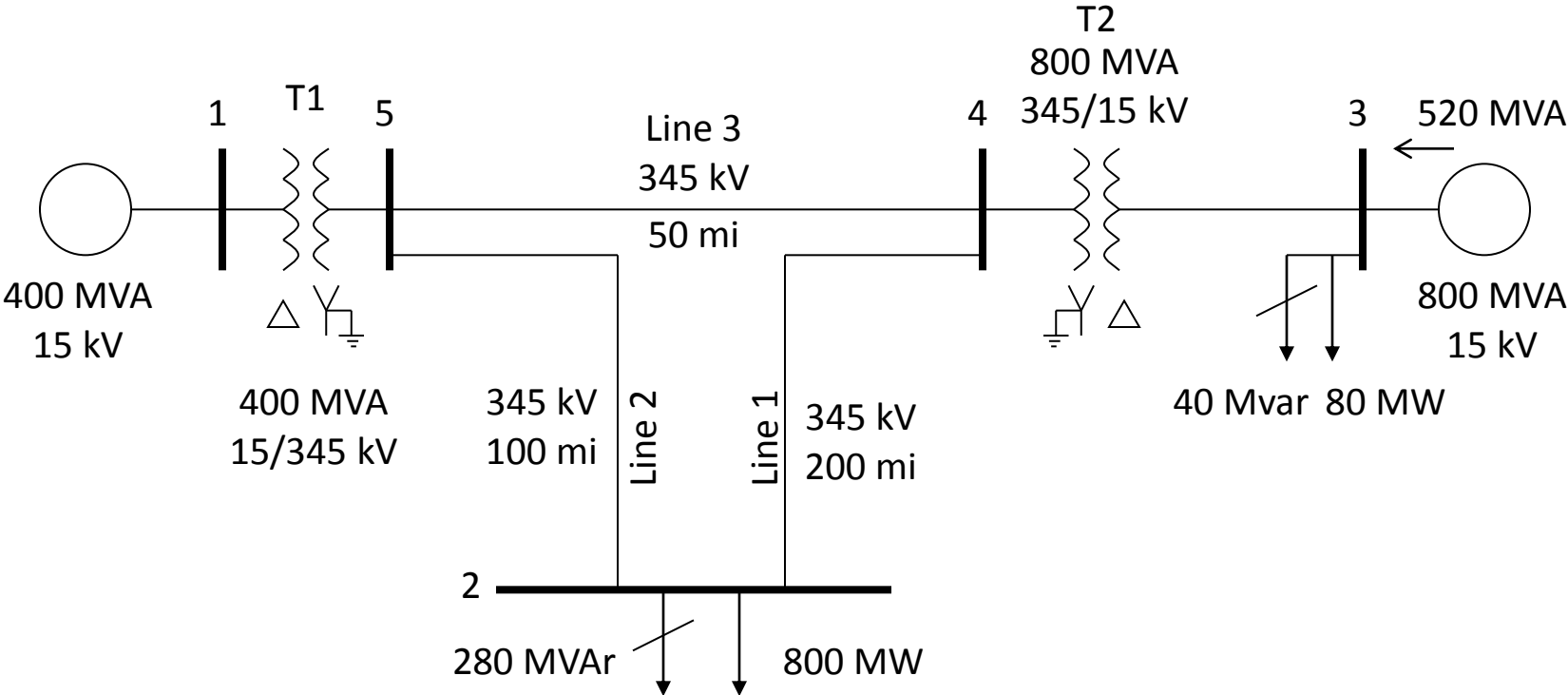


# Lecture 1

# The N-R Power Flow: 5-bus Example



Single-line diagram

# The N-R Power Flow: 5-bus Example

Table 1.  
Bus input data

Bus	Type	V  per unit	$\theta$ degrees	$P_G$ per unit	$Q_G$ per unit	$P_L$ per unit	$Q_L$ per unit	$Q_{Gmax}$ per unit	$Q_{Gmin}$ per unit
1	Slack	1.0	0	—	—	0	0	—	—
2	Load	—	—	0	0	8.0	2.8	—	—
3	Constant voltage	1.05	—	5.2	—	0.8	0.4	4.0	-2.8
4	Load	—	—	0	0	0	0	—	—
5	Load	—	—	0	0	0	0	—	—

Table 2.  
Line input data

Bus-to-Bus	R per unit	X per unit	G per unit	B per unit	Maximum MVA per unit
2-4	0.0090	0.100	0	1.72	12.0
2-5	0.0045	0.050	0	0.88	12.0
4-5	0.00225	0.025	0	0.44	12.0

# The N-R Power Flow: 5-bus Example

Table 3.  
Transformer  
input data

Bus-to-Bus	R per unit	X per unit	$G_c$ per unit	$B_m$ per unit	Maximum MVA per unit	Maximum TAP Setting per unit
1-5	0.00150	0.02	0	0	6.0	—
3-4	0.00075	0.01	0	0	10.0	—

Table 4. Input data  
and unknowns

Bus	Input Data	Unknowns
1	$ V_1  = 1.0, \theta_1 = 0$	$P_1, Q_1$
2	$P_2 = P_{G2} - P_{L2} = -8$ $Q_2 = Q_{G2} - Q_{L2} = -2.8$	$ V_2 , \theta_2$
3	$ V_3  = 1.05$ $P_3 = P_{G3} - P_{L3} = 4.4$	$Q_3, \theta_3$
4	$P_4 = 0, Q_4 = 0$	$ V_4 , \theta_4$
5	$P_5 = 0, Q_5 = 0$	$ V_5 , \theta_5$

# Let the Computer Do the Calculations! (Ybus Shown)

Case: Example6\_9.pwb Status: Initialized | Simulator 13

Case Information Draw Onelines Tools Options Add\_Ons Window

Edit Mode Run Mode Mode

Switch to Free-Floating Windows Arrange Windows

Refresh Displays Ribbon Settings Window

Toggle Full Screen

Contents About... PowerWorld Website Check for Updates Help

Set Help File... Load Auxiliary Auxiliary File Format Export Case Object Fields... Export Display Object Fields... Load Display File... Export Case Object Fields... Export Display Object Fields... Auxiliary Files

el Explorer: YBus

Y Bus (Bus Admittance Matrix)

	Number	Name	Bus 1	Bus 2	Bus 3	Bus 4	Bus 5
1	1	One	$3.73 - j49.72$				$-3.73 + j49.72$
2	2	Two		$2.68 - j28.46$		$-0.89 + j9.92$	$-1.79 + j19.84$
3	3	Three			$7.46 - j99.44$	$-7.46 + j99.44$	
4	4	Four		$-0.89 + j9.92$	$-7.46 + j99.44$	$11.92 - j147.96$	$-3.57 + j39.68$
5	5	Five	$-3.73 + j49.72$	$-1.79 + j19.84$		$-3.57 + j39.68$	$9.09 - j108.58$

Search Search Now Options

1.000 pu Two

Run Mode Solution Animation Stopped AC Viewing Current Case

# Ybus Details

Elements of  $Y_{\text{bus}}$  connected to bus 2

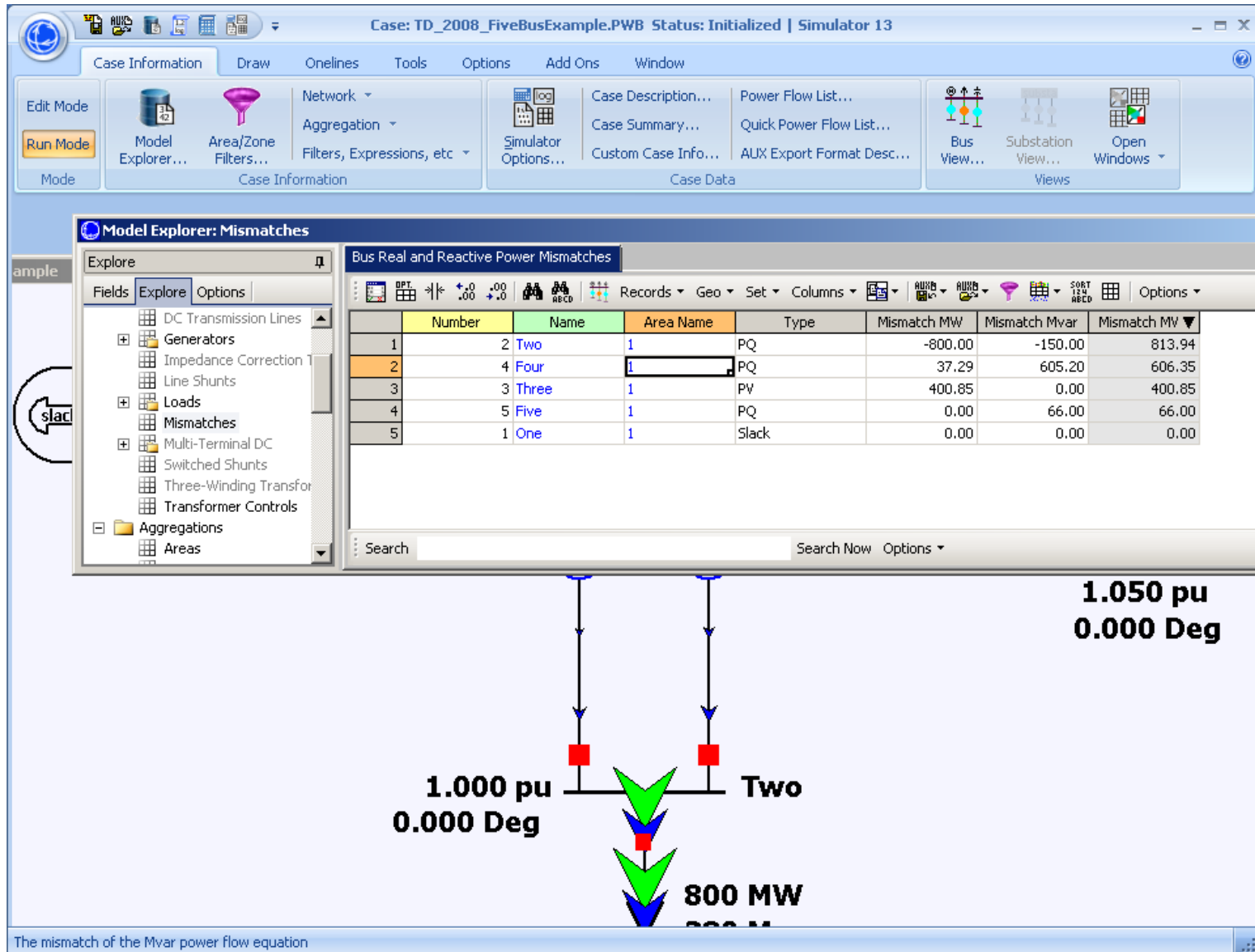
$$Y_{21} = Y_{23} = 0$$

$$Y_{24} = \frac{-1}{R_{24} + jX_{24}} = \frac{-1}{0.009 + j0.1} = -0.89276 + j9.91964 \text{ per unit}$$

$$Y_{25} = \frac{-1}{R_{25} + jX_{25}} = \frac{-1}{0.0045 + j0.05} = -1.78552 + j19.83932 \text{ per unit}$$

$$\begin{aligned} Y_{22} &= \frac{1}{R_{24} + jX_{24}} + \frac{1}{R_{25} + jX_{25}} + j\frac{B_{24}}{2} + j\frac{B_{25}}{2} \\ &= (0.89276 - j9.91964) + (1.78552 - j19.83932) + j\frac{1.72}{2} + j\frac{0.88}{2} \\ &= 2.67828 - j28.4590 = 28.5847 \angle -84.624^\circ \text{ per unit} \end{aligned}$$

# Here are the Initial Bus Mismatches



# And the Initial Power Flow Jacobian

The screenshot displays the 'Model Explorer: Power Flow Jacobian' window. The main area shows a table with 8 rows and 10 columns. The columns are: Number, Name, Jacobian Equation, Angle Bus 2, Angle Bus 3, Angle Bus 4, Angle Bus 5, Volt Mag Bus 2, and Volt Mag Bus 3. The rows represent different power flow equations for various buses.

Number	Name	Jacobian Equation	Angle Bus 2	Angle Bus 3	Angle Bus 4	Angle Bus 5	Volt Mag Bus 2	Volt Mag Bus 3
1	2 Two	Real Power	29.76		-9.92	-19.84	2.68	
2	3 Three	Real Power		99.44	-99.44			
3	4 Four	Real Power	-9.92	-99.44	149.04	-39.68		
4	5 Five	Real Power	-19.84		-39.68	109.24	-1.79	
5	2 Two	Reactive power	-2.68		0.89	1.79	27.16	
6	3 Three	Voltage Magnitude						
7	4 Four	Reactive power	0.89	7.46	-11.92	3.57	-9.92	
8	5 Five	Reactive power	1.79		3.57	-9.09	-19.84	

At the bottom of the window, a partial diagram is visible, showing two red squares representing buses with blue arrows pointing downwards, indicating power injection or load.



# Five Bus Power System Solved

