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Protection Of 200Km Compensated Transmission Line By MOS Arrestor Using MATLAB

Gaurav Sharma[1], Mr. Anshul Mahajan[2]

[1]*Post Graduate Student School of Electronics & Electrical Engineering,*
Lovely Professional University, Jalandhar, Punjab, India
[1]*gaurav1509009@gmail.com*
[2]*Department of Electrical Engineering,*
Lovely Professional University, Punjab, India
[2]*anshul.mahajan@lpu.co.in*

Abstract: *In this paper we are protecting the system from being damaged by the overvoltage develop across the system due to switching and lightning in nature. For analyzing the system we consider case of overvoltage due to lightning. In this paper we emphasize the impact of protection technique used for protecting the various equipment from overvoltage develop across the system.*

In this paper we are protecting the system from being damaged by the overvoltage develop across the system due to switching and lightning in nature. For analyzing the system we consider two case of overvoltage i.e. lightning and switching. All the simulating work is done in MATLAB/Simulink in which we develop different graphical relationship between current, voltage waveforms with respect to time. All the simulation is done by inducing lightning on different point on the transmission line and then comparison is made, then considering the results by using arrestor model and without using arrestor model. In the last we conclude that it is preferable to use arrestor across the line to protect the compensated devices across the system because the arrestor protective device operates immediately in order to remove the heavy overvoltage to pass through the compensated devices

Keywords: *Overvoltage, Lightning Overvoltage, Switching Overvoltage, Arrestor.*

1. INTRODUCTION

Overvoltage is one of the major troubles occurring in the power system and to minimize this problem many methods, equipment's and techniques have used. Basically overvoltage is of two types i.e. lightning and switching. To improve the performance of the power system from lighting several studies has been conducted and many methodologies have been purposed in the technical literature over the last decades. The most important safeguard in electrical power system is to protect overhead high voltages transmission line from lightning strokes. Accurate evaluation of the lightning performance helps to make the system highly efficient. Shield wires and surge arrestors are used for the protection of lines from lightning. Due to the lightning phenomena overvoltage occurs which reduces the reliability of electrical network, leading to interruption and consequences increases the transmission line repair cost. To minimize the annual failure of the line overhead ground wires are placed above the phases to intercept lightning strokes [1]. Surge arrestors are the main measures, which are used in order to protect the system against lightning and switching phenomena

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Franklin"s invention of lightning rod to protected apparatus from lightning strikes. Till today for more than 200 years, the lightning rod has been used for air terminal of lightning protection systems.[1] But lightning rods cannot always function perfectly because they have an unexpected shielding failures, are often due to the uncertainty of lightning phenomenon. For example, several direct strikes to the transformer substations took place in the power grid of north India. For designing a lightning protection system, the protection angle method, the rolling sphere method and the mesh method are used to evaluate the protection zone of a lightning rod, all of these fall considerations on stochastic behaviors of the lightning process. The effectiveness of lightning rods is investigated by means of dynamic simulation of lightning strikes including stochastic [2].

Over voltages in the power system may be due to the lightning strokes that terminate on or near to power lines such over voltages are known as lightning over voltage or surges. Switching over voltages or surges is due to the certain change in the circuit condition brought about by deliberate or unintentional switching operation. The magnitude of lightning over voltage is essentially independent of system voltage is known as external over voltages.

2. MATHEMATICAL MODELLING

In our model we have constructed a 735KV equivalent transmission system feed a load through a 200 Km transmission line. The transmission line is series compensated at the middle point and shunt compensated at the sending end and the receiving end of the system. An overvoltage fault is applied to the transmission line. Firstly we apply lightning fault in which we induce the pulse wave in the transmission line of very high value and then calculate the various results. This lightning is fall on the different position on the transmission line to analysis the result of arrestor across the system. Secondly we introduce switching fault near the load terminal. This fault is cleared by load breaker opening. For simplification purpose only one phase of the transmission system is modeled. All parameters correspond to positive sequence

A 3 phase short circuit level of the transmission system is 15000MVA. The line is 40% series compensated by the capacitor and shunt compensated by 330MVar inductor at the load end. The series capacitance and shunt inductor are protected by the metal oxide varistor. The series capacitor varistor MOV1 consist of 30 columns protecting the capacitor at 2.5 times its rated value. The shunt inductor is protected by a 2 column arrestor at 1.8 pu of nominal phase to ground voltage.

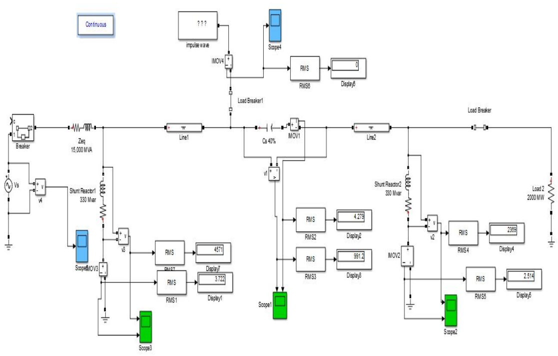

Fig1 A single phase MATLAB/Simulink model of 735KV transmission system feed a load through a 200 Km transmission line

3. RESULT AND DISCUSSION

CASE I- OCCURANCE OF LIGHTNING BEFORE SERIES CAPACITOR WITHOUT USING ARRESTOR

In this case when lightning will fall before the series capacitor on the transmission line there is no arrestor present in parallel to the shunt and series compensated device. All lightning overvoltage will pass though the compensated devices attached across the system.

Table1 RMS value of Voltage and Current of examined transmission line Lightning overvoltage before series capacitor without using arrestor

RMS Voltage at sending end (V_{rms1})	**RMS Current at sending end (I_{rms1})**	**RMS Voltage at midpoint (V_{rms2})**	**RMS Current at midpoint (I_{rms2})**	**RMS Voltage at receiving end (V_{rms3})**	**RMS Current at receiving end (I_{rms3})**	**Time frame (T)**
2.663 e^{04}	13.36	11.11	1477	4545	6.308	0.01
8195	8.514	15.95	432.1	5029	0.6098	0.02
5071	5.484	2.856	289.6	512.1	3.333	0.03
3229	4.081	3.444	723.8	66.07	3.716	0.04
1727	2.389	3.533	1081	118.6	3.629	0.05
1075	2.857	1.27	1298	2339	0.7514	0.06
1390	0.606	0.0435	1430	2183	1.544	0.07
4097	0.1562	0.1145	1394	4387	1.537	0.08
3788	2.118	1.614	1269	5609	2.029	0.09
4571	3.722	4.279	991.2	2369	2.514	0.10

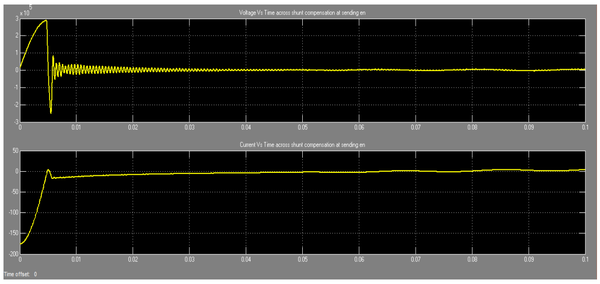

Fig2 Voltage Vs Time and Current Vs Time waveform of the shunt reactor at the sending end of transmission line, Lightning overvoltage before series capacitor without using arrestor

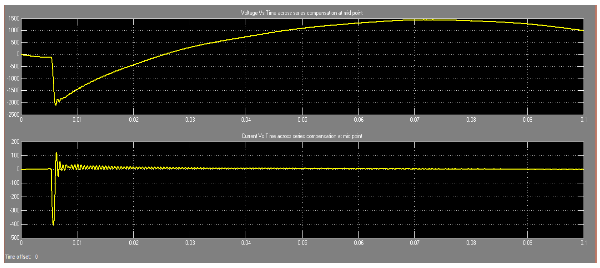

Fig3 Voltage Vs Time and Current Vs Time waveform of the series capacitor at the midpoint of transmission line, Lightning overvoltage before series capacitor without using arrestor

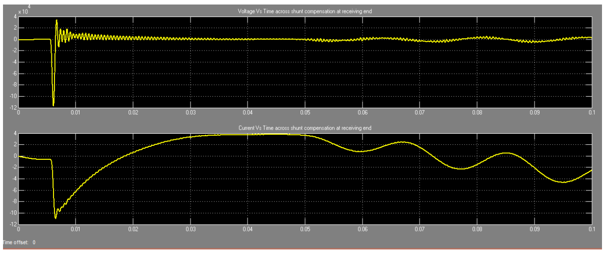

Fig4 Voltage Vs Time and Current Vs Time waveform of the shunt reactor at the receiving end of transmission line, Lightning overvoltage before series capacitor without using arrestor

CASE II- OCCURANCE OF LIGHTNING BEFORE SERIES CAPACITOR BY USING ARRESTOR

In this case when the lightning will fall before the series capacitor, the arrestor installed in parallel to the shunt and series compensation devices protect the system from the heavy voltage develop across the system. When the lightning impulse will fall on the transmission line, the system will produce a back flash to the receiving end and ground the large amount of lightning voltage to the ground and save the system from heavy damage.

Table 2 RMS value of Voltage and Current of examined transmission line, Lightning overvoltage before series capacitor by using arrestor

RMS Voltage at sending end (V_{rmss})	RMS Current at sending end (I_{rmss})	RMS Voltage at midpoint (V_{rmsm})	RMS Current at midpoint (I_{rmsm})	RMS Voltage at receiving end (V_{rmsr})	RMS Current at receiving end (I_{rmsr})	Time frame (T)
2.663 e^{04}	3.804 e^{-77}	1477	1.911 e^{-102}	1.536 e^{-115}	4546	0.01
8191	9.367 e^{-102}	432.1	3.968 e^{-117}	2.435 e^{-112}	5030	0.02
5071	3.667 e^{-112}	289.6	8.02 e^{-128}	0	512.2	0.03
3230	5.843 e^{-122}	723.8	6.292 e^{-118}	0	66.03	0.04
1726	1.429 e^{-128}	1081	3.217 e^{-107}	0	118.7	0.05
1075	7.483 e^{-147}	1298	2.995 e^{-102}	5.695 e^{-120}	2338	0.06
1391	3.006 e^{-141}	1430	3.783 e^{-101}	1.826 e^{-121}	2183	0.07
4098	6621 e^{-118}	1394	1.07 e^{-101}	2.609 e^{-118}	4387	0.08
3785	1.626 e^{-119}	1269	9.775 e^{-104}	5.771 e^{-111}	5611	0.09
4571	2.033 e^{-115}	9912	4.225 e^{-105}	1.104 e^{-129}	2370	0.10

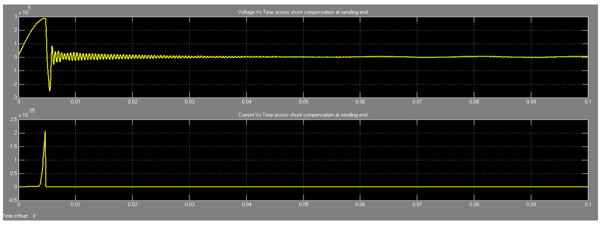

Fig5 Voltage Vs Time and Current Vs Time waveform of the shunt reactor at the sending end of transmission line,Lightning overvoltage before series capacitor by using arrestor

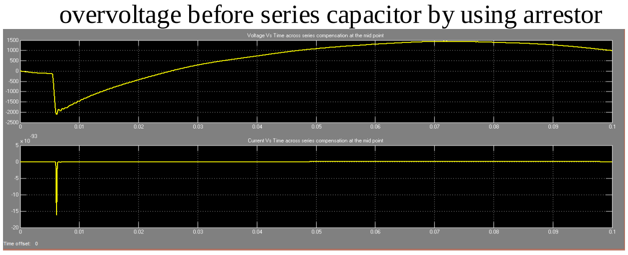

Fig6 Voltage Vs Time and Current Vs Time waveform of the series capacitor at the midpoint of transmission line, Lightning overvoltage before series capacitor by using arrestor

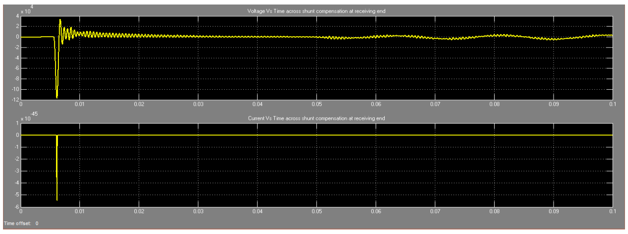

Fig7 Voltage Vs Time and Current Vs Time waveform of the shunt reactor at the receiving end of transmission line, Lightning overvoltage before series capacitor by using arrestor

CASE III- OCCURANCE OF LIGHTNING AFTER SERIES CAPACITOR WITHOUT USING ARRESTOR

In this case when lightning will fall after series capacitor on the transmission line there is no arrestor present in parallel to the shunt and series compensated device. All lightning overvoltage will pass though the compensated devices attached across the system.

Table 3 RMS value of Voltage and Current of examined transmission line, Lightning overvoltage after series capacitor without using arrestor

RMS Voltage at sending end (V_{rmss})	RMS Current at sending end (I_{rmss})	RMS Voltage at midpoint (V_{rmsm})	RMS Current at midpoint (I_{rmsm})	RMS Voltage at receiving end (V_{rmsr})	RMS Current at receiving end (I_{rmsr})	Time frame (T)
4.68	694	652.5	7.005	1.517	59.11	0.01

e^{05}			e^{05}	e^{05}		
3.424 e^{05}	1473	1438	5.931 e^{05}	2.565 e^{05}	481	0.02
1.69 e^{05}	1908	1897	4.259 e^{05}	2.527 e^{05}	971.6	0.03
3.05 e^{05}	2070	2053	2.295 e^{05}	1.855 e^{05}	1376	0.04
6.973 e^{04}	2001	1986	2.841 e^{04}	9.951 e^{04}	1629	0.05
1.631 e^{05}	1741	1731	1.562 e^{05}	9828	1707	0.06
7.488 e^{04}	1482	1461	3.141 e^{05}	2.41 e^{05}	1462	0.07
2.742 e^{05}	1058	1085	4.405 e^{05}	1.62 e^{05}	1622	0.08
2.496 e^{05}	657.7	615.1	5.247 e^{05}	2.647 e^{05}	574.6	0.09
2.322 e^{05}	59.56	92.85	5.597 e^{05}	3.174 e^{05}	128.6	0.10

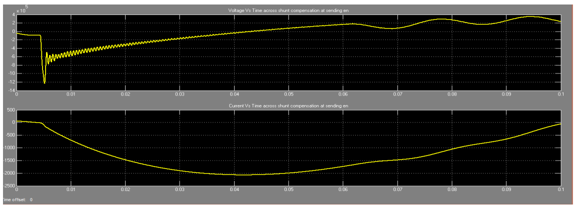

Fig8 Voltage Vs Time and Current Vs Time waveform of the shunt reactor at the sending end of transmission line,Lightning overvoltage after series capacitor without using arrestor

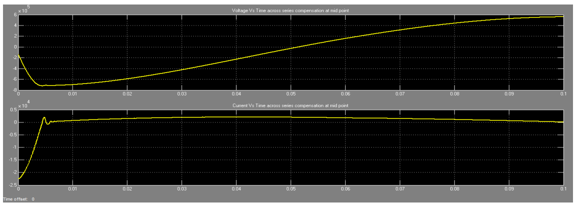

Fig9 Voltage Vs Time and Current Vs Time waveform of the series capacitor at the midpoint of transmission line,Lightning overvoltage after series capacitor without using arrestor

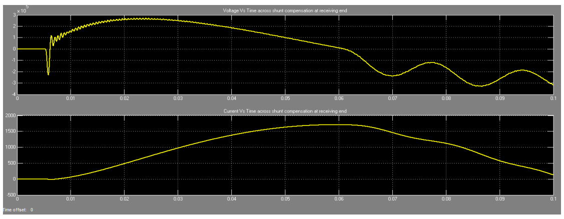

Fig10 Voltage Vs Time and Current Vs Time waveform of the shunt reactor at the receiving end of transmission line,Lightning overvoltage after series capacitor without using arrestor

CASE IV- OCCURANCE OF LIGHTNING AFTER SERIES CAPACITOR BY USING ARRESTOR

In this case when the lightning will fall after the series capacitor, the arrestor installed in parallel to the shunt and series compensation devices protect the system from the heavy voltage develop across the system. When the lightning impulse will fall on the transmission line, the system will produce a back flash to the receiving end and ground the large amount of lightning voltage to the ground and save the system from heavy damage.

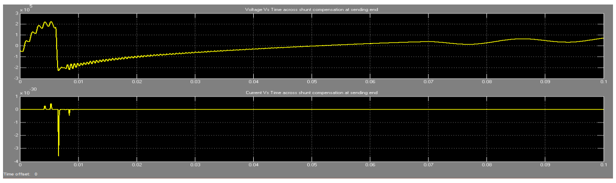

Fig11 Voltage Vs Time and Current Vs Time waveform of the shunt reactor at the sending end of transmission line,Lightning overvoltage after series capacitor by using arrestor

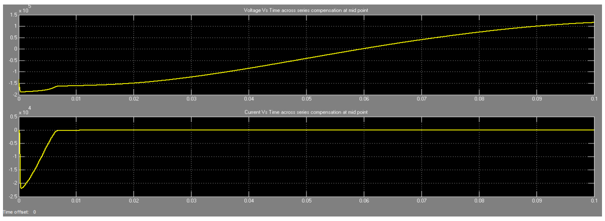

Fig12 Voltage Vs Time and Current Vs Time waveform of the series capacitor at the midpoint of transmission line,Lightning overvoltage after series capacitor by using arrestor

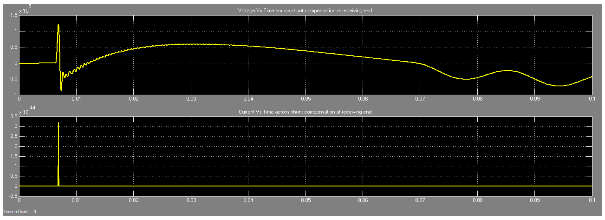

Fig13 Voltage Vs Time and Current Vs Time waveform of the shunt reactor at the receiving end of transmission line,Lightning overvoltage after series capacitor by using arrestor

Table 4 RMS value of Voltage and Current of examined transmission line, Lightning overvoltage after series capacitor by using arrestor1

RMS Voltage at sending end (V_{rmss})	RMS Current at sending end (I_{rmss})	RMS Voltage at midpoint (V_{rmsm})	RMS Current at midpoint (I_{rmsm})	RMS Voltage at receiving end (V_{rmsr})	RMS Current at receiving end (I_{rmsr})	Time frame (T)
1.647 e^{05}	1.401e^{-27}	143	1.61e^{05}	2.61e^{04}	1.387e^{-77}	0.01
1.091e^{05}	1.559e^{-48}	3.477	1.494e^{05}	4.361e^{04}	1.947e^{-86}	0.02
5.95e^{04}	1.082e^{-39}	0.0001876	1.228e^{05}	5.914e^{04}	7.96e^{-80}	0.03
2.955e^{04}	6.865e^{-75}	1.77e^{-11}	8.485e^{04}	5.219e^{04}	1.547e^{-82}	0.04
4498	9.141e^{-116}	6.029e^{-23}	4.162e^{04}	3.72e^{04}	6.871e^{-70}	0.05
2.02e^{04}	3.753e^{-81}	1.149e^{-95}	1603	1.825e^{04}	2.334e^{-85}	0.06
3.844e^{04}	3.515e^{-69}	1.785e^{-23}	4.061e^{04}	2978	1.017e^{-114}	0.07
2.636e^{04}	2.269e^{-77}	1.615e^{-11}	7.376e^{04}	4.676e^{04}	6.333e^{-85}	0.08
4.719e^{04}	1.002e^{-84}	5.52e^{-09}	9.965e^{04}	5.051e^{04}	3.011e^{-82}	0.09
7.01e^{04}	3.937e^{-54}	1.094e^{-05}	1.16e^{05}	4.403e^{04}	3145e^{-88}	0.10

CASE V- SWITCHING OVERVOLTAGE ACROSS COMPENSATION DEVICES WITHOUT USING ARRESTOR

In this system when there is any switching operation when occur, there is no arrestor present in the system. We have calculated the different values of RMS voltage and current in the sending, midpoint and at the receiving end of the transmission line.

Table5 switching overvoltage without using arrestor

RMS Voltage at sending end (V_{rmss})	RMS Current at sending end (I_{rmss})	RMS Voltage at midpoint (V_{rmsm})	RMS Current at midpoint (I_{rmsm})	RMS Voltage at receiving end (V_{rmsr})	RMS Current at receiving end (I_{rmsr})	Time frame (T)
6.026 e^{04}	**358.4**	**6.529 e^{04}**	**501.5**	**1.074 e^{05}**	**348.6**	**0.01**
6.026 e^{04}	**358.4**	**6.529 e^{04}**	**501.5**	**1.074 e^{05}**	**348.6**	**0.02**
1.687 e^{05}	**192.9**	**5.119 e^{05}**	**7775**	**8551**	**330.2**	**0.03**
6.677 e^{04}	**29.18**	**3.073 e^{05}**	**1.752 e^{04}**	**1.89e^{04}**	**341.9**	**0.04**
9.026 e^{04}	**60.92**	**1.621 e^{05}**	**1.771 e^{04}**	**2.011 e^{04}**	**332.6**	**0.05**
3.496 e^{05}	**408.6**	**4.944 e^{05}**	**583.9**	**3.679 e^{05}**	**903.7**	**0.06**
2.005 e^{05}	**376.1**	**3.864 e^{05}**	**1456**	**1.159 e^{06}**	**920**	**0.07**
3.486 e^{05}	**350**	**2.463 e^{05}**	**1508**	**4.288 e^{05}**	**2227**	**0.08**
3.171 e^{05}	**401.5**	**3.986 e^{05}**	**1948**	**4.241 e^{05}**	**1700**	**0.09**
3.014	**322**	**1.461**	**2459**	**5.973**	**2270**	**0.10**

e^{05}		e^{05}		e^{05}		

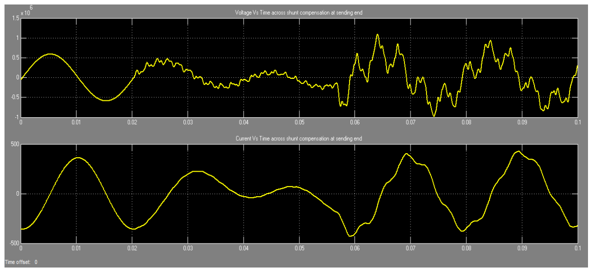

Fig14 Voltage Vs Time and Current Vs Time waveform of the shunt reactor at the sending end of transmission line, switching overvoltage without using arrestor

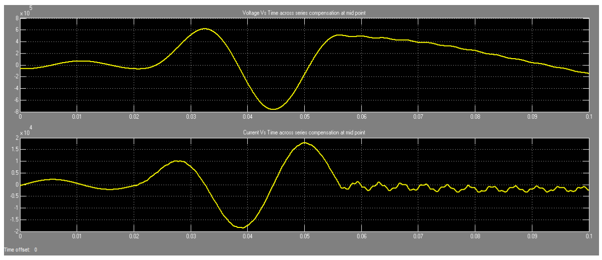

Fig15 Voltage Vs Time and Current Vs Time waveform of the series capacitor at the midpoint of transmission line,switching overvoltage without using arrestor

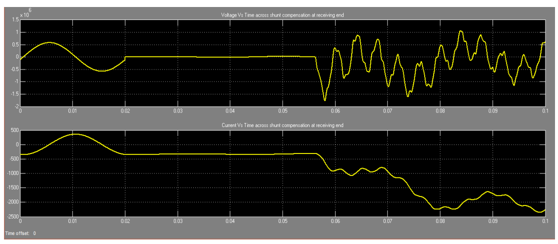

Fig16 Voltage Vs Time and Current Vs Time waveform of the shunt reactor at the receiving end of transmission line,switching overvoltage without using arrestor

CASE V- SWITCHING OVERVOLTAGE ACROSS COMPENSATION DEVICES BY USING ARRESTOR

In this system when there is any switching operation when occur, there is arrestor present in the system. We have calculated the different values of RMS voltage and current in the sending, midpoint and at the receiving end of the transmission line.

Table6 Switching overvoltage by using arrestor

RMS Voltage at sending end (V_{rmss})	RMS Current at sending end (I_{rmss})	RMS Voltage at midpoint (V_{rmsm})	RMS Current at midpoint (I_{rmsm})	RMS Voltage at receiving end (V_{rmsr})	RMS Current at receiving end (I_{rmsr})	Time frame (T)
4.852 e^{04}	3.971 e^{-54}	3.985 e^{04}	6.861 e^{-29}	175.7	0	0.01
1.085 e^{05}	1.228 e^{-46}	2.617 e^{04}	5.091 e^{-38}	1.75 e^{05}	2.866 e^{-36}	0.02
1.165 e^{05}	4.121 e^{-45}	1.785 e^{04}	2.477 e^{-46}	1.663 e^{05}	2.234 e^{-37}	0.03
4.209 e^{05}	3.292 e^{-17}	8421	1.215 e^{-62}	4.193 e^{05}	2.734 e^{-17}	0.04
5.78 e^{05}	2.551 e^{-10}	1837	1.064 e^{-95}	5.337 e^{05}	4.707 e^{-12}	0.05
4.018 e^{05}	3.218 e^{-18}	1.205 e^{04}	7.495 e^{-55}	4.377 e^{05}	2.331 e^{-16}	0.06
1.162 e^{05}	3.775 e^{-45}	2.1 e^{04}	8.536 e^{-43}	1.337 e^{05}	4.046 e^{-42}	0.07
1.486 e^{05}	8.208 e^{-40}	2.758 e^{04}	7.049 e^{-37}	1.662 e^{05}	2.181 e^{-37}	0.08
3.607 e^{05}	1.462 e^{-20}	3.144 e^{04}	4.951 e^{-34}	4.167 e^{05}	1.993 e^{-17}	0.09
5.595 e^{05}	4.979 e^{-11}	3.254 e^{04}	2.763 e^{-33}	4.736 e^{05}	1.198 e^{-14}	0.10

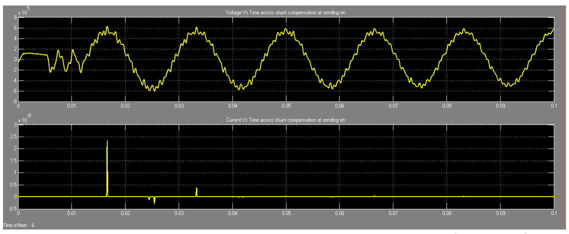

Fig17 Voltage Vs Time and Current Vs Time waveform of the shunt reactor at the sending end of transmission line, switching overvoltage by using arrestor

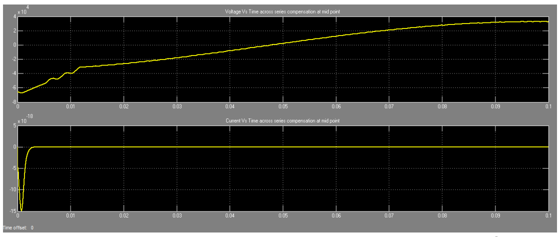

Fig18 Voltage Vs Time and Current Vs Time waveform of the series capacitor at the midpoint of transmission line,switching overvoltage by using arrestor

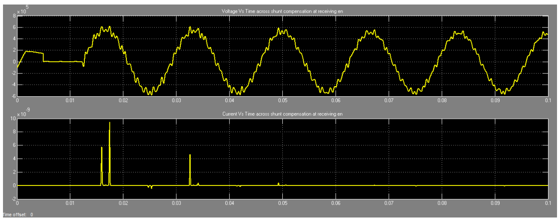

Fig19 Voltage Vs Time and Current Vs Time waveform of the shunt reactor at the receivingend of transmission line,switching overvoltage by using arrestor

4. RESULTS

From all these comparisons we concluded that in case of arrestor models as long as the voltage develops across the compensated devices is above the protective level then all the current is flowing into the MOV. The flow of current is null through compensated devices when the voltage passes below the protective level because the MOV offers a high resistance. But in the absence of arrester model all the high voltage and current will passes through the compensated device which will either turn off the system or damage the whole compensated system because the compensated devices allow the high voltage and current to pass through them as a low resistive path to flow.

5. CONCLUSION

We have also analyses the system by using lightning overvoltage occur in the system. For production of lightning we use a transfer impulse function as impulse generator which induces a large voltage across the transmission just like the occurrences of lightning in the nature. All the simulation is done by inducing lightning on different point on the transmission line and then comparison is made, then considering the results by using arrestor model and without using arrestor model. In the last we conclude that it is preferable to use arrestor across the line to protect the compensated devices across the system because the arrestor protective device operates immediately in order to remove the heavy overvoltage to pass through the compensated devices.

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