# HVDC Dynamic Modeling Using A 9-Bus System

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## Abstract

A direct current (DC) system that operates at high voltage uses are more efficient than an ac system. HVDC allows for easy transfer of power between grids that are operating at different frequencies and that are long distances apart. The intent of this research is to do studies on these HVDC lines and to determine if they improve dynamic performance. In attempting to do so, tools such as PSS/E and a MATLAB based tool, PSAT, will be used to construct a multi-terminal HVDC model on an IEEE 9-bus system. While studying this system, a comparison will be done to see whether using HVDC lines will allow the system to stabilize quicker, as opposed to the lines in the original system. Figure 1 shows the system used throughout the course of this research.

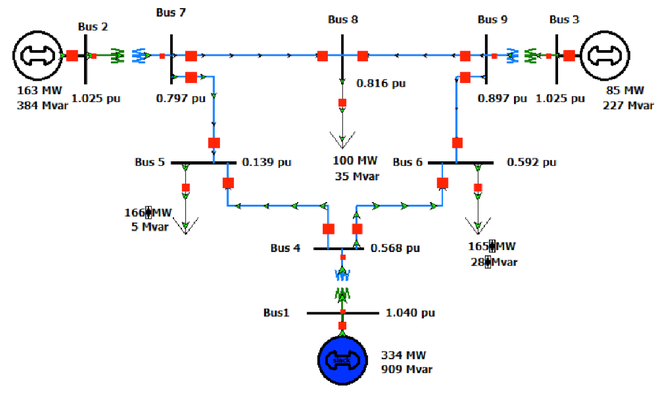



Figure 1: IEEE 9-Bus System

## Method

To study the time domain of the system, PSAT, a MATLAB toolbox was used, figure 2. There were two systems being compared; one without the HVDC lines, figure 3, and one with HVDC lines, figure 4. There were three variables being studied; omega, voltage magnitude of a bus, and theta magnitude of a bus. The data was separated into cases in order to make the comparison process easier. Case one was noted as the simplest case, it studied the time domain of the systems as a fault was applied at bus 1. Case two then added instruments like an exciter or a turbine governor to see if these tools could help speed up the recovery process.

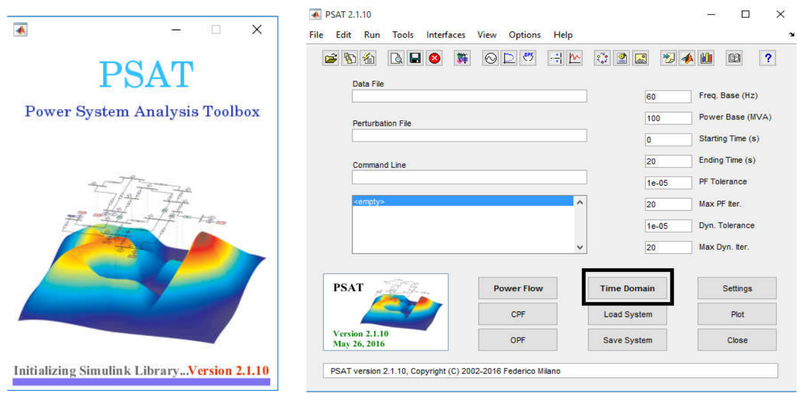



Figure 2: PSAT toolbox

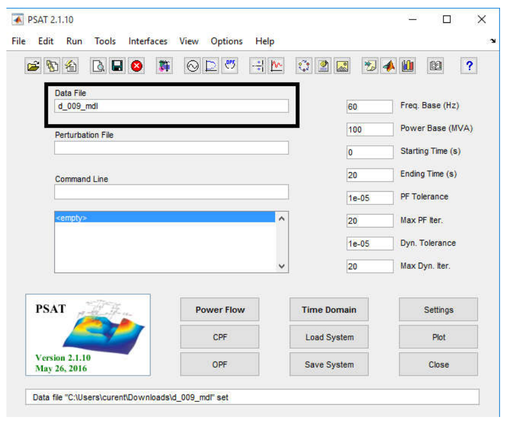



Figure 3: PSAT simulation without HVDC

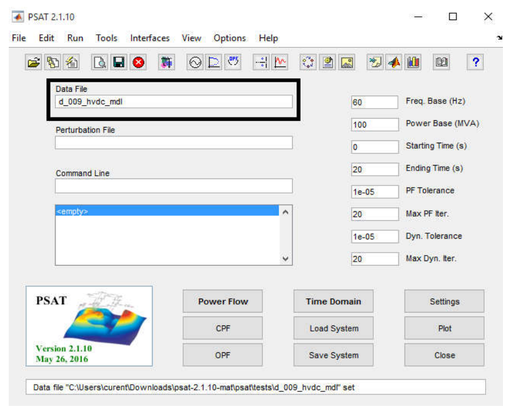


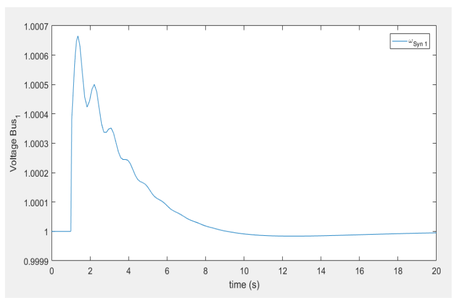

Figure 4: PSAT simulation with HVDC

## Discussion & Results

If the system stabilized quicker with HVDC, then they improve dynamic performance. Figure 5 shows that the system with HVDC stabilized slightly quicker than the non-HVDC system, therefore HVDC lines improve dynamic performance in the case of rotor speed. Figure 6 shows results from two buses. The system with HVDC stabilized quicker than the non-HVDC system, therefore HVDC lines improve dynamic performance in the case of the voltage magnitude on a bus . Figure 7 also shows the result of two buses. The relative angle on the system with HVDC is higher than the relative angle on the system with non-HVDC, therefore HVDC lines improve dynamic performance in the case of relative bus angle.

### Omega Comparison

Non-HVDC




HVDC

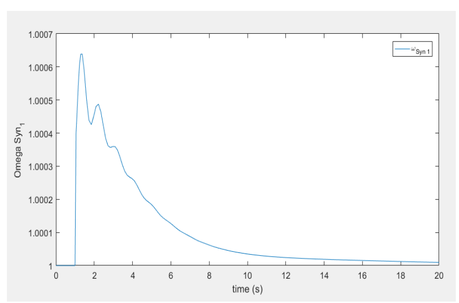
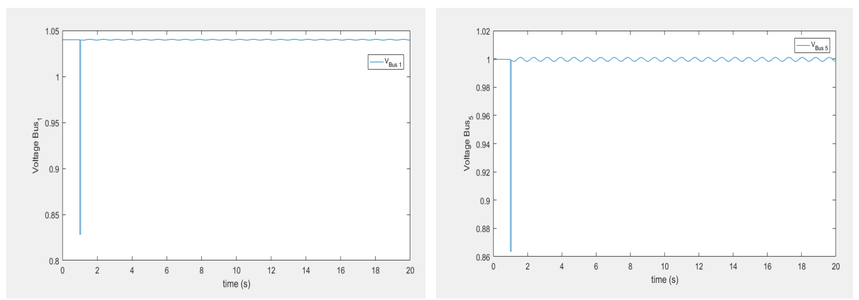



Figure 5

### Voltage magnitude on a bus comparison

Non-HVDC




HVDC

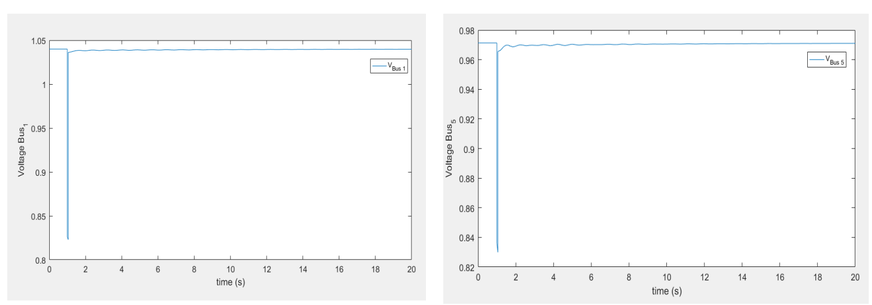
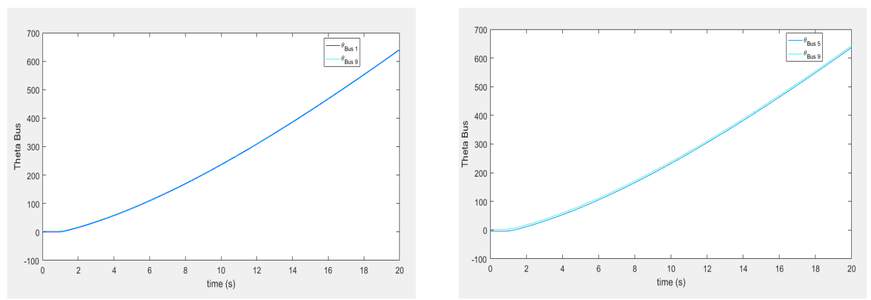



Figure 6

### Relative angle on a bus comparison

Non-HVDC




HVDC

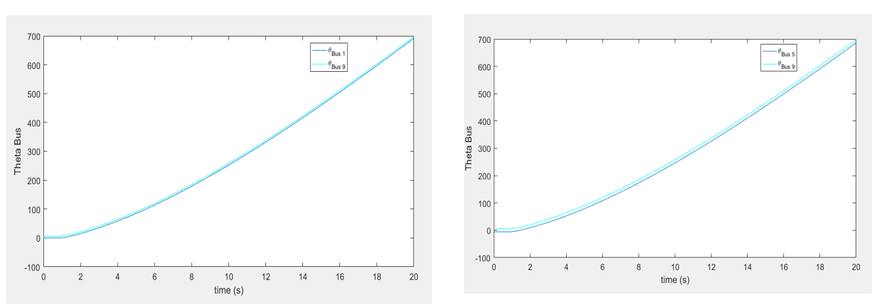



Figure 7

## Conclusion

From this research, it is seen that HVDC lines can improve dynamic performance. In the examples shown in this poster, it is seen that the systems with HVDC stabilize quicker than the systems without HVDC lines. Even though the time difference is very small, this research still shows the improvement of dynamic performance with HVDC lines. Doing this study on larger systems in the future would be the next step in continuing this research.