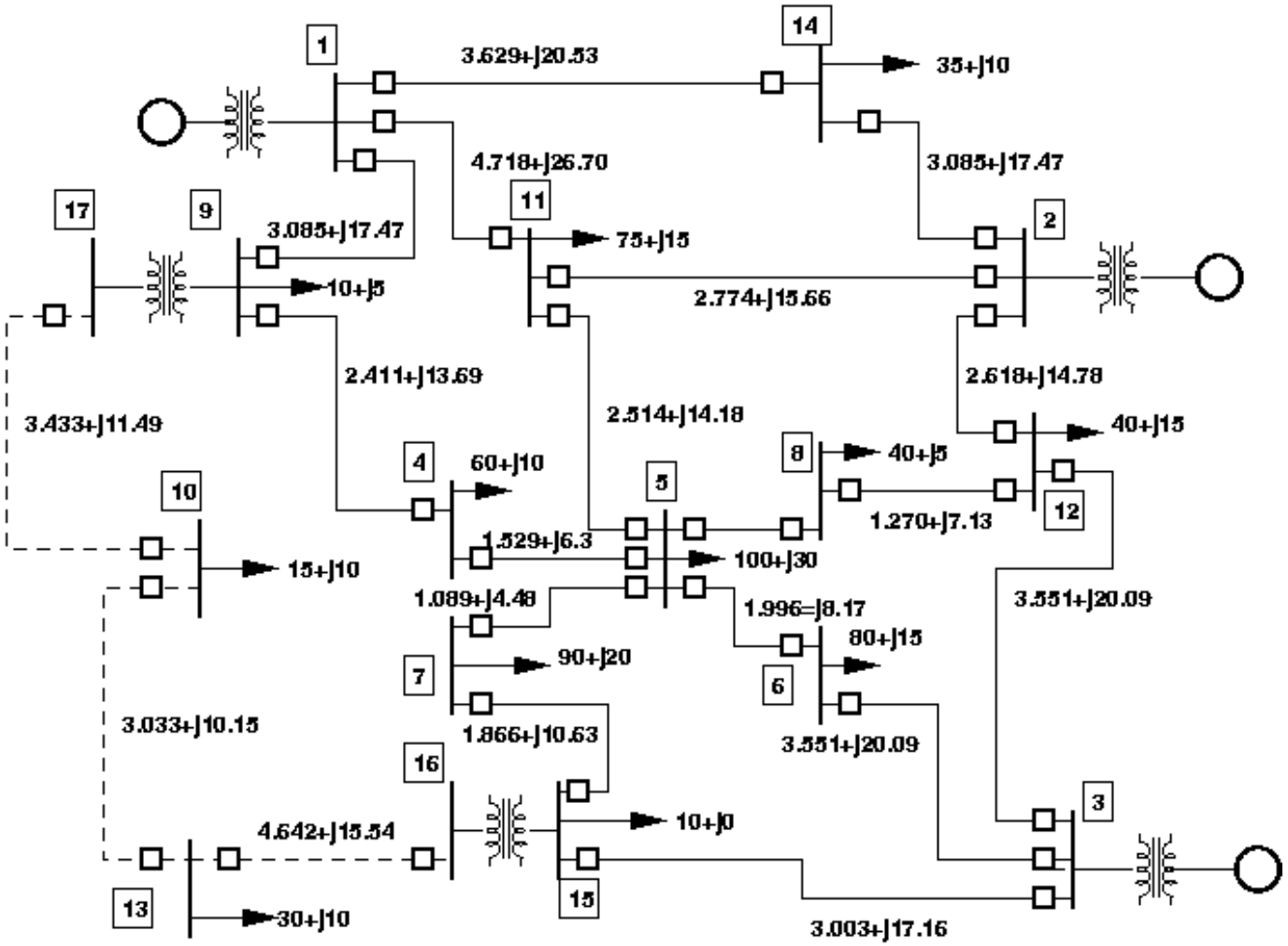
6.691, Spring 2006

Plans and Directions

As of Feb 21, 2006

Here is a small power system



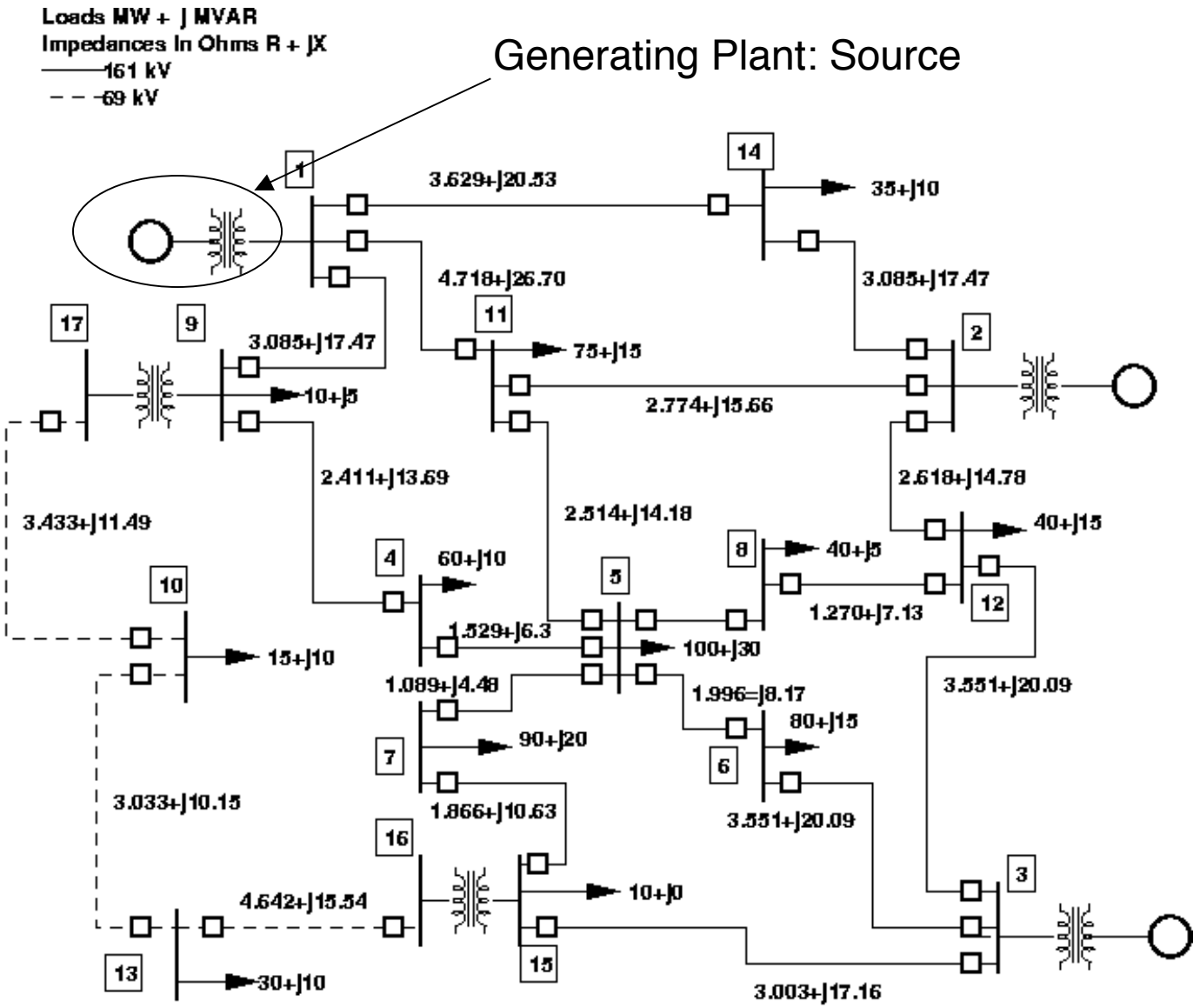
To see what is up we need to understand the parts:

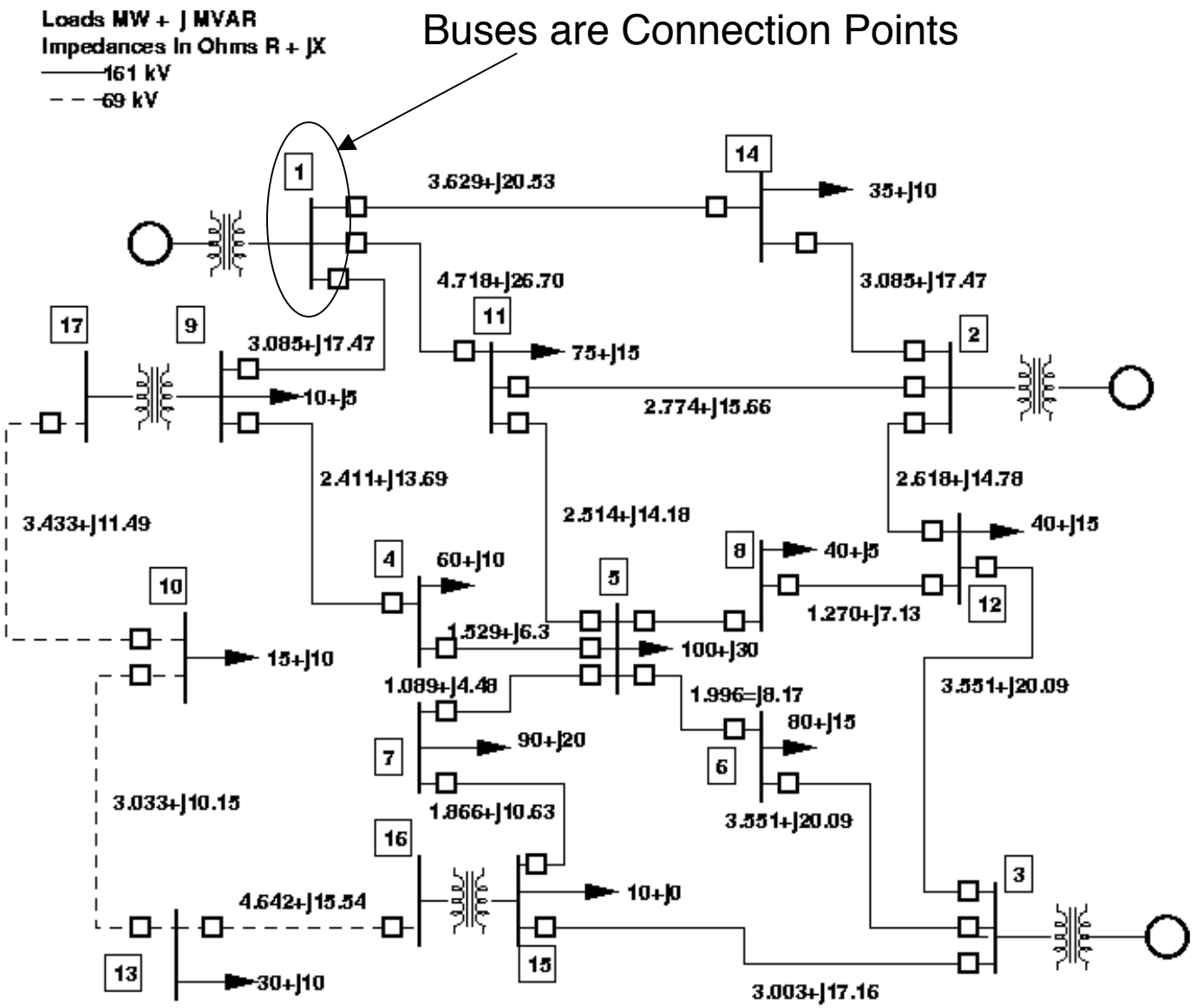
Generating Plants

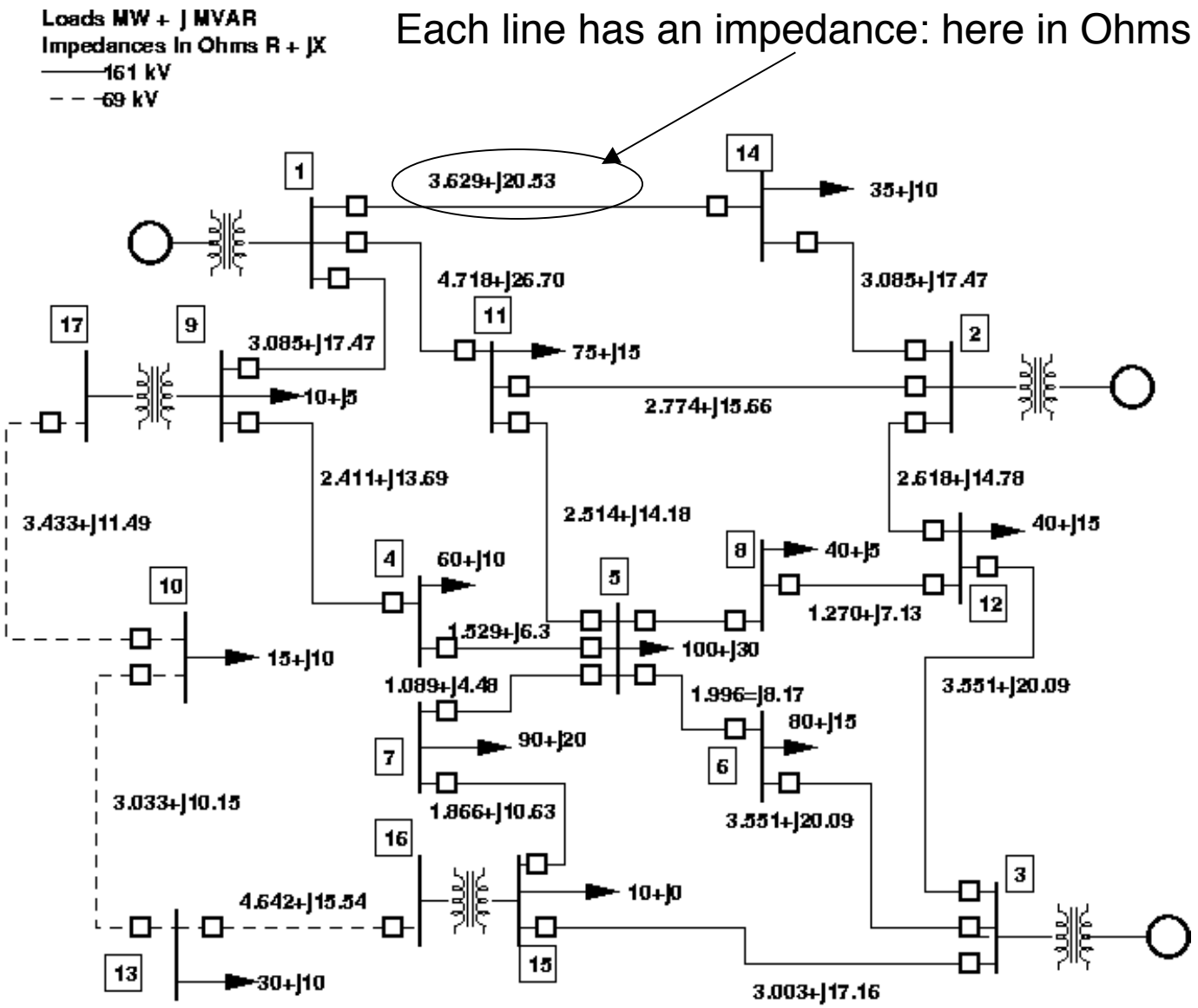
Are Connected to buses (numbered)

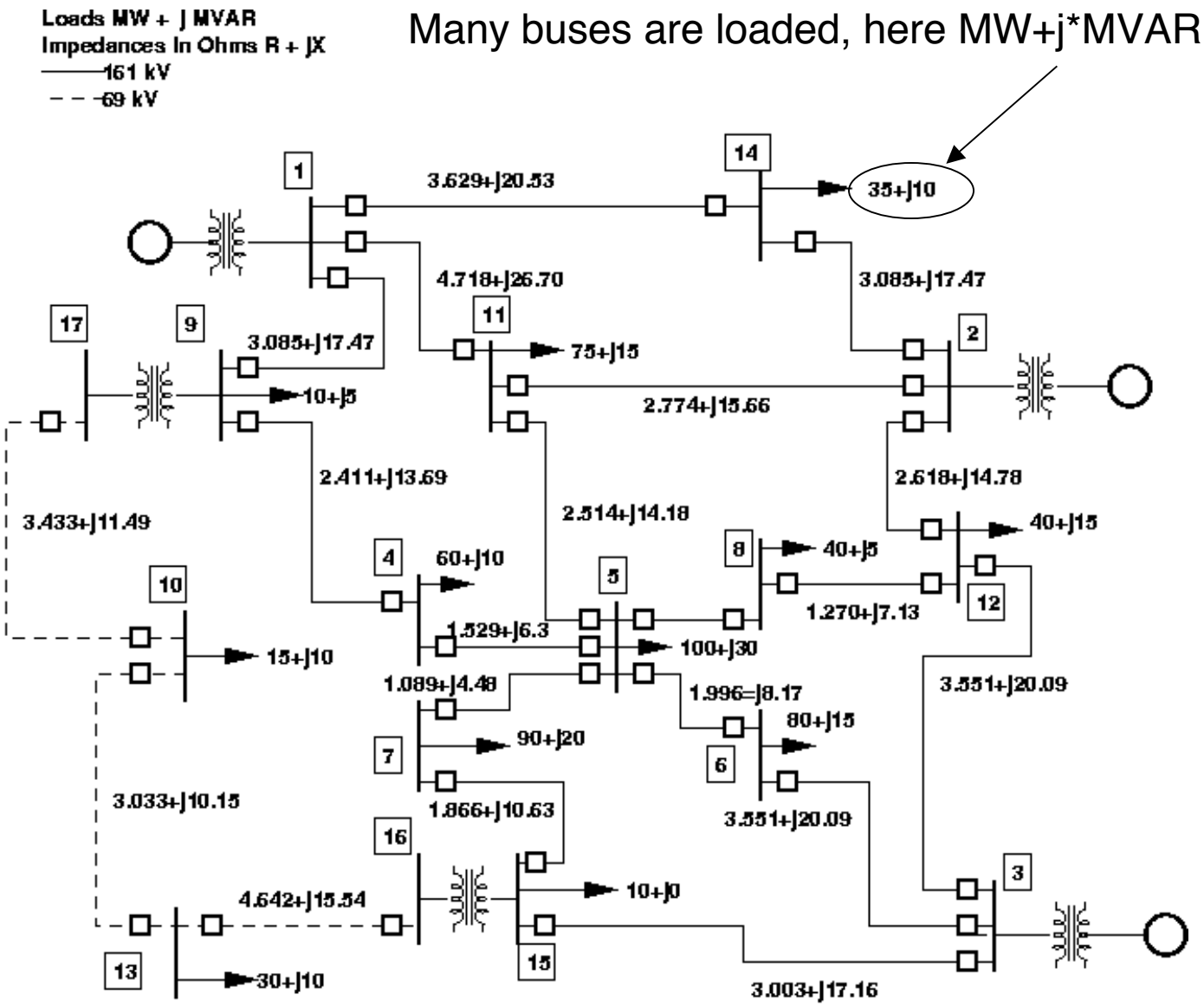
Lines Connect the buses (impedances noted in ohms)

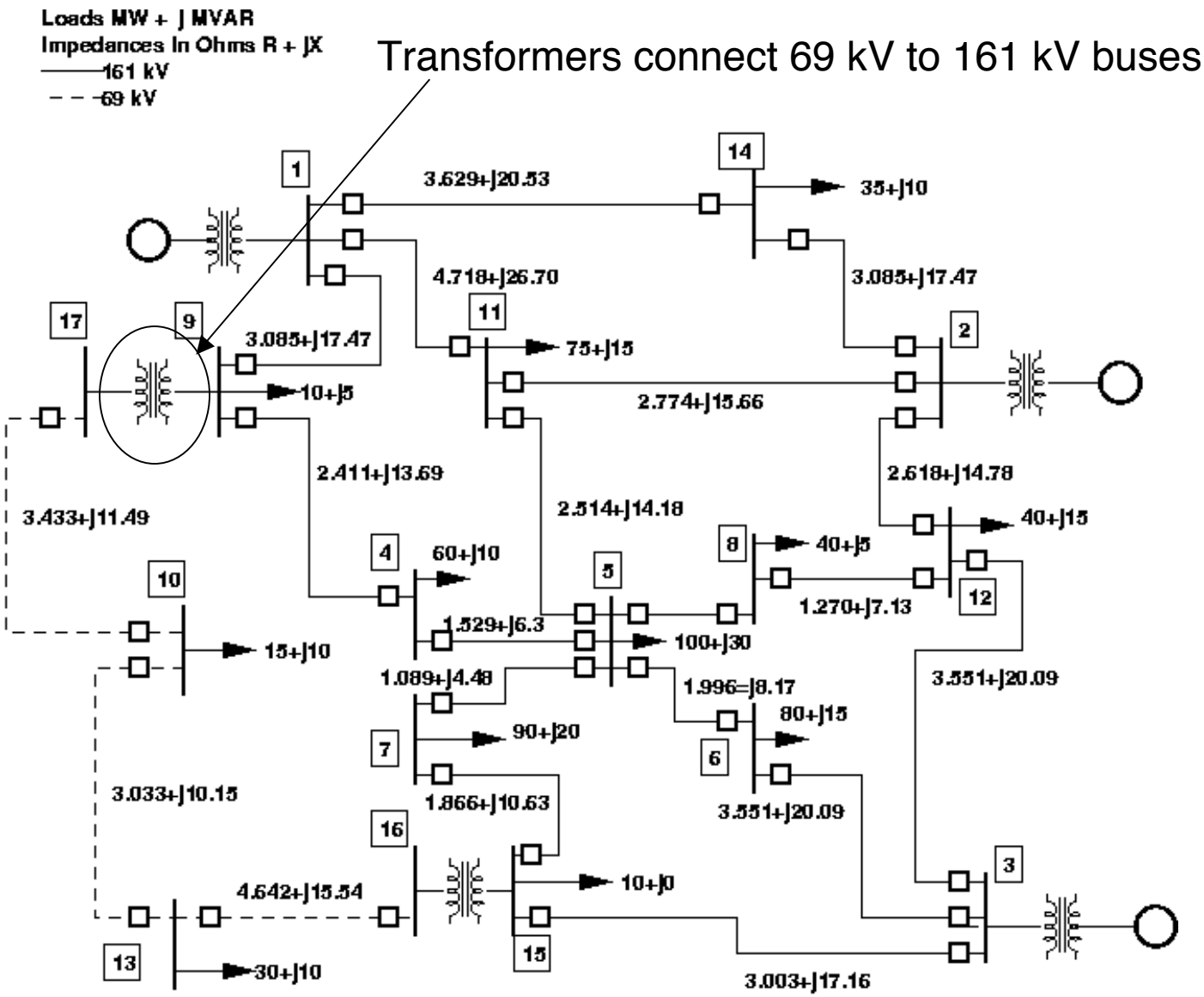
Loads are noted at each loaded bus


Loads MW + J MVAR
Impedances In Ohms R + JX
161 kV
69 kV
Generating Plant: Source
1
14
3.629+J20.53
35+J10
4.718+J26.70
3.085+J17.47
17
9
11
2
3.085+J17.47
75+J15
10+J5
2.774+J15.66
2.411+J13.69
2.618+J14.78
3.433+J11.49
2.514+J14.18
40+J15
4
60+J10
8
40+J5
10
5
1.270+J7.13
12
1.529+J6.3
100+J30
15+J10
1.089+J4.48
1.996=J8.17
3.551+J20.09
80+J15
7
90+J20
6
3.033+J10.15
1.866+J10.63
3.551+J20.09
16
3
10+J0
4.642+J15.54
15
13
30+J10
3.003+J17.16


Loads MW + J MVAR
Impedances In Ohms R + jX
161 kV
69 kV
Buses are Connection Points
1
14
3.629+j20.53
35+j10
4.718+j26.70
3.085+j17.47
17
9
11
2
3.085+j17.47
75+j15
10+j5
2.774+j15.66
2.411+j13.69
2.618+j14.78
3.433+j11.49
2.514+j14.18
40+j15
4
60+j10
8
40+j5
10
5
12
1.270+j7.13
1.529+j6.3
100+j30
15+j10
1.089+j4.48
1.996=j8.17
3.551+j20.09
80+j15
7
90+j20
6
3.033+j10.15
1.866+j10.63
3.551+j20.09
16
3
4.642+j15.54
10+j0
15
13
30+j10
3.003+j17.16


Loads MW + J MVAR
Impedances In Ohms R + jX
161 kV
69 kV
Each line has an impedance: here in Ohms
1
14
3.629+j20.53
35+j10
4.718+j26.70
3.085+j17.47
17
9
11
2
3.085+j17.47
75+j15
10+j5
2.774+j15.66
2.411+j13.69
2.514+j14.18
2.618+j14.78
3.433+j11.49
40+j15
4
60+j10
8
40+j5
5
10
1.270+j7.13
12
1.529+j6.3
100+j30
15+j10
1.089+j4.48
1.996=j8.17
3.551+j20.09
80+j15
7
90+j20
6
3.033+j10.15
1.866+j10.63
3.551+j20.09
16
3
10+j0
4.642+j15.54
13
15
30+j10
3.003+j17.16


Loads MW + J MVAR
Impedances In Ohms R + jX
161 kV
69 kV
Many buses are loaded, here MW+j*MVAR
1
14
35+j10
3.629+j20.53
4.718+j26.70
3.085+j17.47
17
9
11
2
3.085+j17.47
75+j15
10+j5
2.774+j15.66
2.411+j13.69
2.618+j14.78
3.433+j11.49
2.514+j14.18
40+j15
4
60+j10
8
40+j5
5
10
1.270+j7.13
12
1.529+j6.3
100+j30
15+j10
1.089+j4.48
1.996=j8.17
3.551+j20.09
80+j15
7
90+j20
6
3.033+j10.15
1.866+j10.63
3.551+j20.09
16
3
10+j0
4.642+j15.54
15
13
30+j10
3.003+j17.16


Loads MW + J MVAR
Impedances In Ohms R + JX
161 kV
69 kV
Transformers connect 69 kV to 161 kV buses
1
14
3.629+J20.53
35+J10
4.718+J26.70
3.085+J17.47
17
9
11
2
3.085+J17.47
75+J15
10+J5
2.774+J15.66
2.411+J13.69
2.514+J14.18
2.618+J14.78
3.433+J11.49
40+J15
4
60+J10
8
40+J5
5
10
1.270+J7.13
12
1.529+J6.3
100+J30
15+J10
1.089+J4.48
1.996=J8.17
3.551+J20.09
80+J15
7
90+J20
6
3.033+J10.15
1.866+J10.63
3.551+J20.09
16
3
10+J0
4.642+J15.54
15
13
30+J10
3.003+J17.16

To understand how the system works:

1. **Load Flow -- how does power flow through the lines**

   System Representation: Lines, Transformers,

   and Per-unit Systems (Chs 4, 5, 9)

   Load Flow Analysis (Ch 10)

2. **What do generators do?**

   Generator representation (Ch6, 7)

   Dynamics: fault behavior, dynamic swings

   Simplified models (voltage behind reactance

3. **What do exciters and voltage regulators do?**

   They have dynamics of their own. (Ch 8)

4. System Control: generation control

How frequency is stabilized (Ch 11)

Transient stability: limits to operations (Ch 14)

This involves all those models from above

5. Abnormal operations

Unbalanced Operation

Symmetrical Components (Ch 12)

Faults: detection and system protection (Ch 13)

6. Power Systems Economics

Cost of Service: Economic Dispatch (Ch 11)

Deregulated System Economics

Structure of some ‘markets’

Project Topics: (Suggestions-- I am open to negotiation)

- **Regulatory Lag: how often should rate cases be?**
- **Carbon Tax and Nukes: can it be made to work?**
- **DC vs. AC in vehicular systems: tradeoffs and performance**
- **Market Power and Congestion**
- **What are ancillary services worth?**
- **Is there a case for deregulating transmission?**
- **'Net Metering' and Standby power -- how do we pay for it?**
- **Robust Utilities vs. Standby Generators: which is best?**
- **Analysis of the blackout of … (you pick a blackout)**
- **How to (and should we) subsidize green electrons?**