POWER STABILITY OF 500/220/132 KV GRID STATION SYSTEM ON SINGLE-LINE-TO-GROUND FAULT AT 500KV TRANSMISSION LINES

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ABSTRACT— *Power transmission lines provide a link between generation center and end user in every country. These generation power unit are located at different location in country. In Pakistan the generation is provided by hydral unit mostly located at northern areas of Pakistan and thermal power plants. These generation centre are connected with National Grid with long transmission lines. These transmission lines are passing through different areas and are exposed to hostile environment. Due to these hostile conditions there is always high chance for fault occurrence on these transmission lines, fault on these transmission lines can cause serious damage to power system stability In this paper, power stability of 500/220/132KV grid station is analyzed the most critical grid station from Pakistan nation grid system is selected and results are simulated for fault on 500KV transmission lines.*

Index Terms— Power system stability, Transmission Lines, Fault detection.

I. INTRODUCTION

Power is supplied to different locations in country from generation stations by power transmission lines. These transmission lines are usually high voltage (HV) or extra high voltage (EHV) over head transmission lines and plays key role for transmission of bulk power at different locations. The reliable electricity supply plays key role in socio economic progress of every country as the nation resources of country such as security, communication health welfare, food water supply and commercial enterprise are directly depended on the electricity. In Pakistan different voltage level transmission lines are used for the power transmission, 500KV, 220KV and 132 KV grid stations are constructed for transmission and dispatch of electrical power. 500KV and 220 KV grid stations and transmission lines are maintained by National Transmission and Despatch Company Ltd (NTDCL) [1], controlled by Government of Pakistan. As these lines are passing through different areas of Pakistan and all of these lines are exposed to harsh environmental conditions so the probability of fault occurrence on transmission lines is very high. These transmission lines are hundreds of KM in length and the whole network is interconnected so the fault analysis on these transmission lines is essential. As discussed above the chances of fault occurrence of these transmission lines are very high for the stable continuity of the bulk power flow [2] these faults must be cleared immediately otherwise the faulty conditions may lead to blackout in county which has been witness in recent years in Pakistan. As these blackout or electricity failure remains for many hours and has significant impact on almost 170 million people and the entire economy of the country so it is very important to do a critical analysis for specific cause of blackout [3] [4]. The electricity power transmission system is inter-connected and this complex system has more chances of entire electricity failure due to cascade tripping of transmission lines. In Pakistan power transmission 500KV transmission lines are the back bone of the power system and it has vital role to provide power stability in the country. In case of fault on these transmission lines the voltage stability [5] of the power system is compromised.

This paper represents the power stability of 500/220/132KV grid station. For this purpose the most critical Grid station form the NTDCL power transmission network is simulated which is 500/220/132 KV grid station New multan Pakistan. New Multan grid station is located in south Punjab of Pakistan and it is providing transmission in bi direction. It has 6 Nos. 500KV transmission lines, 14 Nos. 220KV transmission lines, 4 Nos. 132KV transmission lines, 3 Nos. 222/132KV 160MVA transformers and 2 Nos. 500/220 KV 450MVA transformers. This grid station is simulated in MATLAB and the power system stability is analyzed by simulating different faults on transmission lines.

The rest of the paper is divided into following sections: Section-II simulation of grid station; Section-III presents the analysis & results and Section-IV concludes the paper.

II. PAKISTAN NATIONAL POWER GRID

Electricity is the economic life line of every country; it is generated at low voltage level (11KV to 23 KV in Pakistan) by various sources. This low voltage is set up for transmission in bulk. In Pakistan all the generating stations are connected to a ring connected transmission network. This inter connected network is known as National Grid and it is maintained by National Transmission And Despatch Company Ltd (NTDCL) owned by Government of Pakistan. NTDCL operates and maintains twelve 500 KV and twenty nine 220 KV Grid Stations, 5077 km of 500 KV transmission line and 7359 km of 220 KV transmission line in Pakistan with prime objective to contribute in the development of prosperous Pakistan by managing smooth and economical transmission and despatch system through excellence of professional work. Figure-1 shows general layout of Transmission Network in Pakistan.

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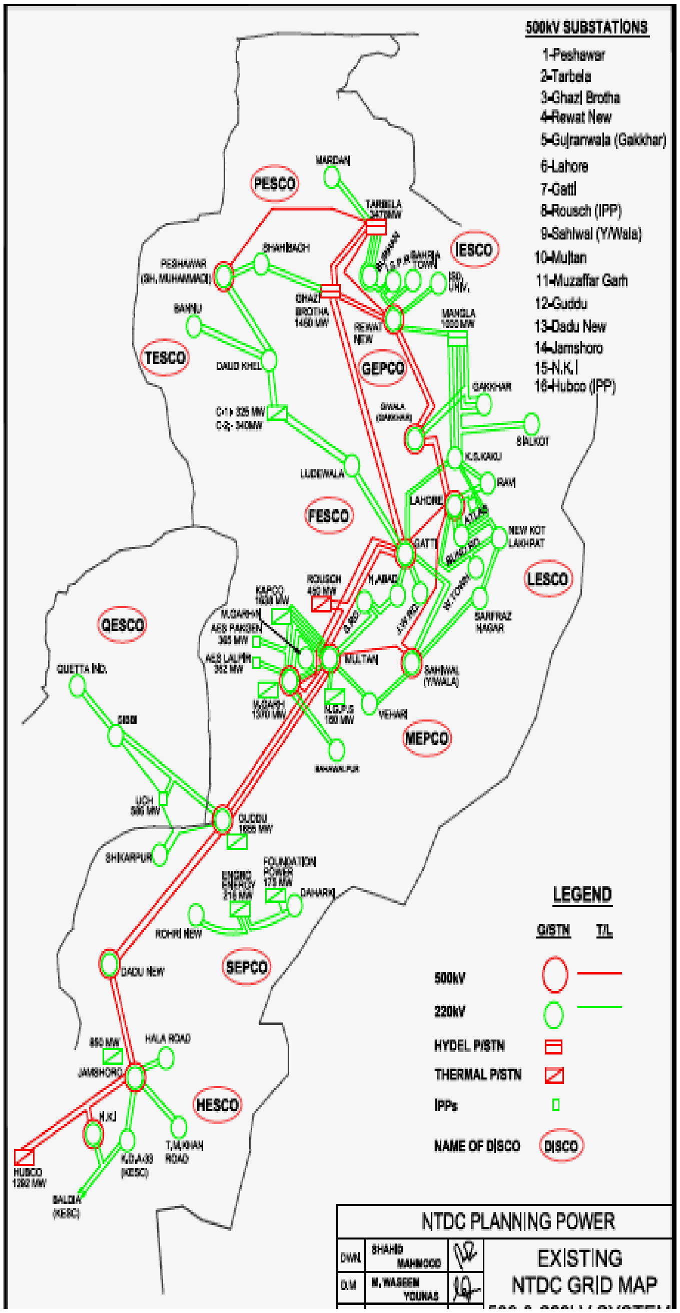

Figure 1: NTDCL Grid map.

A. Grid Station Under Study

The system under study is the 500/220/132 KV Grid Station. This system is given in figure 1 it has two bus bars of 500 KV, 220KV and 132 KV respectively. The bus-bar scheme for 500 KV and 220 KV is breaker-and-a-half bus bar scheme while for 132 KV it has simple main and transfer bus scheme.

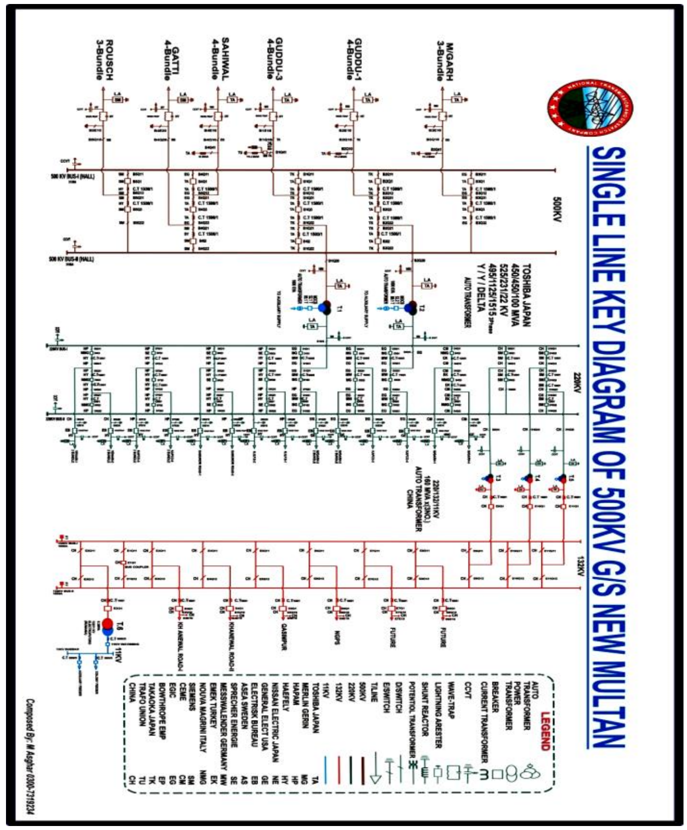

Figure 2: Single Line Diagram.

Right now our main focus is the system current and voltage waveforms of 500 KV bus-bar Bay under healthy and faulty conditions. The load under study is taken right before the blackout on 12-12-2014. However we consider the impact of one and two 500 KV lines tripping while 500/220/132 KV system is in operation, the breaker will take 3 cycles to operate in our system in Matlab. We will also see the impact on other bays current after disconnection of one or two lines of 500 KV Grid. Also we will the impact on lines if protection does not operate. We will witness 132 KV line current as well as it is the system closest to consumer in the grid station under study. Here is the single bay of 500 KV, 220 KV and 132 KV systems in Matlab in figure 3, 4 and 5 respectively.

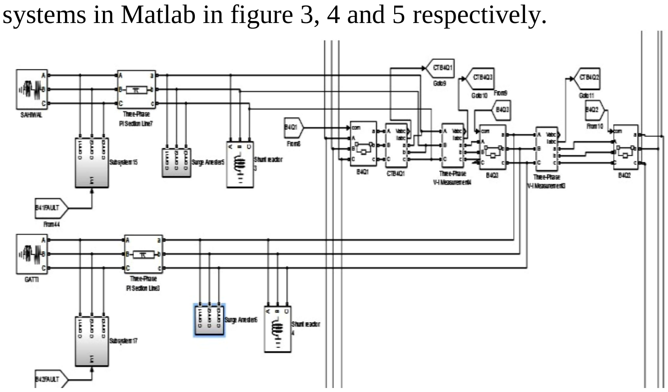

Figure 3: Matlab Model for 500KV Grid Station.

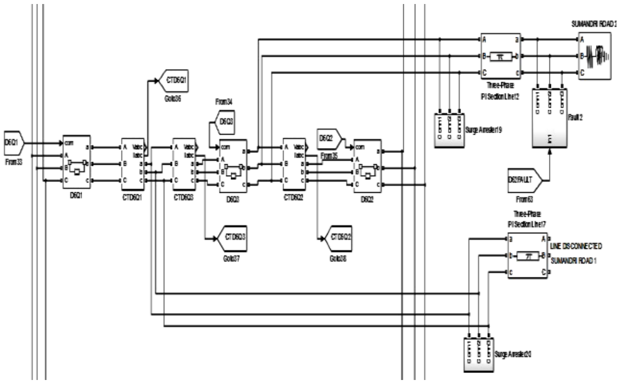

Figure 4: Matlab Model for 220KV Grid Station.

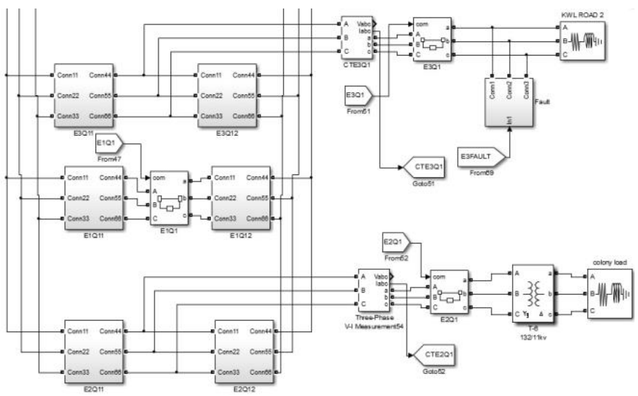

Figure 5: Matlab Model for 132KV Grid Station.

Also the 500/220 KV transformers is shown in figure 6 while 220/132 KV transformers is shown in figure 7.

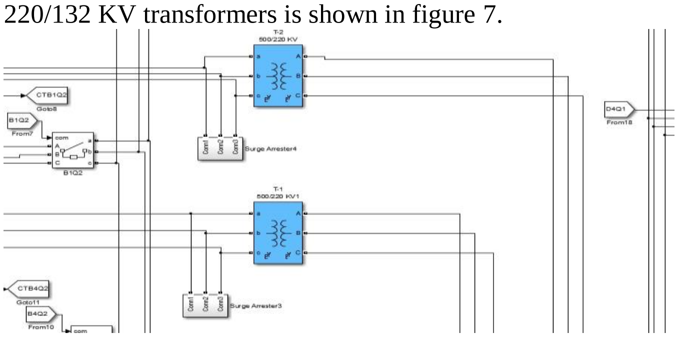

Figure 6: Matlab Model for 500/220 KV Transformers.

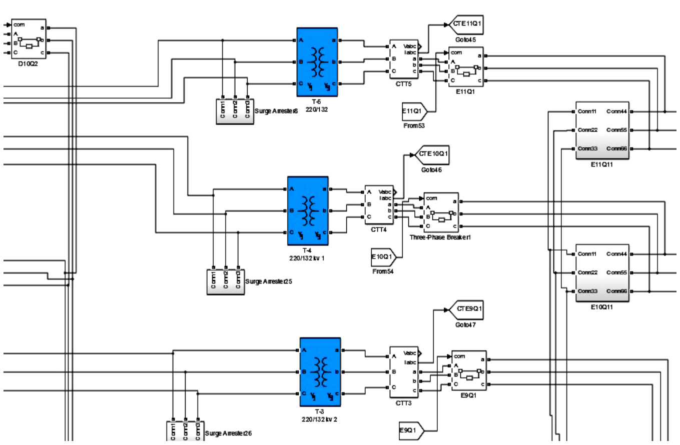

Figure 7: Matlab Model for 220/132 KV Transformers.

B. LOADING CONDITION BEFORE SYSTEM BLACKOUT

500/220/132KV SYSTEM LOADING CONDITION BEFOR SYSTEM BLACKOUT AT 12:51 HRS ON DATED: 12-12-2014.

Table-1 Transmission Lines Loading Condition.

S. No.	Name of Circuit/Transformer	Load (Amp/ MW)	Closing time (Hrs)	Remarks
01	220KV Multan-Kapco-4	390/90 IMP	1709	OPENED BY HAND
02	500KV Multan-M/Garh	860/750 IMP	1918	OPENED BY HAND
03	500/220KV Auto Transformer-1	159/50 EXP	1924	OPENED BY HAND
04	500/220KV Auto Transformer-2	159/50 EXP	1925	OPENED BY HAND
05	500KV Multan-Sahiwal	640/540 EXP	1944	OPENED BY HAND
06	220KV Mutan-Vehari 1	380/150 EXP	2020	OPENED BY HAND
07	220KV Mutan-Vehari 2	380/150 EXP	2020	OPENED BY HAND
08	220KV Multan-S/Road-2	180/70 EXP	2023	OPENED BY HAND
09	220KV Multan-M/Garh-2	130/50 EXP	2034	OPENED BY HAND
10	500KV Multan-Rousch	440/310 EXP	2044	OPENED BY HAND
11	220KV Multan-NGPS-1	180/70 EXP	2049	OPENED BY HAND
12	500KV Multan-Guddu-1	Already PTW	2050	PTW
13	220KV Multan-M/Garh-4	Already PTW	2055	PTW
14	500KV Multan-Gatti	420/350 EXP	2101	OPENED BY HAND
15	220KV Multan-Kapco-3	230/90 IMP	2110	OPENED BY HAND
16	220KV Multan-M/Garh-1	520/210 IMP	2116	OPENED BY HAND
17	220KV Multan-M/Garh-3	450/180 IMP	2117	OPENED BY HAND
18	500KV Multan-Guddu-747	710/610 IMP	2120	OPENED BY HAND
19	220KV Multan-S/Road-1	Already S/DOWN	2135	PTW AT OTHER END
20	220KV Multan-NGPS-2	180/70 EXP	2145	OPENED BY HAND
21	220/132KV Auto Transformer-3	288/56 EXP	1728	OPENED BY HAND
22	220/132KV Auto Transformer-4	288/56 EXP	2031	OPENED BY HAND
23	220/132KV Auto Transformer-5	288/56 EXP	2031	OPENED BY HAND
24	NGPS 132 KV	165/32 EXP	2031	OPENED BY HAND
25	QASIMPUR	185/36 EXP	2031	OPENED BY HAND
26	KWL ROAD-I	257/50 EXP	2031	OPENED BY HAND
27	KWL ROAD-II	257/50	2031	OPENED

		EXP		BY HAND

III. RESULTS AND ANALYSIS

The above mentioned Grid Station is simulated and in case of healthy system the wave form of 500KV Bus Bar voltage is shown in figure-8

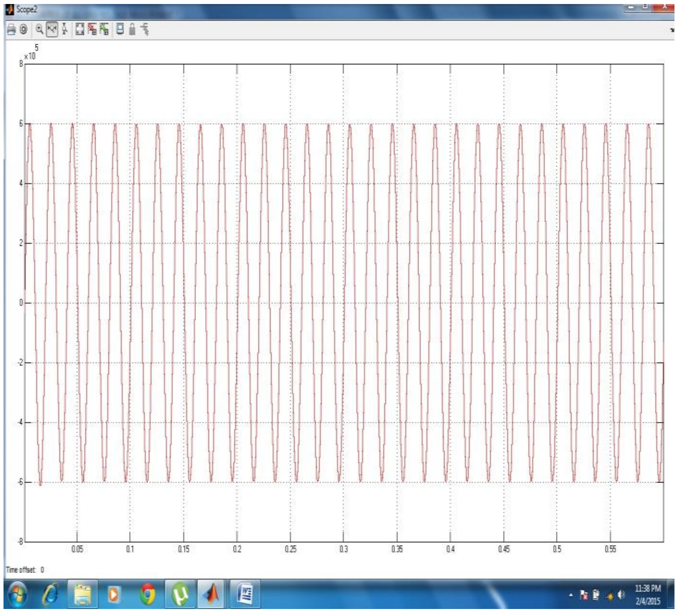

Figure- 8 500KV Bus Bar Voltage.

voltage rise up to few times if we send 500KV at sending end because of farranti effect [6], but in actual we reduce voltages from generation side in order to cope this problem by installation of 11.3Mvar shunt reactor but still we exhibit some voltage rise. Bus bar 2 shows the same voltage as that of bus bar 1.

Now phase-Ground fault is simulated on 500KV Multan-Guddu-1 line, its relevant breakers as designated B2Q1 and B2Q3 are open in 3 cycles after the occurrence of fault effect and its effect on Bay 4 and Bay 2 is observed, while Bay 2 is the faulty Bay now and Bay-1 is the closest bay. Also we see its effect on 132 Kv lines i.e Khanewal road-2 and Qasimpur as well. Waveform of BB1-500KV voltage now decreases as shown in figure-9 from previous value but it is still not out of range

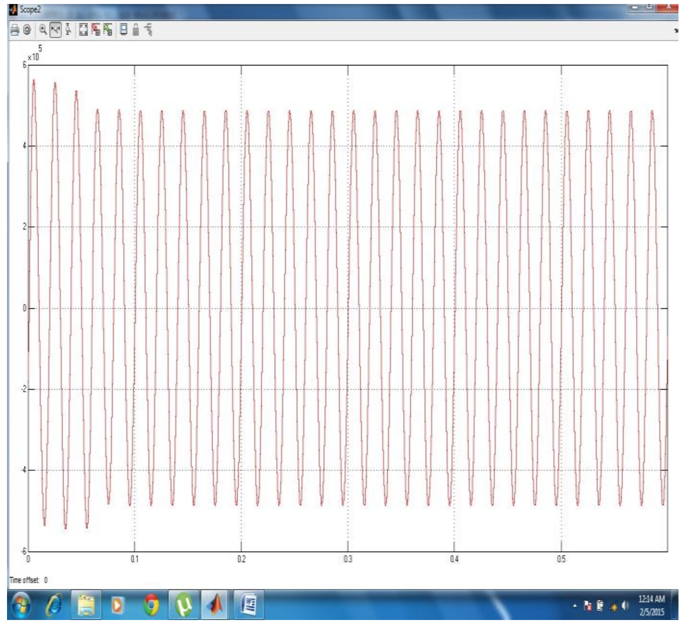

Figure- 9 500KV Bus Bar Voltage during Phase-Ground fault.

In other case the fault is simulated on two 500 KV Transmission lines and the results shows that voltage in normal range.

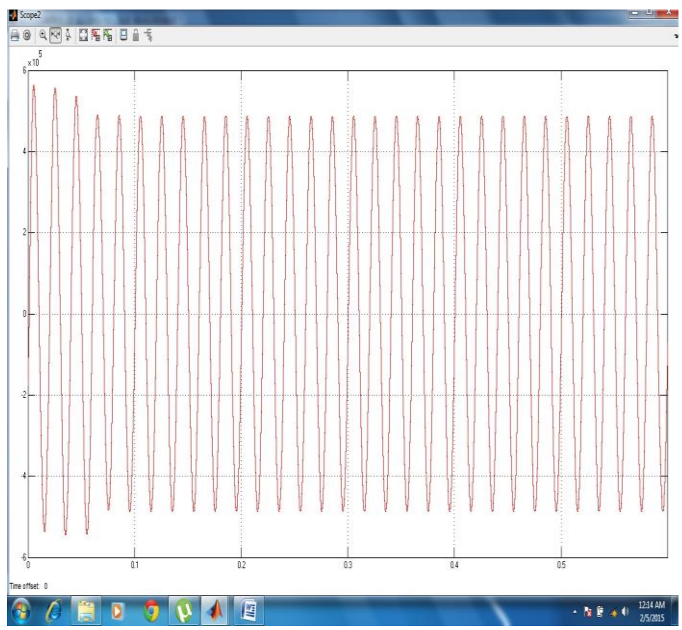

Figure- 10 500KV Bus Bar Voltage during Phase-Ground fault.

Now in other case three 500KV lines Multan-Gudd-1, Multan-Gatti and Multan-Roush are simulated for fault simultaneously. The system voltage is observed as shown in figure-11 which has been decreased to very low value and the it forces the system towards cascading tripping that results in blackout of the system.

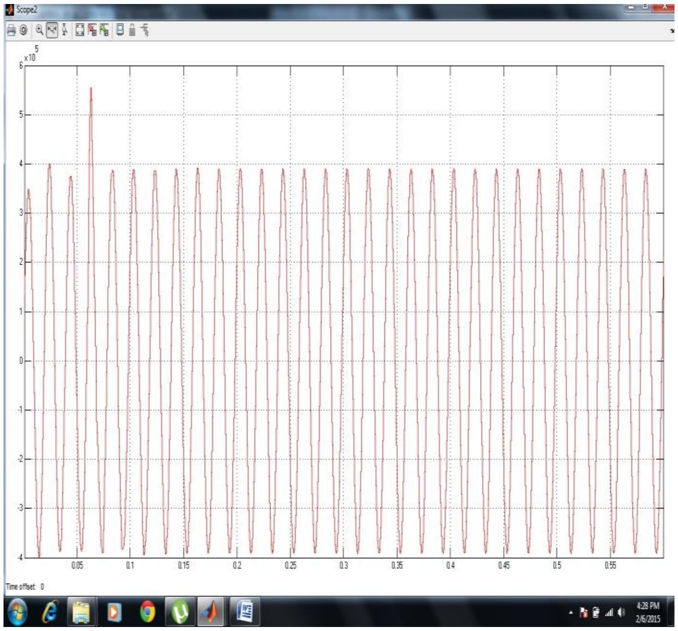

Figure- 11 500KV Bus-Bar Voltage during Fault.

At the same time the 132 KV transmission lines voltage and current are also observed and it is witnessed that the the load imbanalce is found on these transmission lines as shown is figure 12.

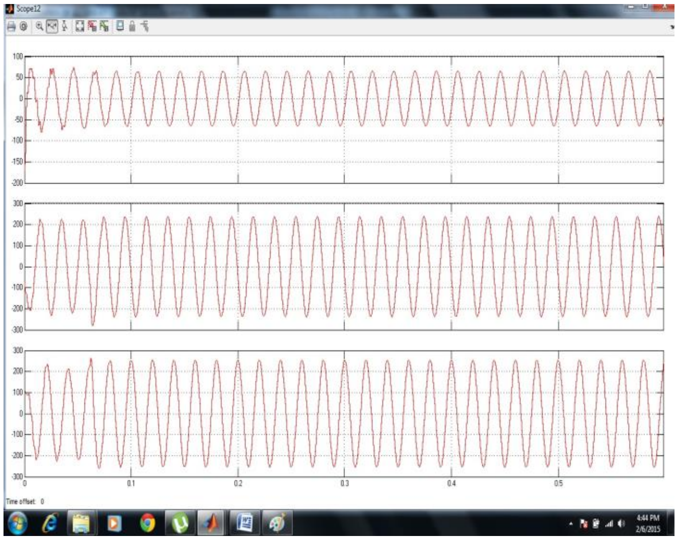

Figure- 12 132 KV Transmission Lines current during 500KV line faults.

This high imbalance of current and voltage on the 132 KV systems itself causes the mal operation of protection relays which also leads towards blackout.

IV. CONCLUSION

The simulation results present the power stability of Pakistan power system. As the 500KV Multan Grid station is the back bone of power transmission and dispatch system. The simulation results show that the fault on three 500KV transmission lines specially Multan-Guddu-1, Multan-Gatti and Multan Roush line decrease the bus bar voltage to very low value due to which the other remaining system is not able to continue the power flow and at the same time the chance of mal operation on 132 KV system is also high and this conditions lead to Black out in country.

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