Problem 1:

The Available Transfer Capability (ATC) is defined as the transmission limit for reserving and scheduling energy transactions in competitive electricity markets. ATC of a transmission system is a measure of unutilized capability of the transmission system at a given time. ATC depends on system generation dispatch and system load level, power transfers between areas, network topology, and the limits imposed on the transmission network due to thermal, voltage and stability constraints.

For the 5-Bus system below, use the PSAT power flow to find the First Contingency Incremental Transfer Capabilities (FCITCs) (1) from zone A to B, and (2) from zone B to zone A. The transmission line constraints reflect the thermal ratings of the lines. *The list of first contingencies for N-1 security assessment is the set of all single-line outages.* Note that the system data can be found in PS 4 except that the line flow limits have been modified as shown below.

Consider the power system in Figure E10.8. Assume that the series line impedances are $z_L = r_L + jx_L = 0.0099 + j0.099 = 0.0995 \angle 84.2894^\circ$. Neglect the capacitive (shunt) impedances.

(a) Verify that a solution of the power flow equations is given by

\[
\begin{bmatrix}
\theta_2 \\
\theta_3 \\
\theta_4
\end{bmatrix} = \begin{bmatrix}
-5^\circ \\
-10^\circ \\
-15^\circ
\end{bmatrix}
\]

\[
|V| = \begin{bmatrix} V_A \\ V_B \end{bmatrix} = \begin{bmatrix} 1.0 \\ 1.0 \end{bmatrix}
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Problem 2:

A 4-bus power system is shown below.

<table>
<thead>
<tr>
<th></th>
<th>Line Flow Limit (p.u.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P_{12}</td>
<td>± 3.0</td>
</tr>
<tr>
<td>P_{23}</td>
<td>± 2.0</td>
</tr>
<tr>
<td>P_{35}</td>
<td>± 2.0</td>
</tr>
<tr>
<td>P_{54}</td>
<td>± 2.0</td>
</tr>
<tr>
<td>P_{41}</td>
<td>± 3.0</td>
</tr>
<tr>
<td>P_{42}</td>
<td>± 3.0</td>
</tr>
</tbody>
</table>

All impedances equal to \( Z = 0.2 \) pu

Line flow constraint in terms of angle difference for all lines \( ± 10^\circ \)

Use the DC load flow model. Plot the complete steady state security region in the *angle* space as well as the *injection* space. (Note that the complete steady state security region is a 3-dimensional “polytope” so you may want to use Matlab to plot it.)