Homework #8

(100 points) As shown in the figure, a radial system has E_S=1.0pu and $Z_{LN}\angle\theta$=j0.5pu. Respectively consider constant lagging and leading power factors equal to 0.95. Answer the following questions:

a. Draw the P_R-V_R curve at bus R. What are the values of P_R and V_R at the critical point?
b. Assume the active load at bus R to be a ZIP load with P_R=P_0(V_R^2+V_R+5.0), where P_0 varies with the load level. Estimate the minimum value of V_R before voltage collapse and the value of P_R at that point.
c. Inject additional reactive power Q_I to bus R. For P_R=0.5pu, draw the V_R-Q_I curve with various values of Q_I and estimate the values of Q_I and V_R at the critical point.
d. According to the V_R-Q_I curve from c, determine voltage stability for condition P_R=0.5 and Q_I= −0.4. Verify it using the reduced Q-V Jacobian matrix $\boldsymbol{J_R}$ (refer to Kundur's Example 14.3).
e. Now, replace the constant voltage source by a generator whose AVR regulates E_S=1.0 pu within its reactive power limits. When the load increases to P_R=0.5 pu with a lagging power factor of 0.95, the generator reaches its reactive power limit and becomes a constant internal voltage E_q behind reactance X_s=j0.4pu. Please redraw the P-V curve together with the old P-V curve, and find the new values of P_R and V_R at the critical point. Calculate the change of the following Voltage Stability Margin at P_R=0.5 pu from the old P-V curve to the new P-V curve when the limit is reached.

   Voltage Stability Margin = (V_R – $V_{\text{critical point}}$)/$V_R$ × 100%.

   (Hint: the value of E_q at the limit makes the old and new P-V curves intersect at P_R=0.5 pu.)