Optimal Distributed Voltage Control via Primal Dual Gradient Dynamics

Mohammed N. Khamees[1], Kai Sun[1], Yang Liu [1]
[1] The University of Tennessee, Knoxville

INTRODUCTION

- The increasing penetration of inverter-based resources into a power transmission network requires more sophisticated voltage control strategies considering their inherent output variabilities.
- Faults and load variations affect the voltage profile over the power network.
- A Primal Dual Gradient Dynamics based optimal distributed voltage control approach that optimizes outputs of distributed reactive power sources to maintain an acceptable voltage profile while preserving operational limits is proposed.

OBJECTIVES

- To minimize the operational cost.
- To keep voltages in acceptable ranges.
- To satisfy reactive power limits.

Assumptions:

$$\begin{pmatrix} \frac{\partial P}{\partial \delta} & \frac{\partial P}{\partial V} \\ \frac{\partial P}{\partial \delta} & \frac{\partial Q}{\partial V} \end{pmatrix} \begin{pmatrix} \Delta\delta \\ \Delta V \end{pmatrix} = \begin{pmatrix} \Delta P \\ \Delta Q \end{pmatrix} \rightarrow \begin{pmatrix} -B & G \\ -G & -B \end{pmatrix} \begin{pmatrix} \Delta\delta \\ \Delta V \end{pmatrix} = \begin{pmatrix} \Delta P \\ \Delta Q \end{pmatrix}$$

SIMULATION RESULTS

- We assume that reactive power sources are available at all load buses and can supply or consume a specified amount of reactive power.
- We considered varying and static load on both IEEE 14 and 30 bus systems .
- We run the controller assuming a ground fault on the transmission line, Fig.2.

$\|v_1\|$	$\|v_2\|$	$\|v_3\|$	$\|v_4\|$	$\|v_5\|$	$\|v_6\|$	$\|v_7\|$
1.0600	1.0450	1.0100	0.9382	0.9393	1.0700	0.9806
$\|v_8\|$	$\|v_9\|$	$\|v_{10}\|$	$\|v_{11}\|$	$\|v_{12}\|$	$\|v_{13}\|$	$\|v_{14}\|$
1.0900	0.9362	0.9348	.9899	1.0167	0.9927	0.8970

Table. I. IEEE 14-bus voltage profiles without controller (Static load).

$\|v_1\|$	$\|v_2\|$	$\|v_3\|$	$\|v_4\|$	$\|v_5\|$	$\|v_6\|$	$\|v_7\|$
1.0600	1.0450	1.0100	0.9500	0.9500	1.0700	1.0131
$\|v_8\|$	$\|v_9\|$	$\|v_{10}\|$	$\|v_{11}\|$	$\|v_{12}\|$	$\|v_{13}\|$	$\|v_{14}\|$
1.0900	0.9848	0.9851	1.0209	1.0500	1.0125	0.9500

Table. I. IEEE 14-bus voltage profiles with controller (Static load).

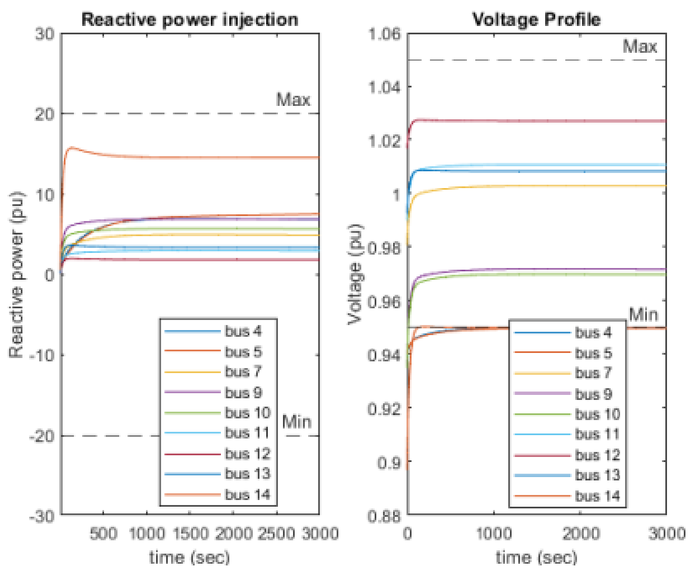

Fig. 1. IEEE 14-bus system simulation results (Static load).

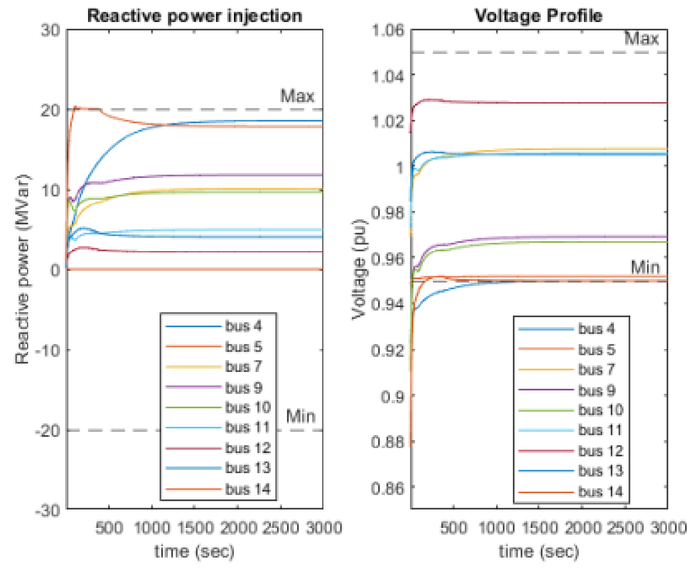

Fig. 2. IEEE 14-bus system simulation results (transmission line 4-5 tripped).

SIMULATION RESULTS

- Varying load at all load buses.

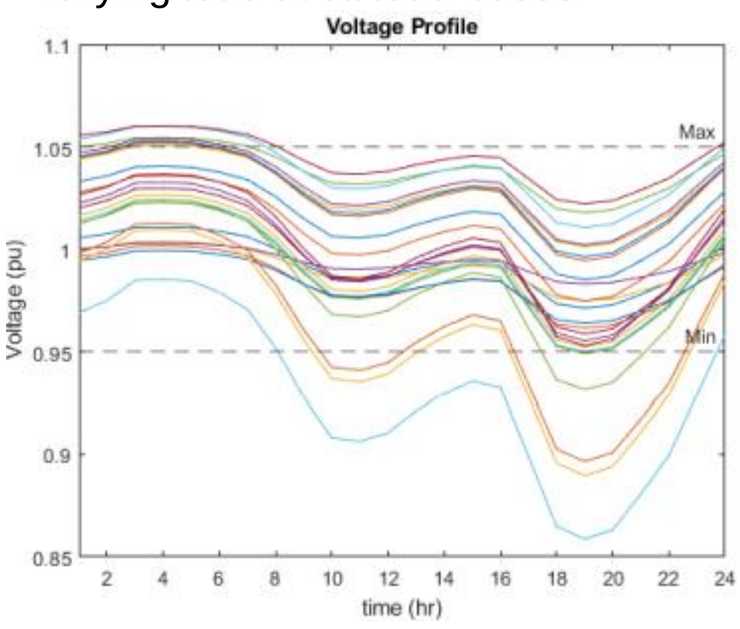

Fig. 3. IEEE 30-bus voltage profile without controller.

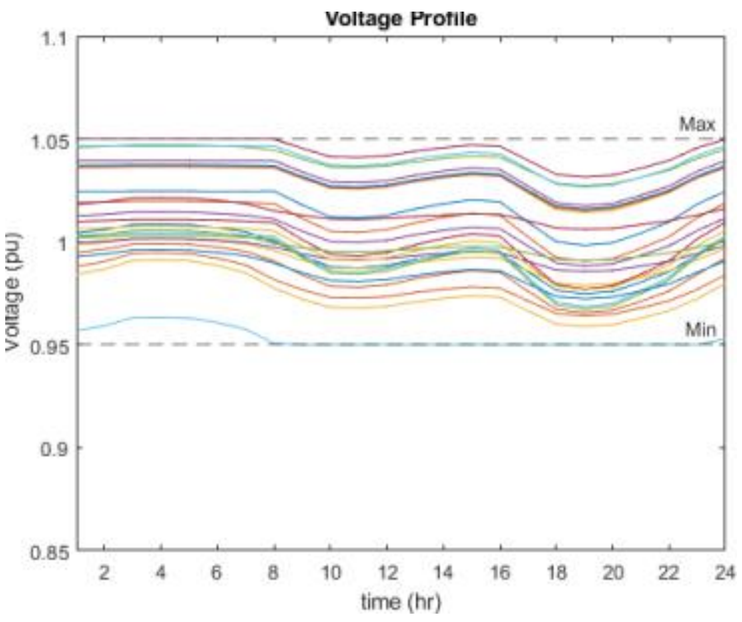

Fig. 4. IEEE 30-bus voltage profile with controller.

Fig. 5. IEEE 30-bus Reactive power injection.

CONCLUSION

- Optimal distributed feedback voltage controller was proposed.
- The performance was tested on two IEEE bus systems under static load and time varying load with time span of one day and 1 hour resolution.
- The controller managed to achieve the three Objectives simultaneously.

FUTURE WORK

- To include real power control scheme.