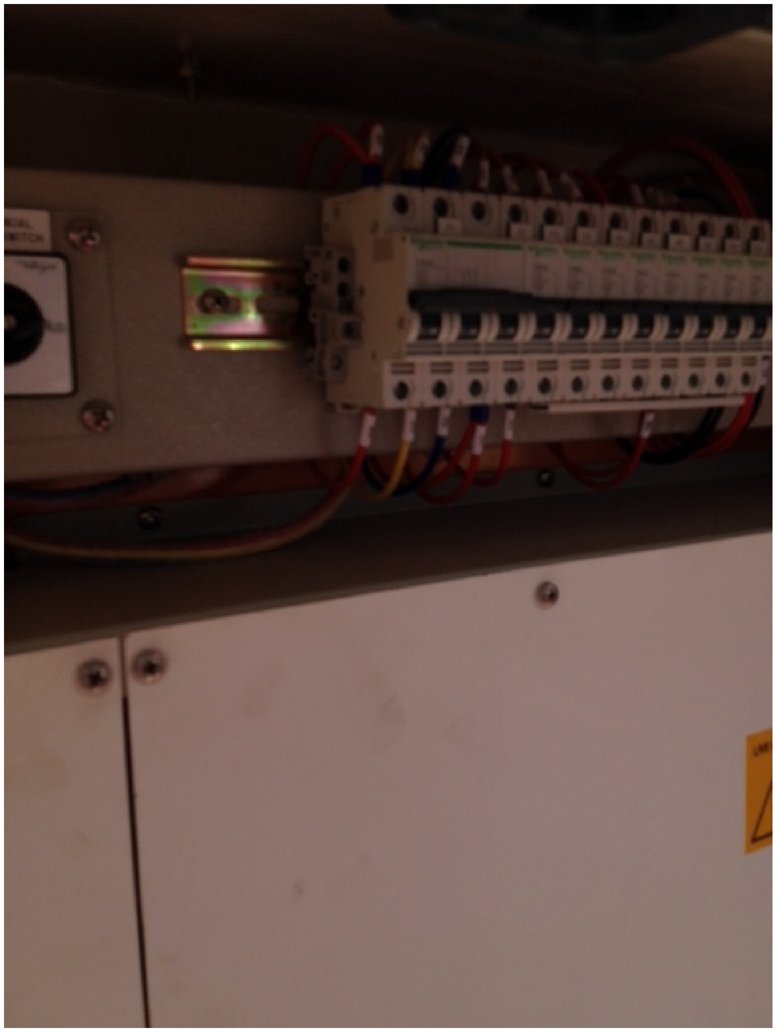


Figure 4: The figure shows the circuit breakers which are installed to protect the circuit from high current in case there is a fault.

The supply for the street lamps and nearby buildings comes from the local substation which has all the protection and transformer equipment to step down the voltage from feeder pillar 11kV to 0.4kV.

Figure 5: The figure shows the electric meter which keeps track of the power consumption of the street lamps.

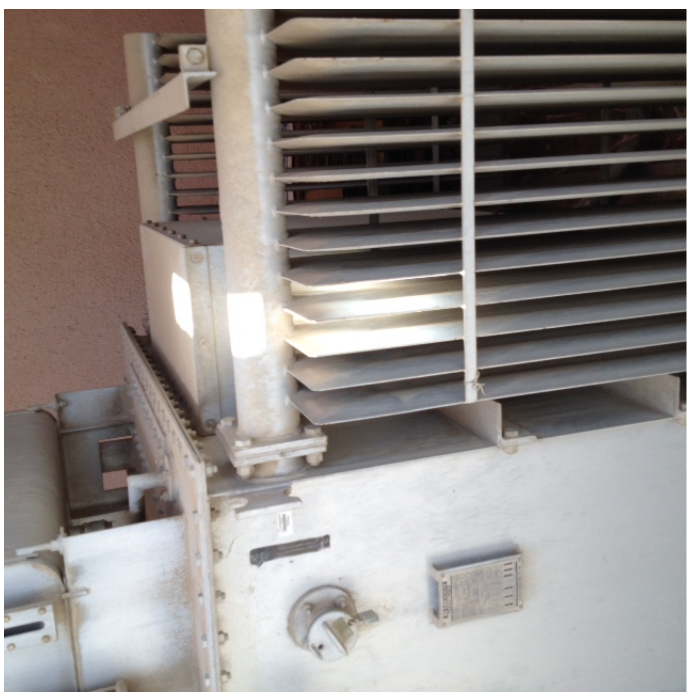


Figure 6: In the picture above, a typical step-down transformer is shown where 11kV is stepped down to 0.4kV.

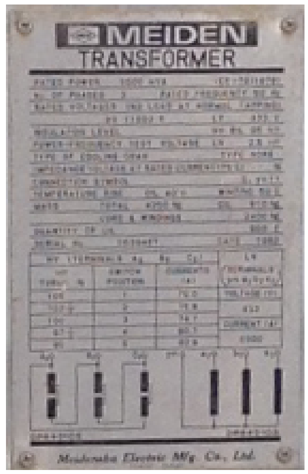


Figure 7: The ratings for the transformer are engraved on the metal plate fixed on the transformer. This transformer is in $\Delta - Y$ configuration.

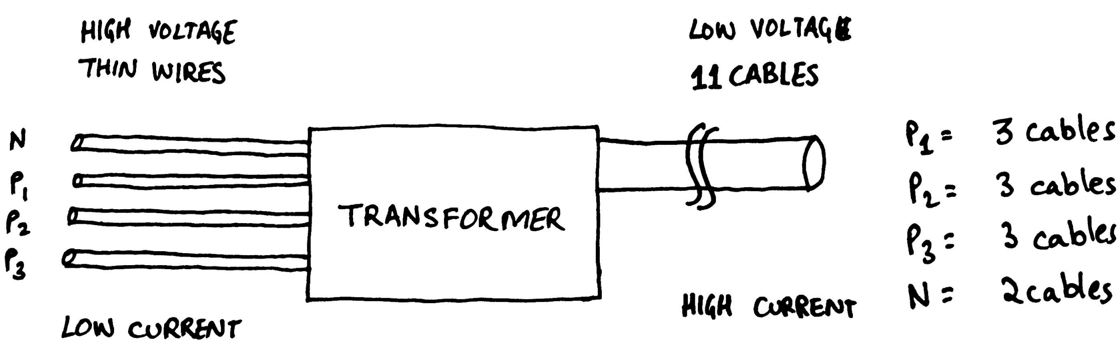


Figure 8: The step down transformer has a high voltage side which is connected to 11kV by three thin cables. The low voltage side is connected via 11 single core very thick cables to the distribution houses.

There is a need to connect thick single core cables in order to reduce the resistance of the cables and allow maximum current to be supplied to the homes and support the load. The high voltage cables are thin because they are not carrying high current and afford to be thin. It is all because of Ohm's Law that the cables in high voltage and low current can be thin to have less transmission losses but cables in low voltage and high current have to be thick to have less transmission losses.

3.4 Testing & Commissioning 22kV\11kV Transformer - Yas Mall

Near the end of second week, we were taken by Technician Kalam to the Yas Mall site where a Siemens step-down transformer 22kV\415V was added in order to supply the mall with the required power. The electrical room was locked and only an authorized person had access to it. Our job at this visit was to test and commission the transformer by finding out all the transformer values using sophisticated equipment.

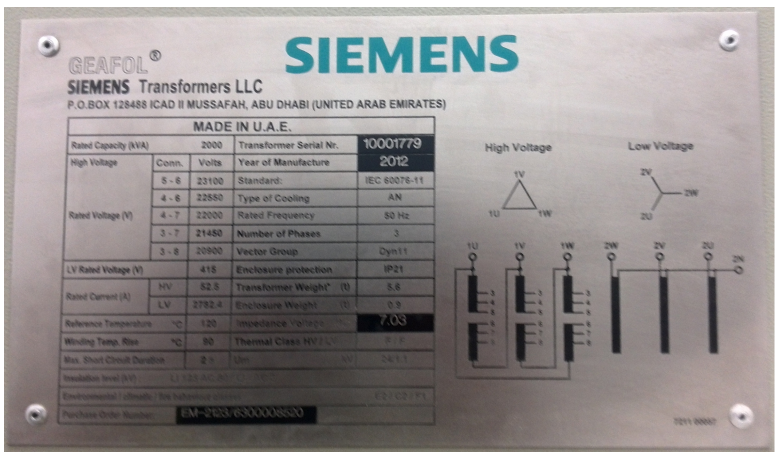


Figure 9: The nameplate details gave us important information about the transformer and its inner workings. We found out that the transformer actually had many taps which could be connected in one of the five configurations to get the required winding ratios.

Name Plate Details	Siemens
Sl. No.	10001779
Year of Manufacture	2012
Rating KVA	2000
Type	DRY
Type of Cooling	FAN
Frequency Hz	50
Rated Voltage kV	22000 V
Impedance Normal Tap %	7.03
Vector Group Symbol	Dyn11
Rated Current A	HV = 52.5A, LV=2782.41A
Total Weight Kg	5.6 Tonns

Figure 10: The Red phase wires on the low voltage side of the transformer.

Figure 11: The Yellow phase wires on the low voltage side of the transformer.

Figure 12: The Blue phase wires on the low voltage side of the transformer.

Figure 13: The neutral wires on the low voltage side of the transformer.

Figure 14: The High voltage side cable cut and ready to be connected. The cables are thin because the voltage is high but the current is low.

Figure 15: The low voltage side of the transformer. All wires are kept away from the transformer and disconnected for testing.

Figure 16: The cavity for changing the transformer taps by using the wrench tool.

Figure 17: The high voltage side of the transformer. All connectors are grounded from outside in order to ensure insulation.

Figure 18: The transformer taps with numbers clearly shown.

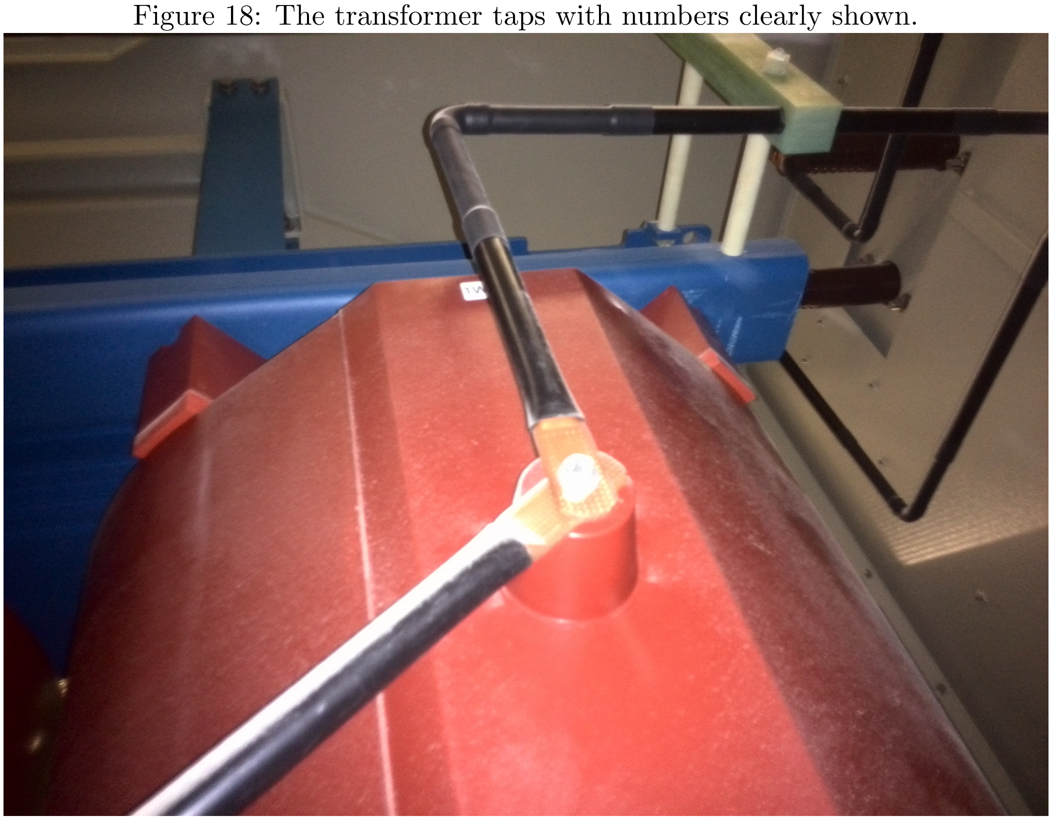


Figure 19: One of the coils of the transformer.

3.4.1 Insulation Resistance Test

This test ensures that the transformer winding are well insulated and there is minimal voltage leak. This test also affirms thermal deterioration values in thermo-plastic insulation systems. We will be performing two universally accepted diagnostics tests for insulation.

1. Insulation Resistance (IR)
2. Polarization Index (PI)

Winding	Voltage (V)	Insulation Resistance in G Ω		
		15 Sec	60 Sec	PI Values
HV to Earth	5 kV	74.8	125	1.671122995
HV to LV	2.5 kV	152	194	1.276315789
LV to Earth	1 kV	1.26	14.4	11.42857143

Figure 20: The table shows the insulation values in 15 seconds and 60 seconds from HV to earth, LV to earth, and HV to LV.

PI is the variance measure of insulation resistance value after 60 seconds to 15 seconds. It gives us an idea of how much current is being used to polarize the molecules of the conductor. Every conductor has to some degree polar molecules and these polar molecules align themselves to the electric field when it is applied. The current consumed in aligning the molecules is called polarization current.

$$PI = \frac{R_{60}}{R_{15}} \tag{1}$$

In a typical insulator there are four currents:-

1. Capacitive Current (I_C)
2. Conduction Current (I_R)
3. Surface Leakage Current (I_L)
4. Polarization Current (I_P)

After 1 minute, the capacitive current is almost zero so the total current becomes [2]

$$I_t(1min) = I_R + I_L + I_P \tag{2}$$

After 10 minutes, the polarization current is also zero so the total current becomes

$$I_t(10min) = I_R + I_L \tag{3}$$

Therefore,

$$PI = \frac{I_R + I_L + I_P}{I_R + I_L} = \frac{R_{10}}{R_1} \tag{4}$$

Figure 21: The figure shows the Megger 10kV insulation tester. This device is used to test the insulation of electrical component.

3.4.2 Winding Resistance Test

1. H.V. Side

Taps	Resistance in Ω		
	1U - 1V	1V - 1W	1W - 1U
1 (5 - 6)	1.2	1.24	1.24
2 (4 - 6)	1.17	1.23	1.22
3 (4 - 7)	1.17	1.16	1.17
4 (3 - 7)	1.29	1..27	1.18
5 (3 - 8)	1.07	1.09	1.09

Figure 22: The table shows the test results for the winding resistances of high voltage side.

2. L.V. Side($\mu\Omega$)

Tap	2u - 2v	2v - 2w	2w - 2u	2u - n	2v - n	2w - n
3	415	416	423	221	227	247

Figure 23: The table shows the test results for the winding resistances of low voltage side.

Figure 24: The figure the Megger Transformer Ohmmeter which is used to find out small resistances of transformers. The unit takes 240V AC supply and the test current can be selected through a knob from 10mA - 10 A. This test current is then passed through the winding and the resistance is calculated. The unit can also be connected through a USB cable to the computer for detailed analysis.

We can right away notice several points.

- H.V. side has much higher winding resistance than the L.V. side. This is because of the fact that the H.V. side has large number of turns and the winding wire length is long. For example, 1u-1v resistance is 1.2 Ω while 2u-2v resistance is 0.000415 Ω. Below is the formula that relates a length of a conductor to its resistance.

$$R = \frac{\rho L}{A} \tag{5}$$

- The megger transformer ohmmeter unit that the company had measured the resistances in the range of $m\Omega - \mu\Omega$ effectively. So a normal multi-meter was used to measure the winding resistances at high voltage side. However, since the multi-meter does not provide stable values as the professional Megger transformer ohm meter, some time was given for the multi-meter reading to get stable.

Figure 25: The transformer ohmmeter giving readings.

When the current and voltage test clippers are attached to the particular windings, the red test button should be pressed to energize the coil. After the test is done, the wire should not be immediately removed as the discharging of the coil is automatically done and it takes some time.

The way transformer ohmmeter works is by keeping the current injected into the windings constant and measuring the voltage drop across the winding. Then by applying Ohm's Law, the resistance of the winding is calculated.

3.4.3 Turns Ratios Test

It is very crucial for the ratio test to be done because it gives the engineers an idea of the voltage mapping that is going to be happening in future and small deviations in the actual values.

Another sophisticated equipment of Megger was used in this test called turns ratio tester. The way it works is by inducing a test voltage into one of the H.V. coil and measuring the voltage across the L.V. coil. The turns ratio is given by:-

$$T_{ratio} = \frac{N_{secondary}}{N_{primary}} = \frac{V_{secondary}}{V_{primary}} \tag{6}$$

Figure 26: The turn ratio tester showing the injected voltage = 8.0V and the current = 1.1mA. The turn ratio found was = +92.052 in this particular case.

No. of Tap Connection	Connection phase HV	Connection phase LV	Measurement Turn Ratio
1 (5 - 6)	R - Y	R - N	96.882
	Y - B	Y - N	96.911
	B - R	B - N	96.929
2 (4 - 6)	R - Y	R - N	94.419
	Y - B	Y - N	94.434
	B - R	B - N	94.555
3 (4 - 7)	R - Y	R - N	92.052
	Y - B	Y - N	92.079
	B - R	B - N	92.101
4 (3 -7)	R - Y	R - N	89.867
	Y - B	Y - N	89.945
	B - R	B - N	90.037
5 (3 - 8)	R - Y	R - N	87.695
	Y - B	Y - N	87.677
	B - R	B - N	87.771

Figure 27: The table shows the test results for the turns ratio test results.

3.4.4 Vector Group Check

Any three phase transformer consists of three primary windings and three secondary windings wound on the same iron core. It is of utmost importance for the transformers connected in parallel to each other to be having the same phase shift as the other or else one of the transformer will always be supplying the current to the other one. In other words, there will be a circulating current between the transformers connected in parallel themselves.

Any transformer has written on its details plate the winding connection type and vector group as short hand. [3]

- **First Symbol:** for High Voltage. It is always capital letter. D = Delta, S = Star, Z = Interconnected Star, N = Neutral
- **Second Symbol:** for Low Voltage. It is always small letter. d = Delta, s = Star, z = Interconnected Star, n = Neutral
- **Third Symbol:** Phase displacement expressed as clock hour number.

On close inspection of the details plate, the transformer vector group was Dyn11. So the first letter is capital which says that the High voltage side is delta connected. The second letter is small case y and then n which means that the low voltage side is star connected with neutral. Then number 11 represents that the phase shift is -30 degrees.

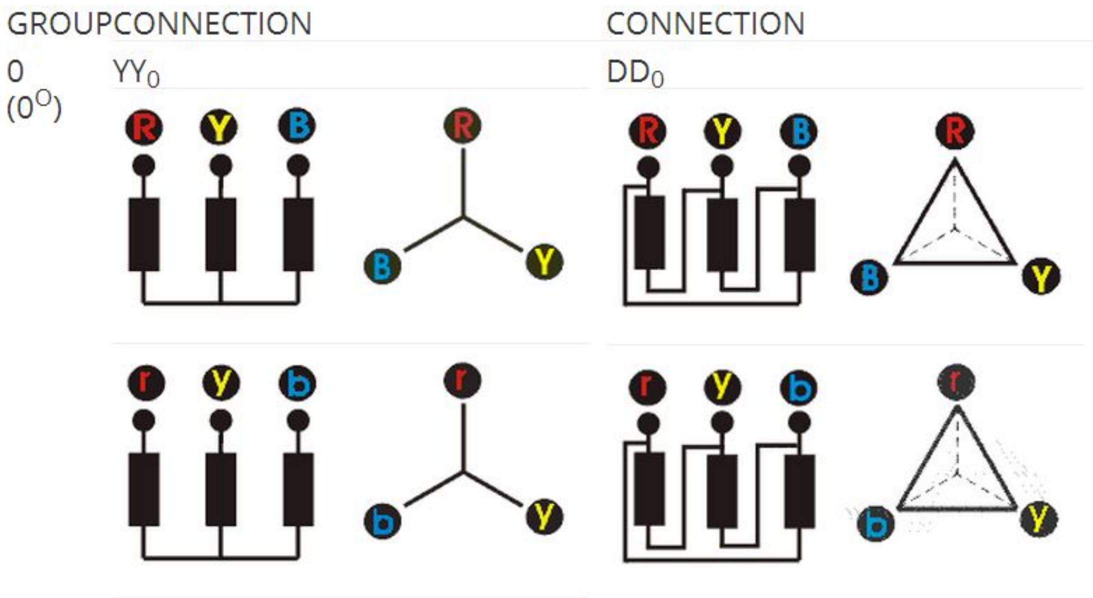


Figure 28: The figure shows the connection for Yy0 and Dd0. The phase shift is 0 degrees. [4]

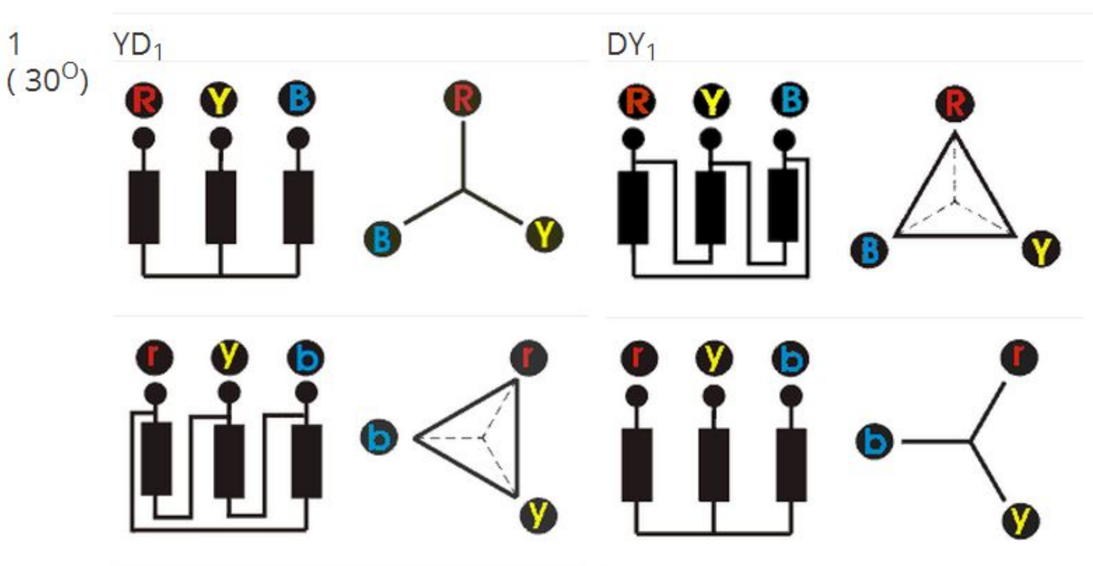


Figure 29: The figure shows the connection for Yd1 and Dy1. The phase shift is 30 degrees. [4]

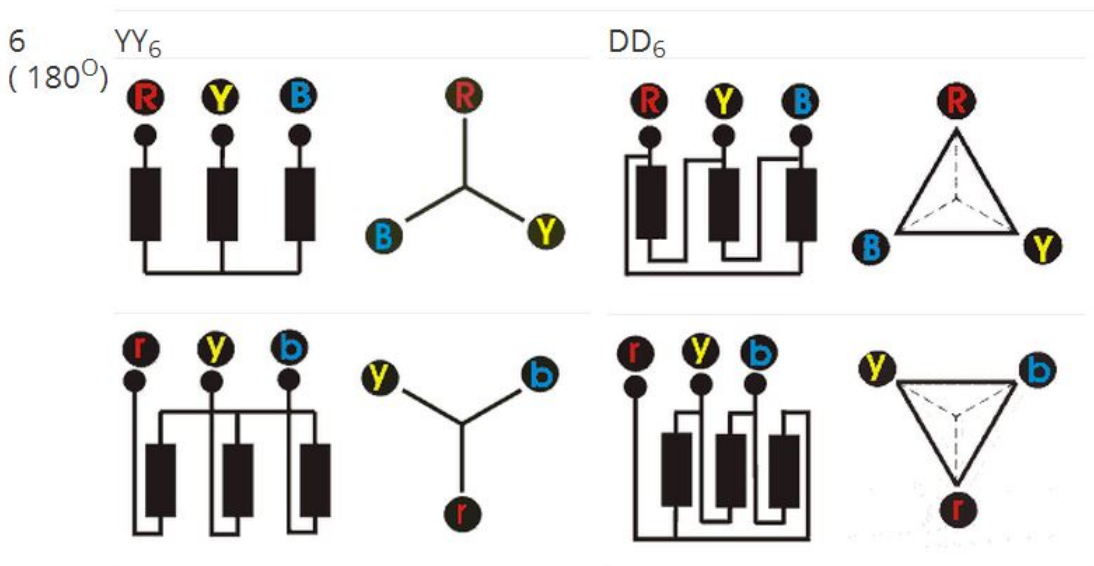


Figure 30: The figure shows the connection for Yy6 and Dd6. The phase shift is 180 degrees. [4]

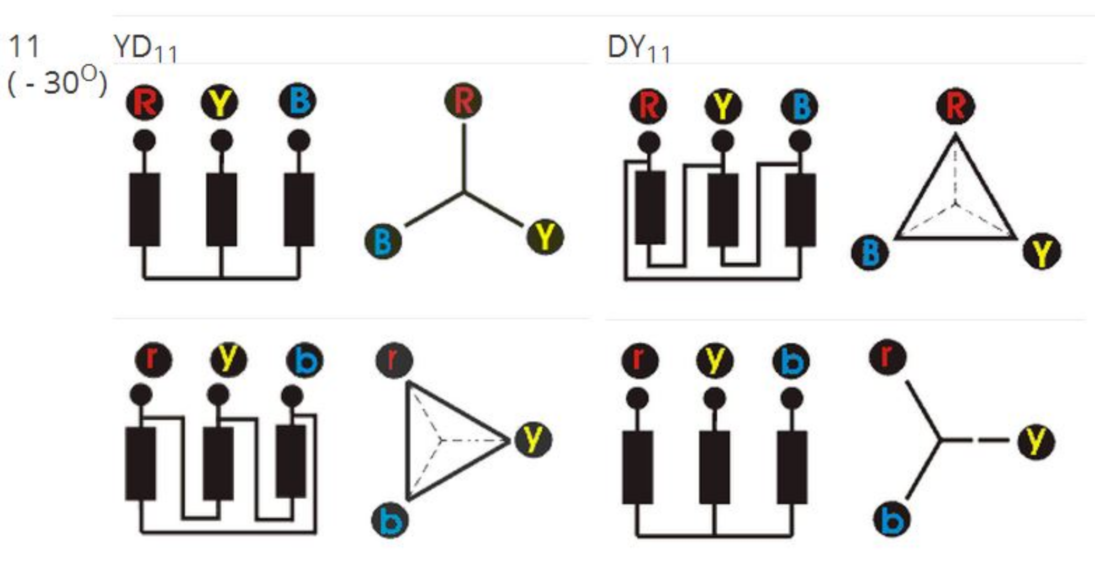


Figure 31: The figure shows the connection for Yd11 and Dy11. The phase shift is -30 degrees. [4]

For vector group there is a need to supply three phase supply to the primary windings and measure the voltage out from the secondary windings. From these ratios, the vector group diagram can be plotted and the actual phase shift can be calculated.

1. Short one of the high voltage terminal to one of the low voltage terminal.
2. Connect three phase voltage supply to the primary side of the transformer.
3. Measure the voltage going in from the primary side.
4. Measure the voltage coming out from the secondary side.
5. Draw the vector group diagram for the values found and find the angle to confirm details plate values.

Figure 32: The wires are being cut for the three phase supply to the high voltage side.

Figure 33: The voltage going in from the high voltage side of the transformer is being measured by multi-meter.

3.5 Cable Testing

3.6 Drawing Single Line Diagrams in Easy Power

Easy Power, as the name suggest is a simple yet powerful software tool to simulate power systems and perform numerous analysis such as:-

Figure 34: The analysis options available in Easy Power 9.5 Demo version of the software.

- **Short Circuit Analysis** - This analysis simulates some common faults in the circuit and the fault current is found at different location of the diagram.
- **Coordination Analysis** - This analysis simulates the current flow in the devices over time (Time Coordination Curve, TCC) so that the designer can choose the right timings for the circuit breaker to trip or the relay to switch etc.
- **Power Flow Analysis** - This analysis simulates the amount of power consumed by the loads and different components of the circuit. The voltages and currents show up at different parts of the diagram while this simulation is running for the engineer to analyze.
- **Harmonics Analysis** - Temperature often causes the equipment to act as non-linear devices. This non-linearity produces secondary harmonics in addition to the primary applied frequency. If these harmonics can be simulated before the actual implementation, some preliminary measure can be taken in order to avoid it.
- **Stability Analysis** - Power system stability is categorized into three main categories. Steady State Stability where the changes are restricted to minute changes in operating conditions and the system parameters are closely watched as this happens. Transient Stability where any major disturbance is caused and the reaction of the system is studied. Dynamic Stability is where reaction to small disturbances or random fluctuations are closely studied.

We were given a case where the objective was to find out the relay settings. We started off with drawing the same single line diagram in easy power as follows.

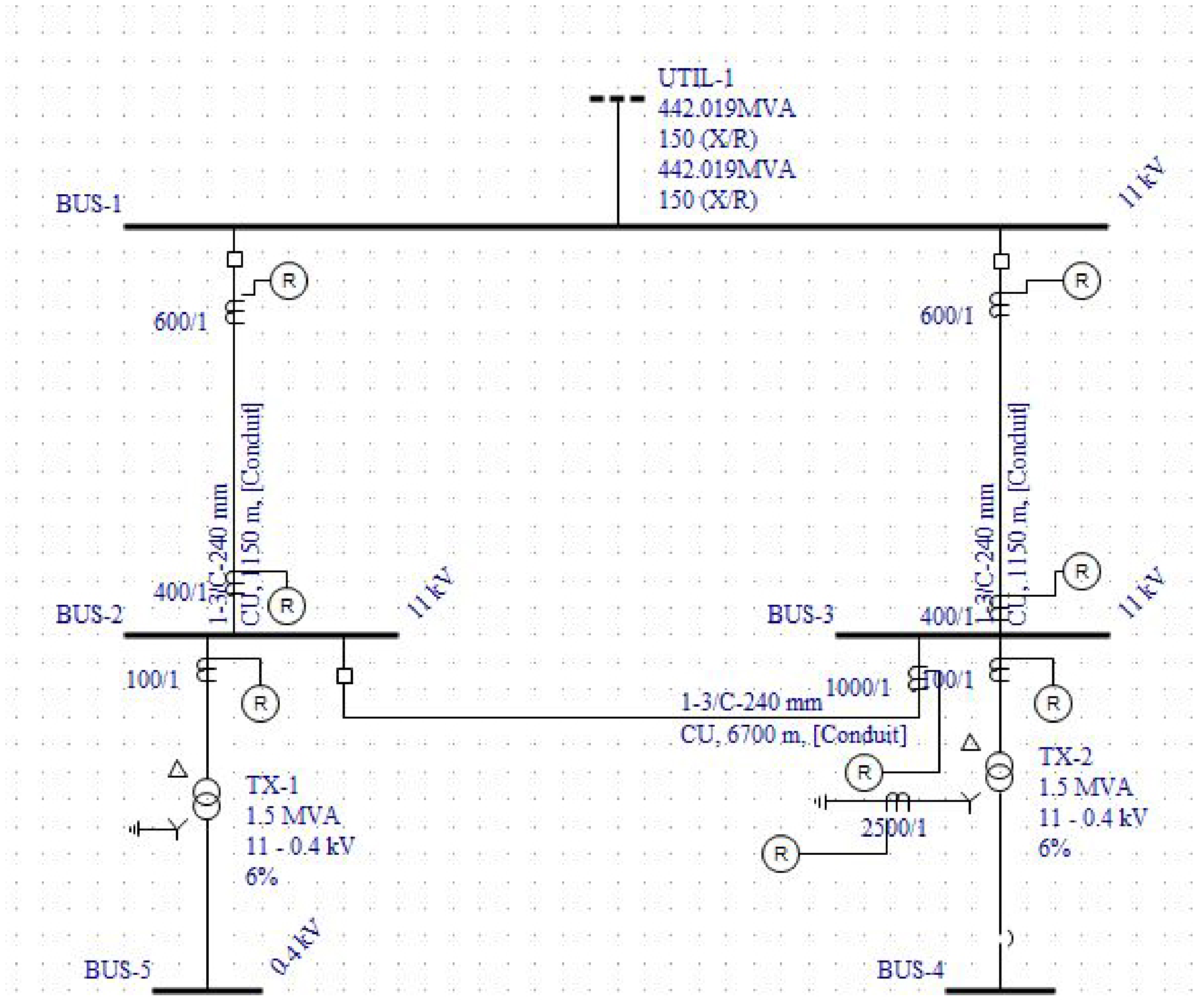


Figure 35: The complete single line diagram of the site.

3.7 Short Circuit Analysis in Easy Power

After the single line diagram was drawn, the next step in any single line diagram design of the power system is to test what currents flow in the circuit when a fault occurs. This is known as short circuit analysis.

Easy power allows the user to choose the type of short circuit Phase - Ground, Phase - Phase etc. Then the fault currents that go in and out of the bus bars are shown via simulation. According to these currents, the circuit breakers and the relays should be set so that in the case of fault the circuit trips. Easy power also allows the users to run the simulation for $\frac{1}{2}$ cycle, 1 cycle, or 30 cycles in order to perform detailed and through simulation.

Easy Power has a very nice feature of generating reports so that the engineers can analyze, keep in the file for future reference, get approval to work from electricity regulation entities such as ADDC.

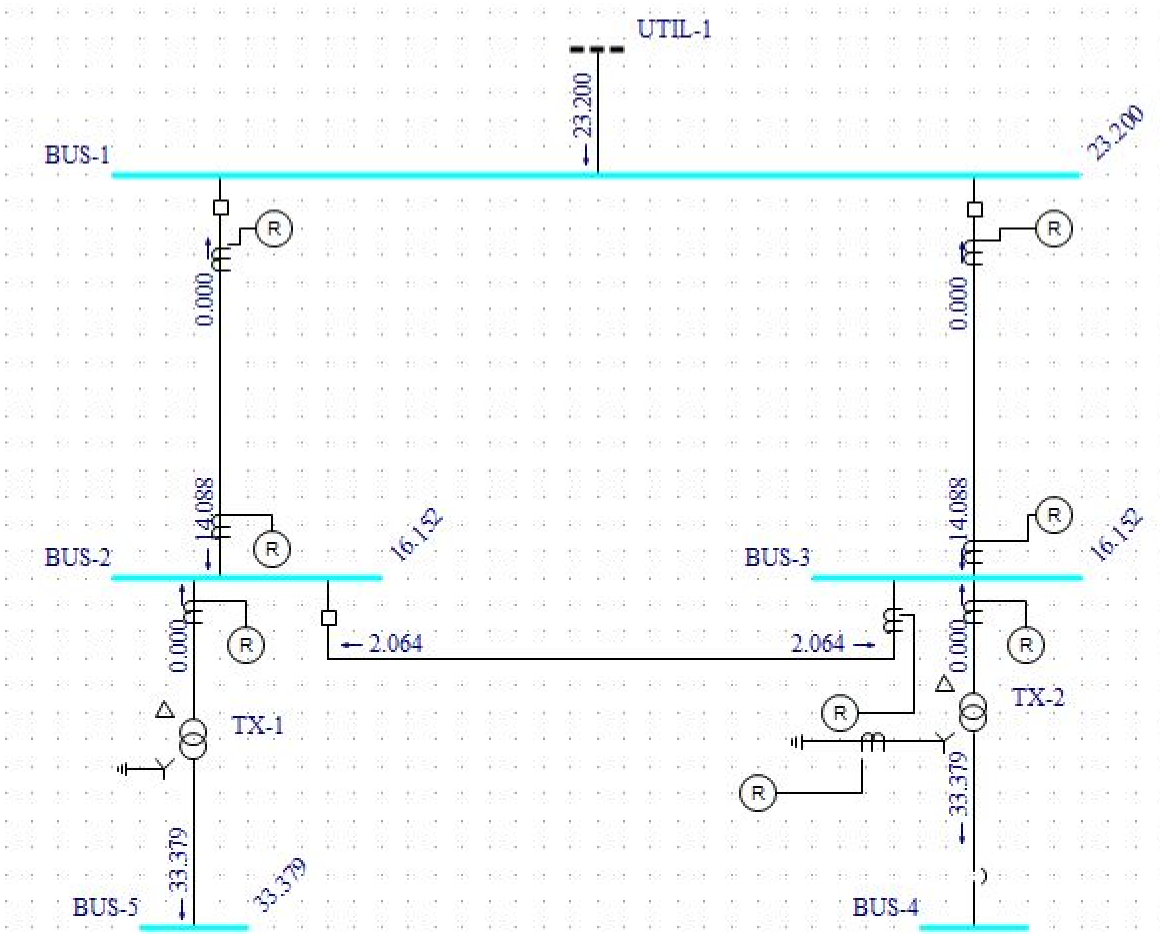
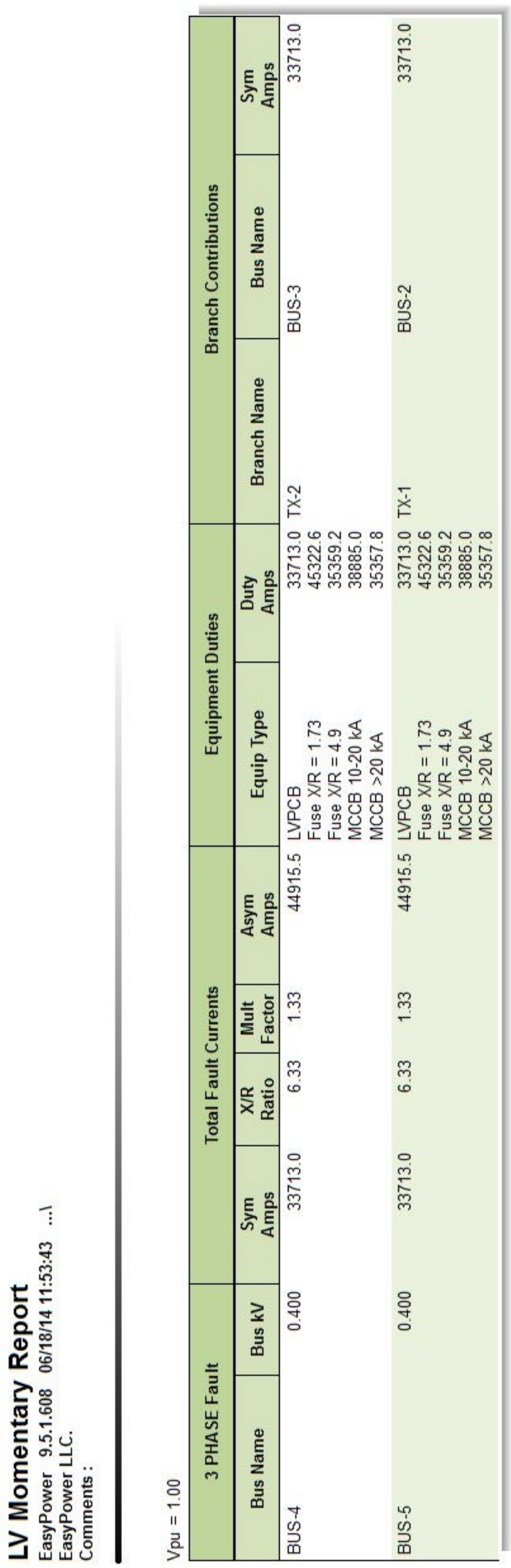


Figure 36: The complete short circuit analysis of the system. The currents are shown in kA.

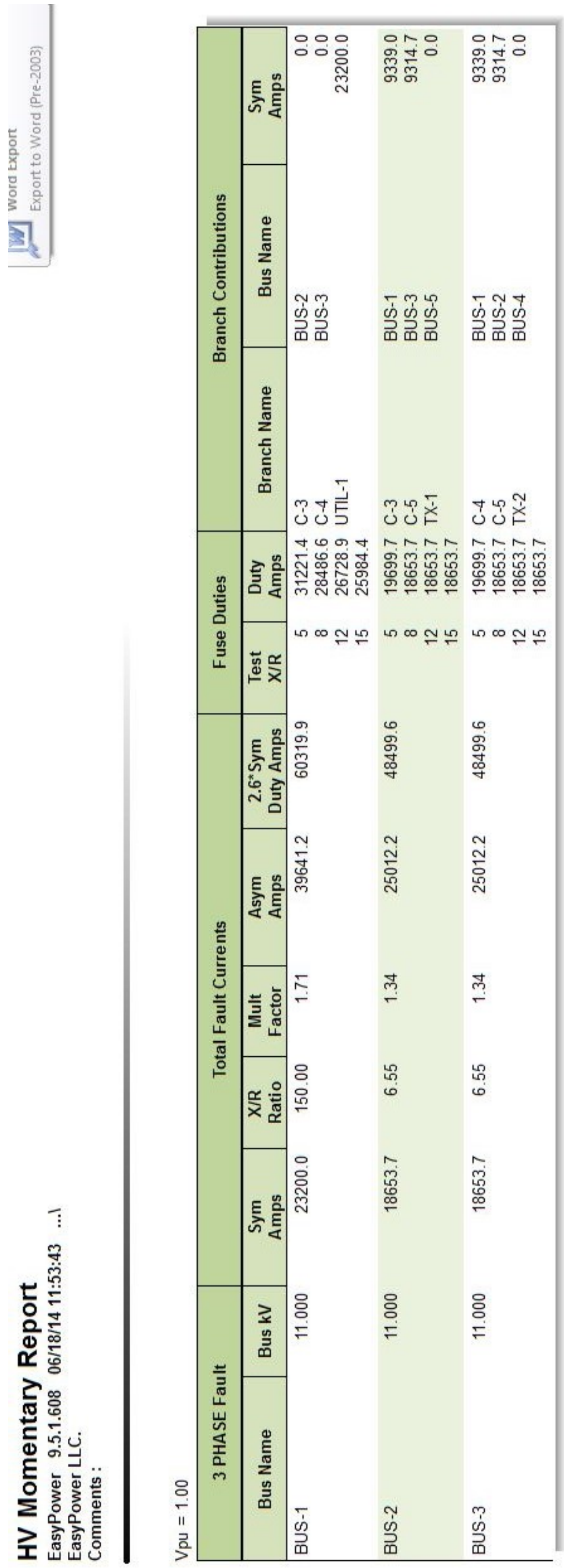


LV Momentary Report
EasyPower 9.5.1.608 06/18/14 11:53:43 ...\
EasyPower LLC.
Comments :

Vpu = 1.00

3 PHASE Fault		Total Fault Currents				Equipment Duties		Branch Contributions		
Bus Name	Bus kV	Sym Amps	X/R Ratio	Mult Factor	Asym Amps	Equip Type	Duty Amps	Branch Name	Bus Name	Sym Amps
BUS-4	0.400	33713.0	6.33	1.33	44915.5	LVPCB	33713.0	TX-2	BUS-3	33713.0
						Fuse X/R = 1.73	45322.6			
						Fuse X/R = 4.9	35359.2			
						MCCB 10-20 kA	38885.0			
						MCCB >20 kA	35357.8			
BUS-5	0.400	33713.0	6.33	1.33	44915.5	LVPCB	33713.0	TX-1	BUS-2	33713.0
						Fuse X/R = 1.73	45322.6			
						Fuse X/R = 4.9	35359.2			
						MCCB 10-20 kA	38885.0			
						MCCB >20 kA	35357.8			

Figure 37: The Low voltage momentary report generated.



Word Export
Export to Word (Pre-2003)

HV Momentary Report
EasyPower 9.5.1.608 06/18/14 11:53:43 ...\
EasyPower LLC.
Comments :

Vpu = 1.00

3 PHASE Fault		Total Fault Currents					Fuse Duties		Branch Contributions		
Bus Name	Bus kV	Sym Amps	X/R Ratio	Mult Factor	Asym Amps	2.6*Sym Duty Amps	Test X/R	Duty Amps	Branch Name	Bus Name	Sym Amps
BUS-1	11.000	23200.0	150.00	1.71	39641.2	60319.9	5	31221.4	C-3	BUS-2	0.0
							8	28486.6	C-4	BUS-3	0.0
							12	26728.9	UTIL-1		23200.0
							15	25984.4			
BUS-2	11.000	18653.7	6.55	1.34	25012.2	48499.6	5	19699.7	C-3	BUS-1	9339.0
							8	18653.7	C-5	BUS-3	9314.7
							12	18653.7	TX-1	BUS-5	0.0
							15	18653.7			
BUS-3	11.000	18653.7	6.55	1.34	25012.2	48499.6	5	19699.7	C-4	BUS-1	9339.0
							8	18653.7	C-5	BUS-2	9314.7
							12	18653.7	TX-2	BUS-4	0.0
							15	18653.7			

Figure 38: The High voltage momentary report generated.

3.8 Power Flow Analysis in Easy Power

In power engineering, the calculation of voltages, voltage angles, real powers, and reactive powers at different locations is known as Power-Flow Analysis or Load-Flow Study. Since our power system does not have any load such as motor etc. attached, this analysis was not required and necessary. Nevertheless, it gave us an idea of how to perform this analysis in cases where the loads are present.

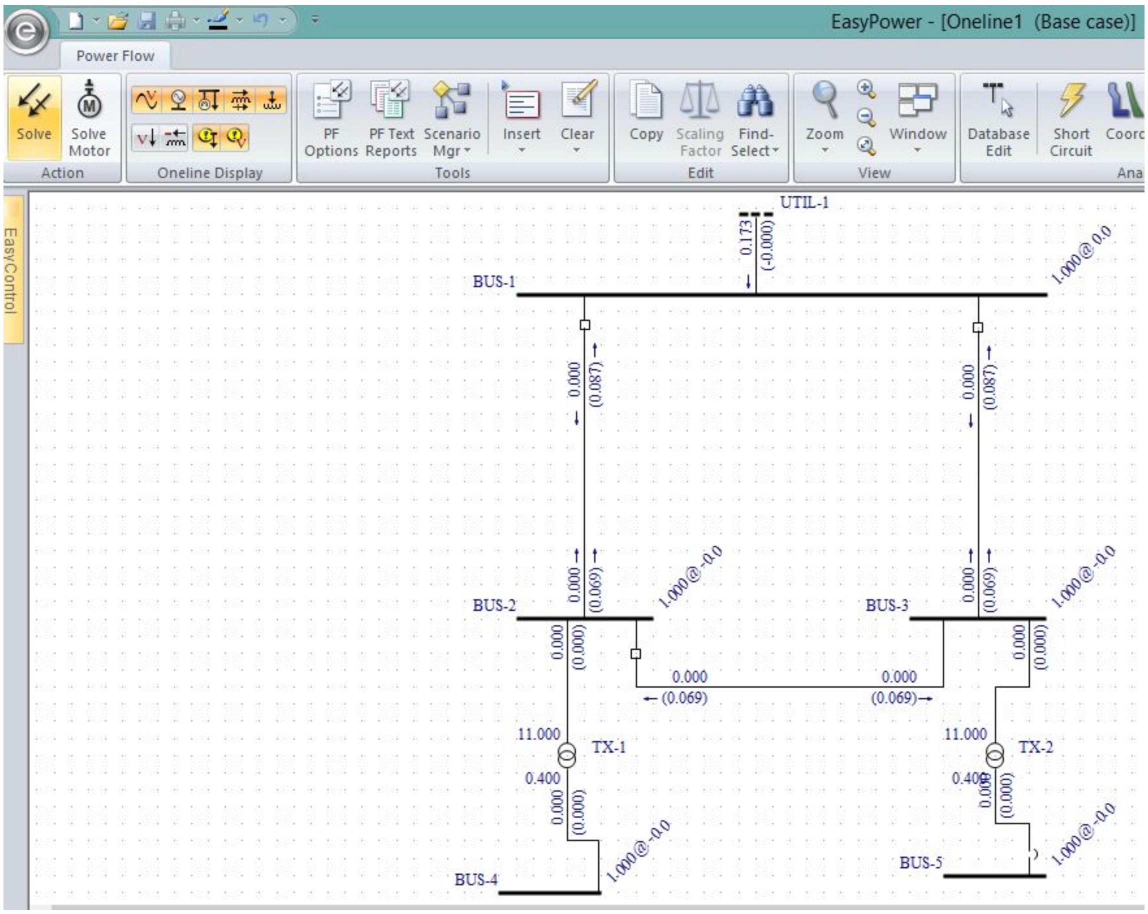


Figure 39: The complete single line diagram of the site.

3.9 Relay Coordination in Easy Power

Proper installation and coordination of over-current relays and other protection devices is crucial in a system. The time it takes for a relay to switch in over-current situations can be difference between millions of dollars. When a fault occurs, the circuit should not immediately trip and disconnect. Doing so will allow huge back current to pass which may burn down the electrical loads and wires. So some amount of time is allowed for the system to reach steady state and then the circuit is broken. This is exactly what the coordination study of power system is all about.

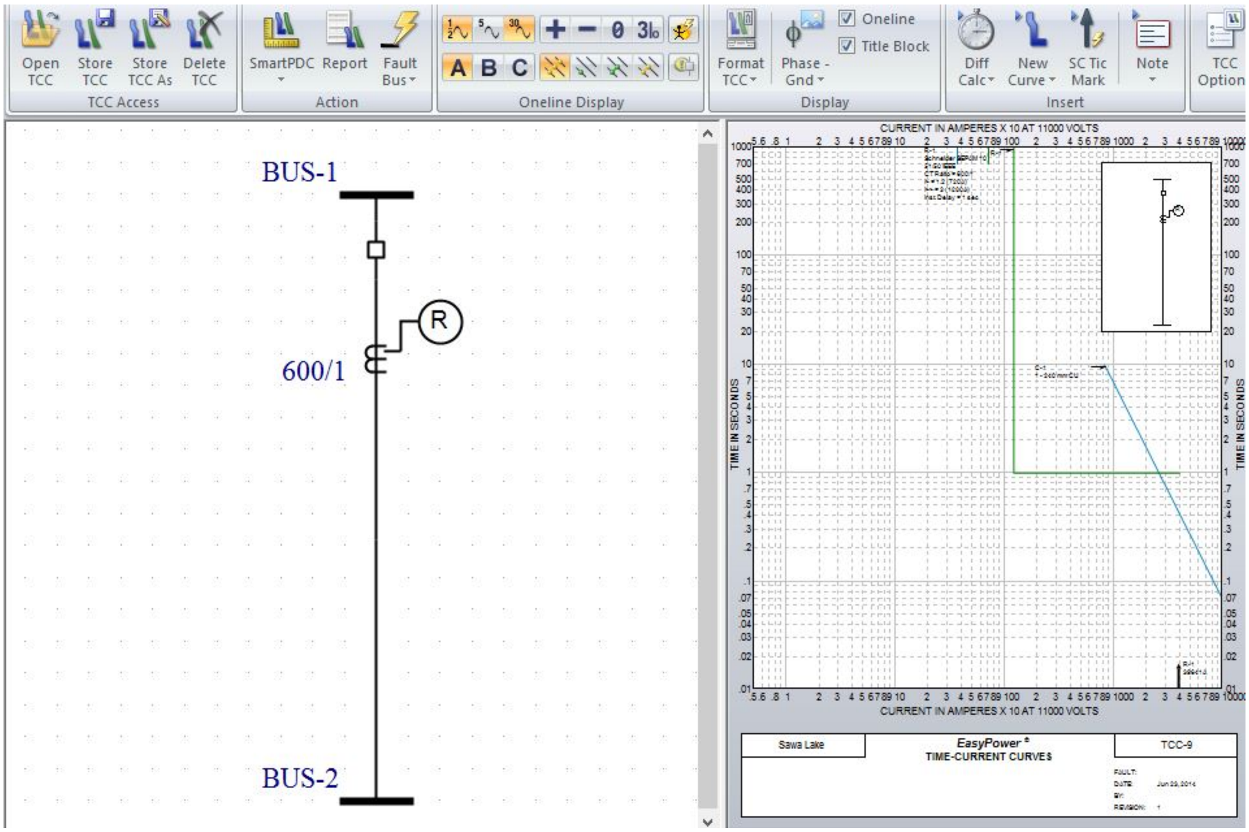


Figure 40: The TCC curve for BUS1 and Relay 1.

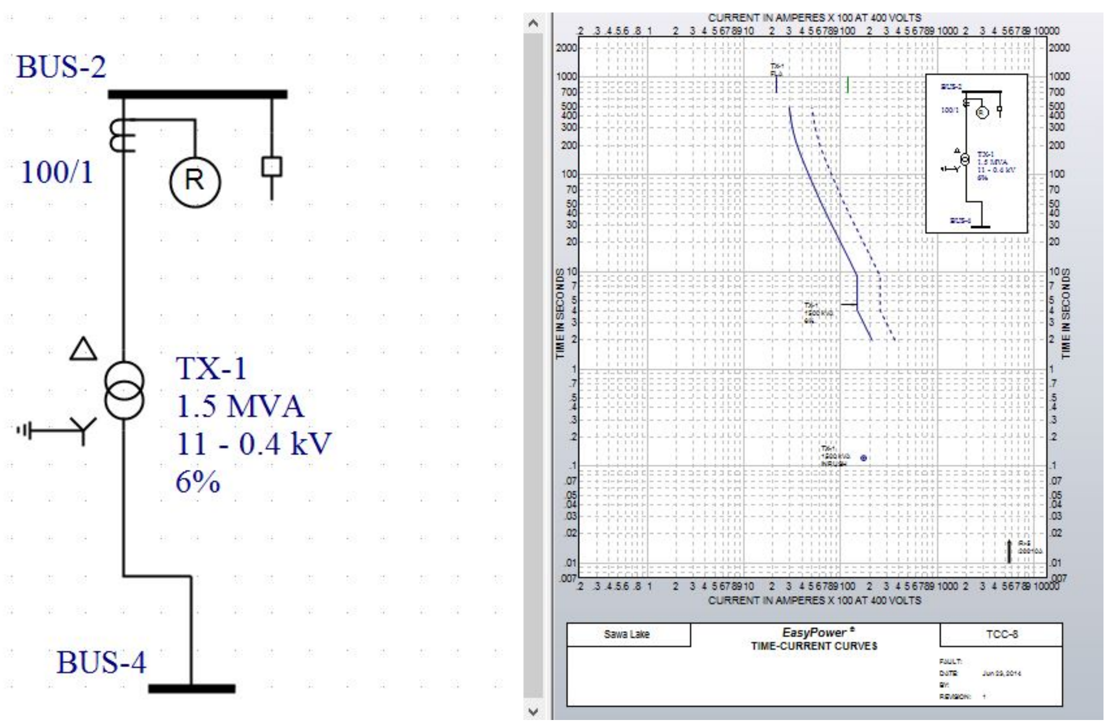


Figure 41: The TCC curve for BUS2.

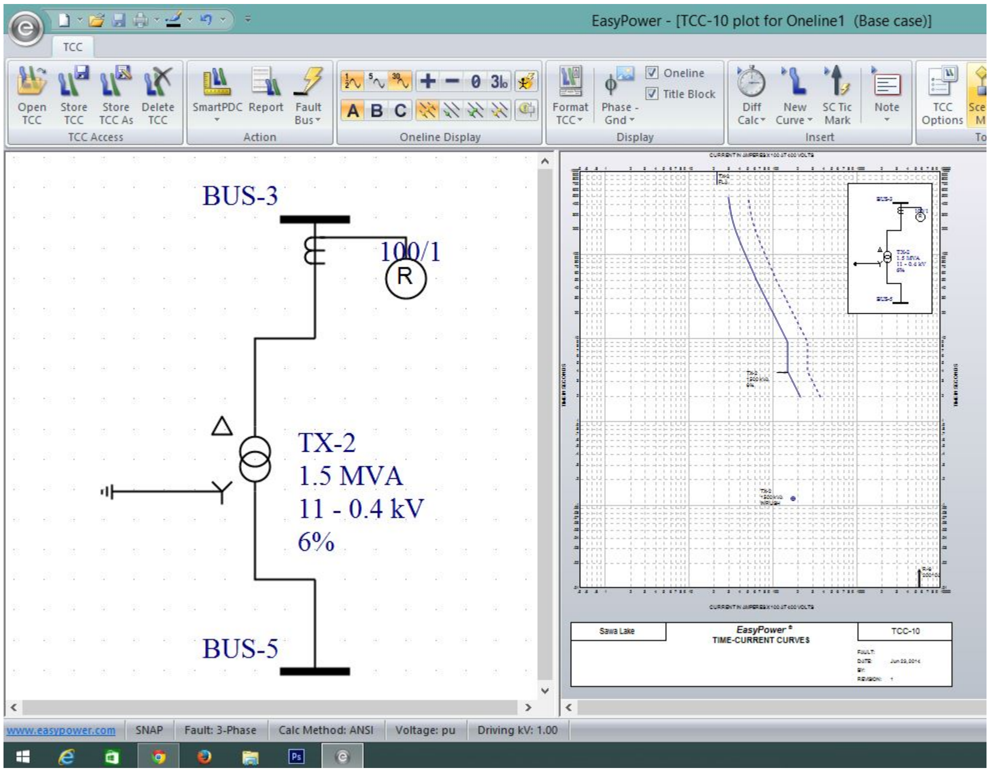


Figure 42: The TCC curve for BUS3.

TCC Coordination Report
EasyPower 9.5.1.608 06-23-14 11-31-17 ...
EasyPower LLC.
Comments :

Relay					Tap						
ID	Manufacturer	Type	Device Function	CT Ratio	Name	Range	Setting	PA	Name	Curve	Range
R-3	Schneider	SEPAM 10	51/50 IEEE	600/1	I>	0.1 - 2.4	1.2	720	Curves	<None>	-

		Time Dial									
Setting	PA	Name	Curve	Range	Setting	Shift Range	Shift Setting	Time Adder	Unit	Minimum Time	Unit
1.2	720	Curves	<None>	-					Seconds		Seconds

ST Pickup				ST Delay			Inst					Delay	
Name	Range	Setting	PA	Name	Setting	Unit	Name	Range	Setting	PA	Maint Pickup	Name	Setting
ST Pickup	-			ST Delay		Seconds	I>>	0.1 - 24	2	1200		Inst. Delay	2.14

Figure 43: The figure shows a Time-Current Curve report generated after doing the coordination study.

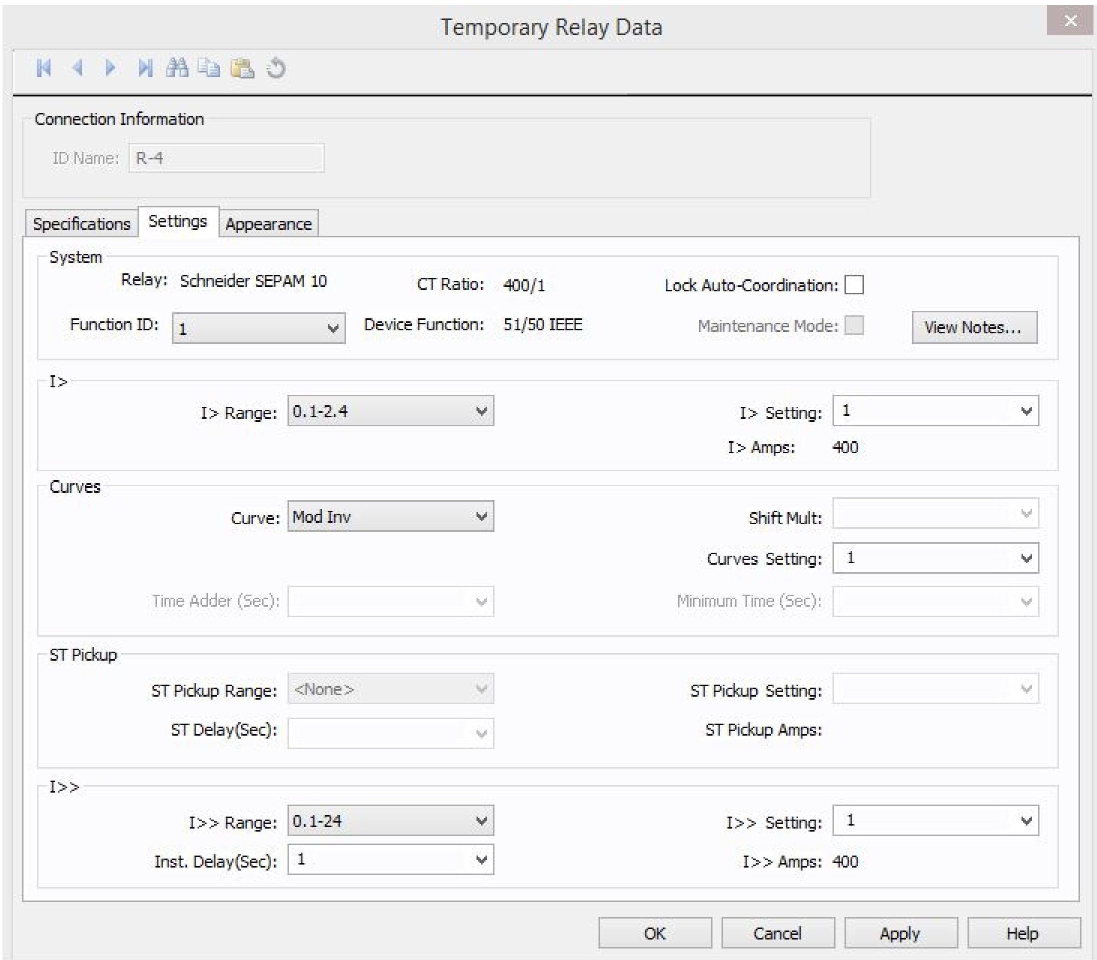


Figure 44: The settings we choose for the relay 4 in order to perform the coordination study.

3.10 CCTV Camera Streaming over Internet

The company had recently installed the CCTV (Closed Circuit Television) camera system. The company manager used the system to monitor the company on-goings. But recently he had to travel to America and wanted to watch through the internet live camera streaming. We were assigned the task to convert the system from local stream to global accessible stream.

The first step was to get any information about the camera system and the DVR (Digital Video Recorders). Most DVRs already have an option for connecting LAN cable. This allows the Web Client system for the cameras to be accessible through the local network by using the local IP. The local IP usually starts from 192.168... But the real problem was to access DVR's IP from outside the local network.

After much research, we found out that there is a way to allow the router to access the DVR's IP by using Port Forwarding.

Port Forwarding It is a setting which allows the router to forward all the packets of either TCP or UDP or both protocols from one port to another. This was very beneficial because the router had a global IP address from ISP but the camera did not. So if the router forwarded all the packets from local IP to a port on the global IP then we can access this specific port and get all the streaming data through the router.

There are several steps and things that the engineer should perform in order to get the port forwarding right. The information required is:-

- **Start Port & End Port** This specifies the range of ports that the router should forward data from.
- **Port Map** This specifies the port to which it is forwarded.
- **Protocol** This specifies the packet protocol type to forward. If TCP is selected then the router forwards only packet which have TCP protocol and if UDP is selected then the router forwards only packet which have UDP protocol and if both is selected then the packet protocol does not matter, all will be forwarded.

DMZ (Demilitarized Zone) If enabled, It does allows the user to connect to internal IPs through the router. In essence, if it is disabled the router acts as the server and is isolated from the rest of the network in case the server is compromised. When DMZ is disabled, the outside networks can easily access the local network's data. We have to enable DMZ in order to allow users from outside the network to access the cameras.

Dynamic DNS (Domain Name System) Every time a computer connects to the internet, it is provided with a unique IP address and this is different for every session. So in case the company switches OFF the router or after 24-hours, the IP address of the company's router changes and the camera stream can no longer be accessed through the same IP. This is known as Dynamic IP.

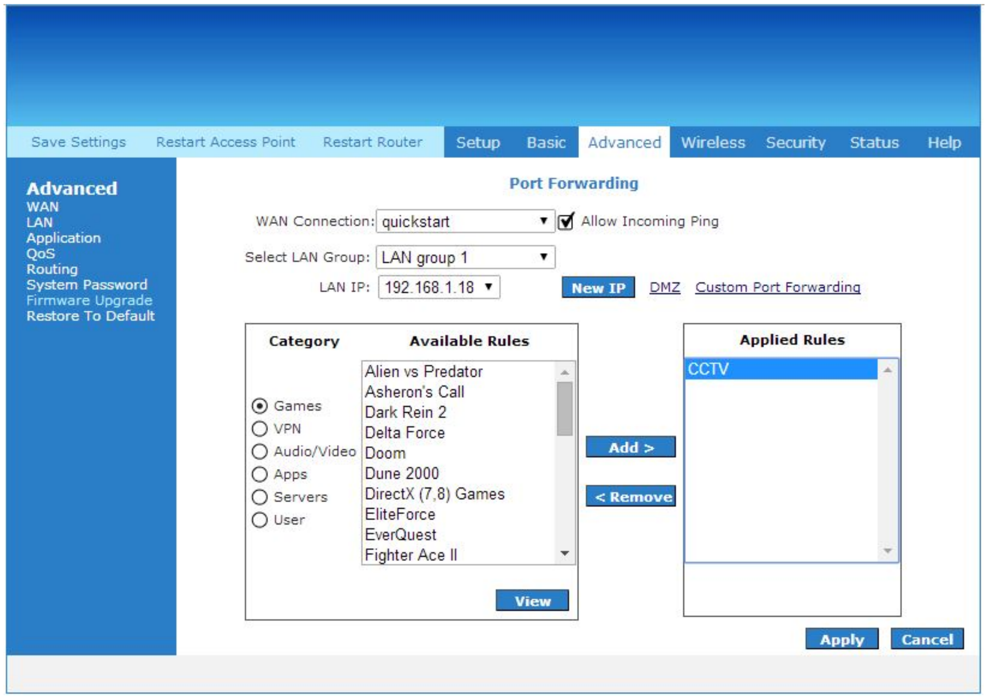


Figure 45: The rule we created "CCTV" for the port forwarding.

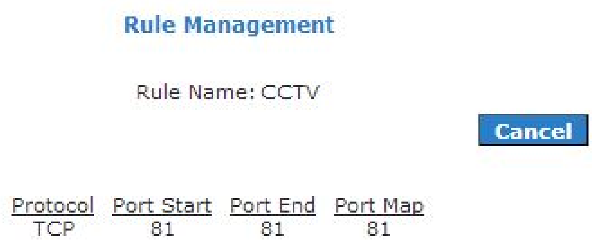


Figure 46: The rule we created "CCTV" for the port forwarding and the ports in details.

No-IP.com This free web service provides a track of dynamic IP changes of a set computer and points it to a static domain name. We pointed the company's router to web address `http://obninja.ddns.net/` so every time the user enters the web address in the browser the DNS lookup service will take the user to the company's router. And since we had configure the camera stream to be accessible through port 81 of the router, we can access the DVR through `http://obninja.ddns.net:81/`

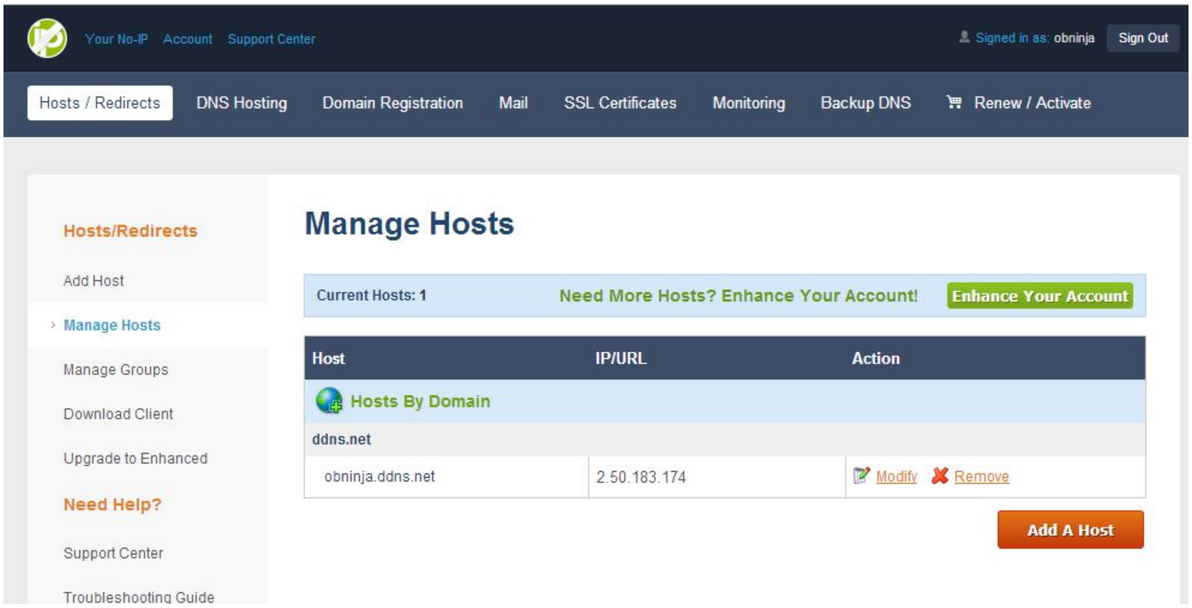


Figure 47: The settings in the no-ip.com.

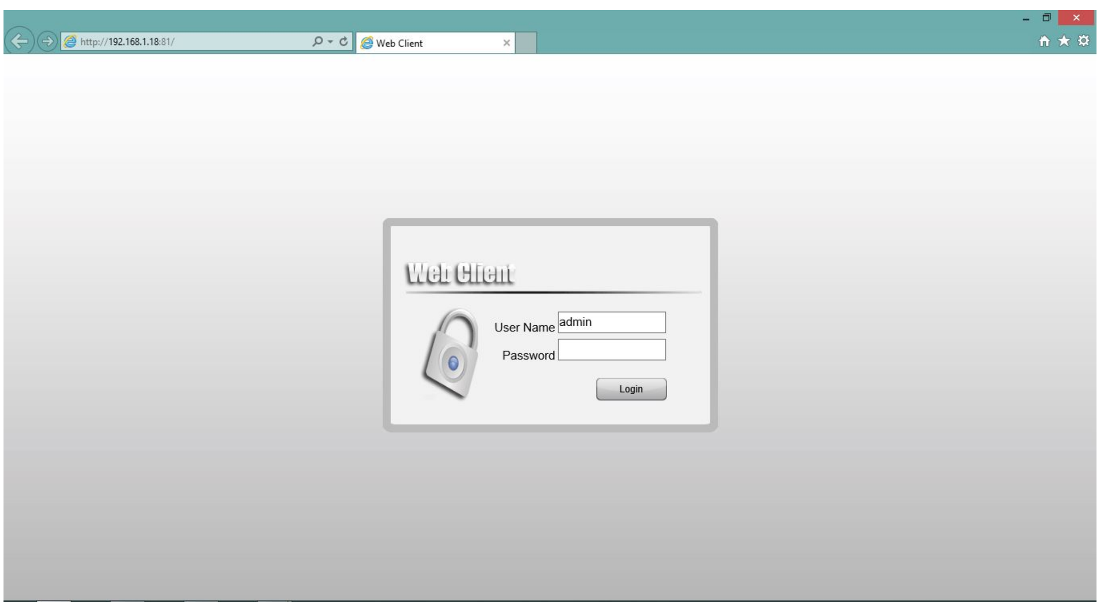


Figure 48: The Web Client Login screen in Internet Explorer. As the web client requires Active X plugin, it only runs in Internet Explorer.

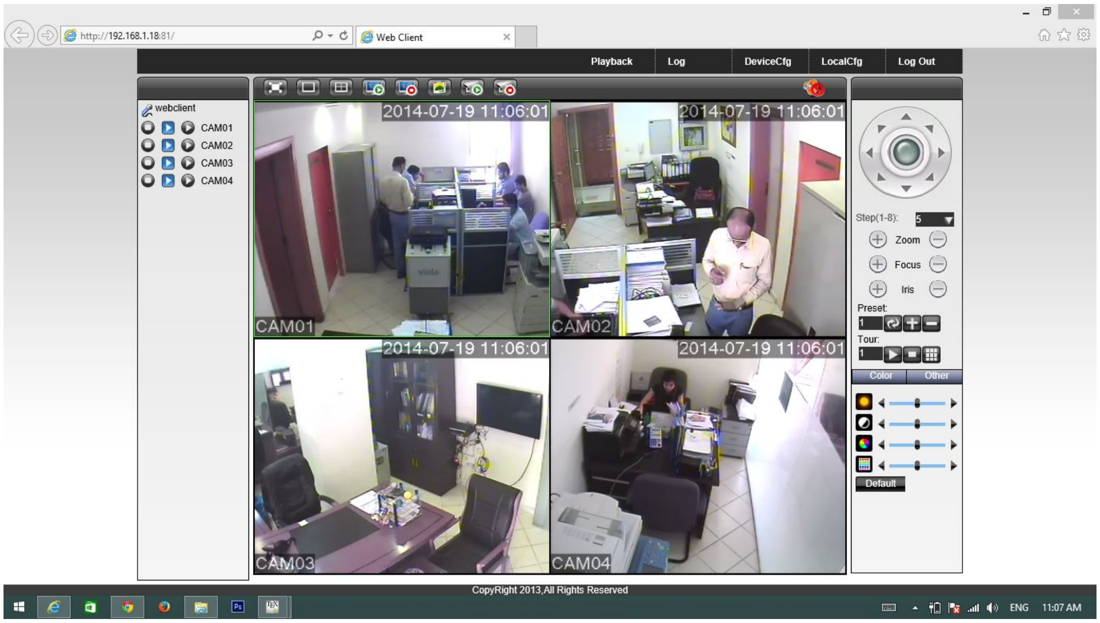


Figure 49: The Web Client CCTV stream with 4 channels showing.

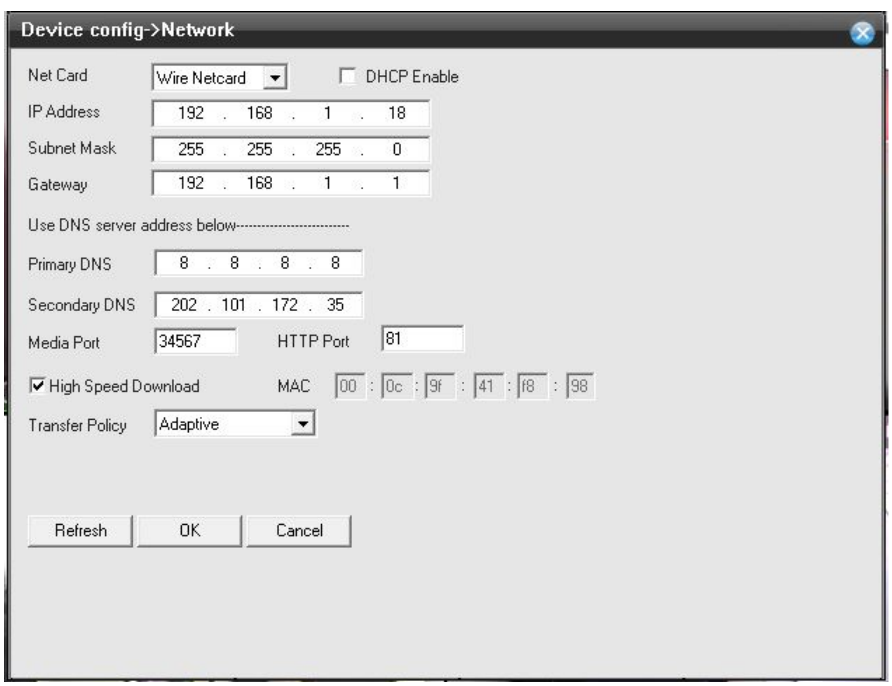


Figure 50: The Web Client network settings including I.P. Address, Http Port Number, and Media Port.

3.11 Tri Ring Main (TRM) Unit Maintenance

A TRM Unit on the center of the road near ADNEC was recently installed and Sawa Lake Electro Mechanical was assigned a contract for performing maintenance and testing of this unit so that it is ready to be started up. We went to the site and cleaned the TRM Room and then checked if all components are in order and working. Name plate details:-

- **Rated Voltage (kV):** 12
- **Normal Current (A):** 250
- **Short Circuit Peak Making Current (kA):** 20
- **Short Circuit Breaking Current (kA):** 20
- **3 Second Short Time Current (kA):** 20
- **Earth Switch Peak Making Current (kA):** 9

Figure 51: Outside part of the switch gear box. The Switch gear used was of Lucy brand.

Figure 52: The Earth fault indicator attached inside the room. it works by detecting high amount of current flowing through wire by using current transformer.

Figure 53: The TRM cabinet containing two switches to cut off supply to one side of the ring and various circuit breakers.

Figure 54: The Current transformer with a zip tie so that it can be tied to one of the live wires and detect the current. This with combination of a relay is used for earth fault protection when high current flow can cause damage to equipment.

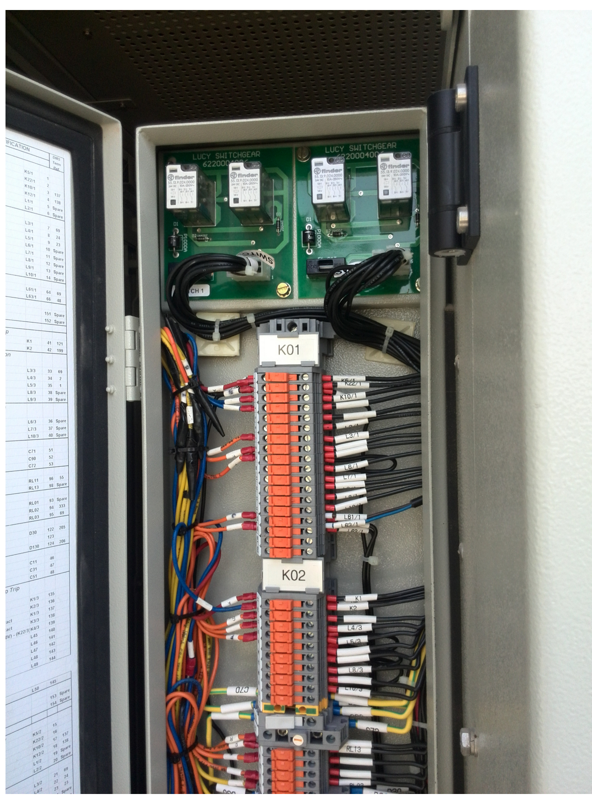


Figure 55: A seperate cabinet with circuit breakers and protection relays at the top for the protection of the whole TRM room.

Figure 56: A separate cabinet was there for remote control using Gemini Remote Terminal Unit (RTU).

Figure 57: The RTU cabinet contains a rechargeable battery pack in case that supply is cut, the RTU is still functioning.

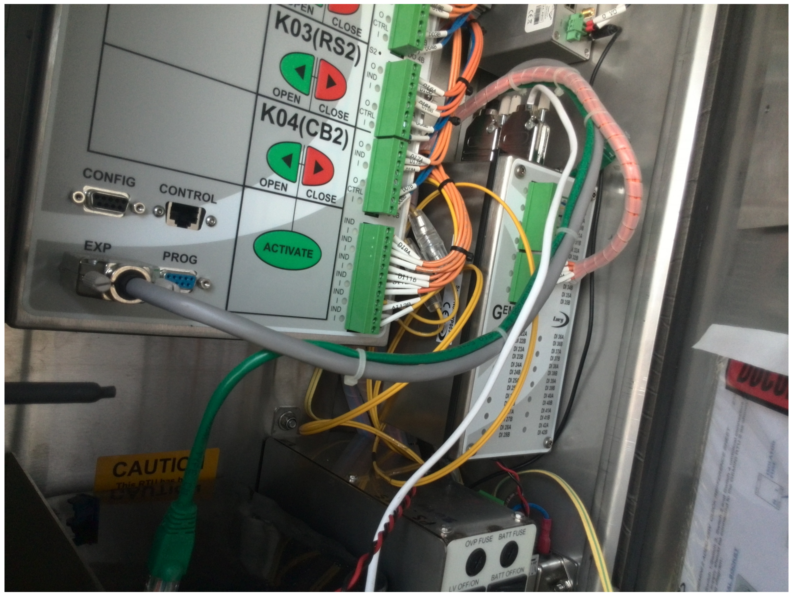


Figure 58: The RTU had several ports for configuring, controlling, expanding, and programming it. The Control port was ethernet and the configuration, programming, and expansion port was RS-232 protocol. The control port can be connected to internet via WiFi or LAN cable and then the whole TRM room can be controlled and monitored from anywhere.

Figure 59: The TRM room contains a single transformer also for stepping down the voltage from a single point in one ring into two points in another ring.

4 Weekly Time Table

4.1 Week 1

1. Engaged in research about RMUs (Ring Main Units), TRM (Tri Ring Main), and QRM (Quad Ring Main).
2. General Information about how RTUs (Remote terminal units) work.
3. W10 Khalidiyah Site Visit.
4. Feeder Pillars and Substation understanding and practical view.
5. Analyzing two previous company cases including AutoChim and Dhafir.

4.2 Week 2

1. Introduction to EasyPower.
2. Studying AutoCAD drawings from basic to complex systems provided by supervisor.
3. Using Easy Power to build High Voltage (HV) and Low Voltage (LV) systems
4. Yas Mall Site visit for transformer testing and commissioning.
5. Researching the theory behind the vector group test and developing the understanding.
6. Practical vector group test on the transformer.
7. Insulation Resistance Test and Polarization Index formulas and understanding.
8. practically finding out the insulation resistance using the Megger equipment.
9. Performing winding Resistance Test using the Megger's transformer ohm meter on all three coils and all 5 taps options.
10. Finding out transformer winding ratios test using the Megger's equipment and verifying it from the nameplate on the transformer.

4.3 Week 3

1. Using Easy Power to analyze the operation of relays.
2. Setting and configuring the relays on Easy Power for optimal simulation.
3. Generating Graphs Time-Current Curves (TCCs) to find the coordination values in case of fault for relays.
4. Generating different reports and understanding them.
5. Simulating the short circuit at different locations on the single line diagram and finding the fault currents at the fault buses.
6. Using short circuit analysis to set the protection relays and other protection equipment.
7. Generating reports of short circuit based on the analysis.

4.4 Week 4

1. General research about ETAP software and how to obtain legal license.
2. Familiarization with Abu Dhabi Distribution Company (ADDC) rules and regulations regarding safety at sites and work places.
3. Connecting DVR to local network for local access using the static IP.
4. Getting insight into previous clients of the company.

4.5 Week 5

1. Theoretical understanding and research of VLF cable testing and Practical analyses of the equipment used.
2. Getting to know the official procedure for acquiring ADDC approval for competent person, site access, and other permissions.
3. Configuring the router to perform Port Forwarding so that the local IP packets can be accessed globally using the ISP provided IP address.
4. Making the router's global IP static using the online services such as ddns and no-ip.com.

4.6 Week 6

1. Site visit near ADNEC for maintenance of TRM Unit.
2. Researching on RTUs and their connections.
3. Understanding and researching on TRMs and QRMs in detail.

5 Assessment of Internship

5.1 Skills Gained

- Engineering accounting.
- Proficiency in Easy Power.
- Team Work and Management.
- Electrical Single Line Diagrams.
- Time-Current Curves for electrical equipment coordination.
- TRM, QRM, RTUs, and DVR.
- Networking.
- Collaboration.
- VLF Cable Testing.
- Router, Internet, and IP configurations.

- Time Management.
- Testing and Commissioning.
- Short Circuit Fault Analysis.

5.2 Responsibilities Taken

- Testing a Transformer.
- Researching on TRM, QRM, and RTUs.
- Commissioning a Transformer.
- Configuring the company's DVR and router for global camera access.
- Maintenance of ADDC Lucy Switch gear.
- Analysis of single line diagrams.
- Drawing single line diagrams on Easy Power software.
- Performing power flow analysis, relay coordination, and short circuit analysis.
- Producing automatic reports using the Easy Power software.
- VLF cable testing.
- Researching on ADDC rules and regulations.
- Making a Dynamic IP into Static IP.
- Port Forwarding in the company's router for global access.
- Testing and analyzing control cabinet of street lamps.

5.3 Effect on my Future

Sawa Lake Electro Mechanical is a electrical and mechanical engineering company that offers all kinds of services in electrical and mechanical for new or existing sites. In the coming years and the rest of the life, I will have all the information and hands-on experience for any work that is relating to electrical power distribution and security computer networking.

After completing my degree I have several career options to go for. For example, I can start my own electro mechanical company that handles contracts from the local distribution company or work as a engineer in one of the distributions companies. All the experience relating from handling contracts with ADDC to executing the job was gained. I also can combine my communication major choices taken in Abu Dhabi University and the experience gained at Sawa Lake to go for the telecommunication engineer at one of the telecommunication company in the world.

While going through the previous clients of the company, it gave me and idea of how much money is given by the client in total and what percentage is used as costs and the remaining as profits or other payments like salaries. This information was crucial for us as we become familiar with the market and understand what rate is going on at the moment for a job such as testing and commissioning. I also learnt that having contact inside the distribution company boosts the number of contracts a company gets. There are two factors a contractor company looks at:-

Tender Price: The lower price the electro mechanical company requires, the more the contractors are attracted and lean towards the company in offering the tender.

Reliability and Reputation: This is also an important factor as the contracting company prefers a well reputed and reliably company for performing the job in highest quality standard possible at given cost.

One of the lessons that I learnt for my future from this internship is that starting an engineering sub-contracting company requires about 400,000 Dhs of initial capital cost then in about 1 year the profit starts coming after recovery of original invested amount.

5.4 Theoretical Relation with Internship

Every time I visited the site, there were surprising amounts of relationship between the practical equipment and the theoretical knowledge which was gained in Abu Dhabi University.

The transformer testing and commissioning at Yas Mall reignited the memories of Electric Circuits II and Energy Conversion in which we learnt about transformers and different properties of it. We saw the resistance of the winding increase as expected in theory if the number of turns are high. We also saw in reality the diameter of wires increase if the current flowing through them was high and reduce if the current wasn't that high. Also the cables were separated more if they contained high voltage and less separated if they contained low voltage. This was clearly visible in the H.V. and L.V. side of the transformer. Then again, there were several things that we did not encounter at the university and had to research ourselves such as the vector group and why it is used in transformer testing.

The street lamp control cabinet allowed us to revisit the knowledge gained in Electronics I and Electric circuits I of how the LDR works. The prior knowledge of LDR enabled us to visualize the circuit without the need to rip apart the wires inside the cabinet. The circuit breakers, Current Transformers and Busbars used were easily understandable because we already had the theoretical knowledge.

6 Conclusion

Several site visits were done throughout the internship and huge experience in hands-on equipment handling was gained. We saw almost all the distribution components used in the power distribution network such as TRM, QRM, RTU, Feeder Pillar, Transformers, Switchgears, Current Transformer, Electricity Meter, LDR for control, Timer for control, MCBs, Busbars, Protection Relays, and Earth Fault Indicators.

All in all, this internship provided us with mind blowing opportunities and gave us humongous amount of experience in field work of electrical engineering. The company we were assigned operated majorly in Power related jobs. Even though my major is Communication and not Power, I was able to expand the horizons and explore the world of LV and HV power. I was very lucky to find a internship activity related to communication and networking in the middle of the internship period. The General Manager wanted the company's CCTV cameras to be accessible through internet. Implementing such kind of system required expert networking and data communications skills.

References

[1] Schweitzer Engineering Laboratories. (2013) *SCADA RTU - System Diagram* [Online]. Available: `https://www.selinc.com/uploadedImages/Products/Automation_and_Integration/Monitoring_and_Control/Callouts/axion_app_scada_rtu_lg.jpg`

[2] Energy Manager Training *Insulation Resistance and Polarization Index Test of Generator & Motor* [Online]. Available: `http://www.energymanagertraining.com/Journal/09032007/InsulationResistanceandPolarizationIndexTestofGenerator&Motor.pdf`

[3] Jiguparmar (3 June 2012) *Understanding Vector Group of Transformer* [Online]. Available: `http://electrical-engineering-portal.com/understanding-vector-group-transformer-1`

[4] Electrical4u *Online Electrical Engineering Study Site* [Online]. Available: `http://www.electrical4u.com/vector-group-test-of-power-transformer/`