

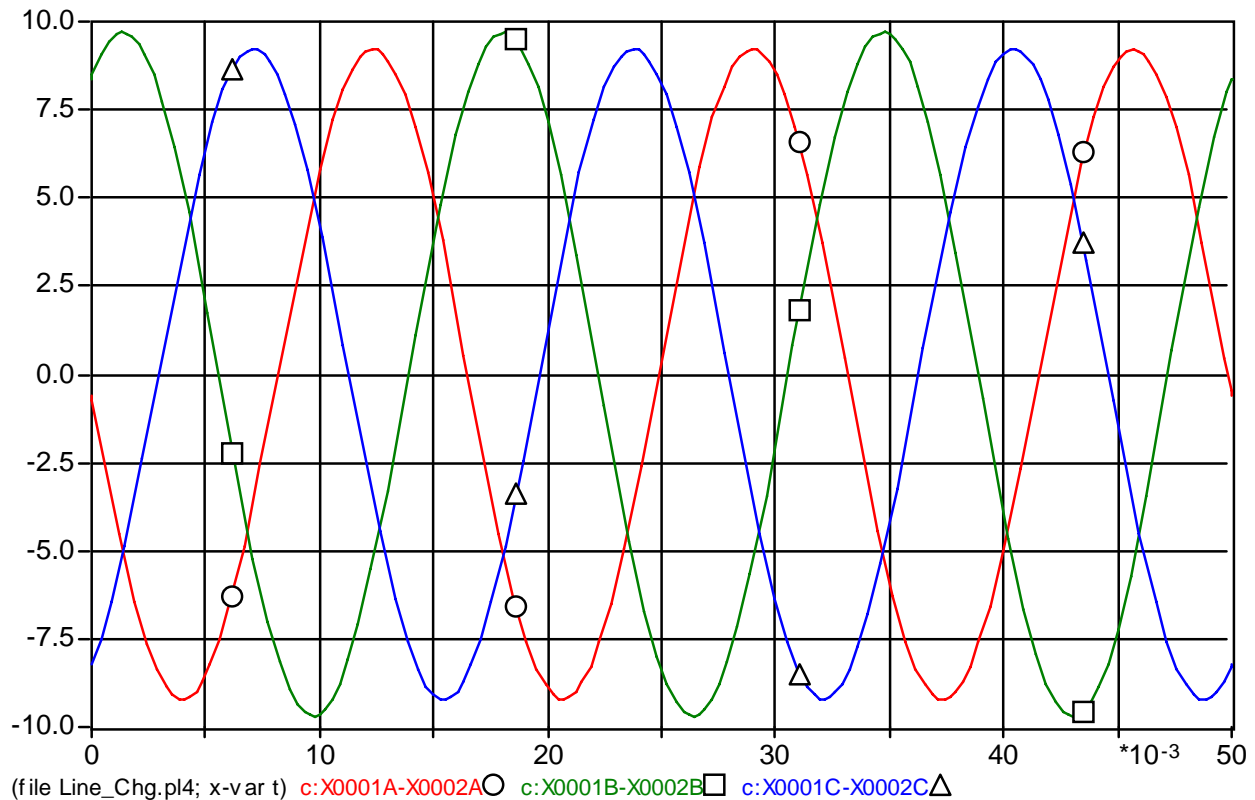
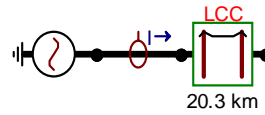
### Topics for Today:

- Course Info:
  - Web page: <https://pages.mtu.edu/~bamork/ee5220/index.htm>
  - Book, references, syllabus, more are on web page.
  - Software - Matlab. ATP/EMTP [ License - [www.emtp.org](http://www.emtp.org) ] ATP tutorials posted on our course web page
  - [EE5220-L@mtu.edu](mailto:EE5220-L@mtu.edu) (participation = min of half letter grade)
- HW#6 - due Tues Mar 5<sup>th</sup>
- Term Project milestone 2: reference list and table of contents (outline) of project work by Tues after spring break.
- Use of ATPDraw's Line Constants to obtain parameters, build line models.
  - Transposition issues
  - Double Circuit lines
  - Conductor Sag, NESC guidelines for minimum clearance
  - Weather-affected changes in parameters
- Use of Line Constants .lis output file to obtain detailed matrices, line parameters, propagation constants.
  - Obtaining the .lis file
  - Interpreting the matrices
    - Phase matrices
    - Sequence matrices



Line Charging Example: LCC\_3b.alc (Coupled-PI, 60 Hz model).

Simulation file: Line\_Chg.acp



As predicted, phase B line current is larger than A or C, due to larger capacitive coupling to phase B. Larger capacitive effect  $\Rightarrow$  smaller input impedance  $\Rightarrow$  higher current...

See Line Constants output log file, LCC\_3b.lis, on following pages. Be sure to print these with fixed-pitch font so that columnar data is aligned. This file is created in atp\atpdraw\atp\ folder when you "build" the line model (from within Line Constants parameter/dialog box, click on Run ATP).

- 17 cards of disk file read into card cache cells 1 onward.  
 Alternative Transients Program (ATP), Watcom translation. All rights reserved by Can/Am user group of Portland, Oregon, USA.  
 Date (dd-mth-yy) and time of day (hh.mm.ss) = 29-Feb-08 15.24.27 Name of disk plot file is LCC\_3B.pl4  
 Consult the 860-page ATP Rule Book of the Can/Am EMTTP User Group in Portland, Oregon, USA. Source code date is 22 January 2002.  
 Total size of LABCOM tables = 7546726 INTEGER words. VARDIM List Sizes follow : 6002 10K 192K 900 320K 1200  
 15K 120K 2250 3800 720 1200 72800 510 90K 800 90 254 120K 100K 3K 15K 192K 30 30K 160K 600 210K 300 60

-----  
 Descriptive interpretation of input data cards. | Input data card images are shown below, all 80 columns, character by character  
 0 1 2 3 4 5 6 7 8  
 0123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890

-----  
 Comment card. KOMPAN > 0. | C data:LCC\_3B.ATP  
 Marker card preceding new EMTTP data case. | BEGIN NEW DATA CASE  
 Compute overhead line constants. Limit = 120 | LINE CONSTANTS  
 Erase all of 0 cards in the punch buffer. | \$ERASE  
 New XOPT, COPT = 6.0000000E+01 6.0000000E+01 | \$UNITS, 60., 60.  
 Pairs of 6-character bus names for each phase. | BRANCH IN\_\_AOUT\_\_AIN\_\_BOUT\_\_BIN\_\_COUT\_\_C  
 Request for metric (not English) units. | METRIC  
 Line conductor card. 3.330E-01 1.042E-01 4 | 10.333 0.10418 4 | 1.197 1. 55. 35. 18. 0.0 2  
 Line conductor card. 3.330E-01 1.042E-01 4 | 20.333 0.10418 4 | 1.197 28. 60.8 40.8 18. 0.0 2  
 Line conductor card. 3.330E-01 1.042E-01 4 | 30.333 0.10418 4 | 1.197 55. 55. 35. 18. 0.0 2  
 Line conductor card. 5.000E-01 2.400E+00 4 | 0 0.5 2.4 4 | 0.385 15. 81. 61. 0.0 0.0 0  
 Line conductor card. 5.000E-01 2.400E+00 4 | 0 0.5 2.4 4 | 0.385 42. 81. 61. 0.0 0.0 0  
 Blank card terminating conductor cards. | BLANK CARD ENDING CONDUCTOR CARDS  
 Frequency card. 1.000E+02 6.000E+01 2.030E+01 | 100. 111111 111111 0 20.3 44

Line conductor table after sorting and initial processing.

Table Row Number	Phase	Skin effect R-type	Resistance R (ohm/km)	Reactance X-type	Reactance data specification X(ohm/km) or GMR	Diameter (cm)	Horizontal X (mtrs)	Avg height Y (mtrs)	Name
1	1	.33300	.10418	4	.000000	1.19700	0.910	41.667	
2	2	.33300	.10418	4	.000000	1.19700	27.910	47.467	
3	3	.33300	.10418	4	.000000	1.19700	54.910	41.667	
4	1	.33300	.10418	4	.000000	1.19700	1.090	41.667	
5	2	.33300	.10418	4	.000000	1.19700	28.090	47.467	
6	3	.33300	.10418	4	.000000	1.19700	55.090	41.667	
7	0	.50000	2.40000	4	.000000	.38500	15.000	67.667	
8	0	.50000	2.40000	4	.000000	.38500	42.000	67.667	

Matrices are for earth resistivity = 1.000000000E+02 ohm-meters and frequency 6.000000000E+01 Hz. Correction factor = 1.000000000E-06



Inverted susceptance matrix, in units of [ohm-kmeter ] for the system of equivalent phase conductors.  
Rows and columns proceed in the same order as the sorted input.

```
1 3.643293E+05
2 4.515578E+04 3.618017E+05
3 2.043237E+04 4.503427E+04 3.640893E+05
```

Inverted susceptance matrix, in units of [ohm-kmeter ] for symmetrical components of the equivalent phase conductor  
Rows proceed in the sequence (0, 1, 2), (0, 1, 2), etc. ; columns proceed in the sequence (0, 2, 1), (0, 2, 1), etc.

```
0 4.371550E+05
  0.000000E+00
1 -3.618781E+03 8.621409E+03
  6.476654E+03 1.493445E+04
2 -3.618781E+03 3.265326E+05 8.621409E+03
  -6.476654E+03 0.000000E+00 -1.493445E+04
```

Susceptance matrix, in units of [mhos/kmeter ] for the system of equivalent phase conductors.  
Rows and columns proceed in the same order as the sorted input.

```
1 2.792660E-06
2 -3.341842E-07 2.847155E-06
3 -1.153863E-07 -3.334109E-07 2.794294E-06
```

Susceptance matrix, in units of [mhos/kmeter ] for symmetrical components of the equivalent phase conductor  
Rows proceed in the sequence (0, 1, 2), (0, 1, 2), etc. ; columns proceed in the sequence (0, 2, 1), (0, 2, 1), etc.

```
0 2.289382E-06
  0.000000E+00
1 2.685381E-08 -8.177182E-08
  -4.790199E-08 -1.415826E-07
2 2.685381E-08 3.072363E-06 -8.177182E-08
  4.790199E-08 2.193008E-23 1.415826E-07
```



```

6  5.941020E-03  4.892146E-04  -5.698013E-01  5.814883E-03  -1.271745E-04  6.636963E-01
   6.514757E-02  9.931377E-02  1.227803E+00  6.540305E-02  1.006009E-01  -1.972585E+00

7  -3.826235E-02  -4.103578E-02  -2.594205E-02  -3.835165E-02  -4.066019E-02  -2.584631E-02  3.678260E-01
   1.611574E-02  1.707574E-02  1.353646E-02  1.611066E-02  1.709846E-02  1.353963E-02  -1.295084E-01

8  -2.556308E-02  -4.013470E-02  -3.886552E-02  -2.565606E-02  -4.051901E-02  -3.878624E-02  -1.298829E-02  3.677574E-01
   1.345330E-02  1.701024E-02  1.626901E-02  1.345057E-02  1.698801E-02  1.627394E-02  -1.273678E-02  -1.295857E-01

```

Impedance matrix, in units of [ohms/kmeter ] for the system of equivalent phase conductors.  
 Rows and columns proceed in the same order as the sorted input.

```

1  1.338254E-01
   7.457905E-01

2  8.542610E-02  1.429545E-01
   2.270646E-01  7.388557E-01

3  8.082529E-02  8.559932E-02  1.341662E-01
   1.798439E-01  2.269184E-01  7.455102E-01

```

Both "R" and "X" are in [ohms]; "C" are in [microhmhos].

Impedance matrix, in units of [ohms/kmeter ] for symmetrical components of the equivalent phase conductor  
 Rows proceed in the sequence (0, 1, 2), (0, 1, 2), etc. ; columns proceed in the sequence (0, 2, 1), (0, 2, 1), etc.

```

0  3.048825E-01
   1.165937E+00

1  -1.411331E-02  -2.911309E-02
   -2.753773E-03  1.696461E-02

2  9.307584E-03  5.303180E-02  2.925462E-02
   -1.048399E-02  5.321098E-01  1.672600E-02

```



Sequence	Surge impedance magnitude(ohm)	angle(degr.)	Attenuation db/km	velocity km/sec	Wavelength km	Resistance ohm/km	Reactance ohm/km	Susceptance mho/km
Zero :	7.25537E+02	-7.32712E+00	1.84000E-03	2.28831E+05	3.81384E+03	3.04883E-01	1.16594E+00	2.28938E-06
Positive:	4.17193E+02	-2.84574E+00	5.52738E-04	2.94481E+05	4.90801E+03	5.30318E-02	5.32110E-01	3.07236E-06

Inverted impedance matrix, in units of [mho-kmeter ] for the system of equivalent phase conductors.  
 Rows and columns proceed in the same order as the sorted input.

```

1  1.875775E-01
  -1.490192E+00

2  -5.601184E-04  2.090670E-01
  4.018895E-01  -1.559992E+00

3  2.325374E-02  -2.602338E-04  1.881962E-01
  2.616178E-01  4.017776E-01  -1.490408E+00
  
```

Inverted impedance matrix, in units of [mho-kmeter ] for symmetrical components of the equivalent phase conductor  
 Rows proceed in the sequence (0, 1, 2), (0, 1, 2), etc.; columns proceed in the sequence (0, 2, 1), (0, 2, 1), etc.

```

0  2.099025E-01
  -8.033406E-01

1  -2.022159E-02  -1.124957E-01
  -1.252160E-02  3.857806E-02

2  2.059020E-02  1.874691E-01  8.965024E-02
  -1.082245E-02  -1.868626E+00  7.812573E-02

Request for flushing of punch buffer.           |$PUNCH
  
```

A listing of 80-column card images now being flushed from punch buffer follows.  
 =====  
 123456789012345678901234567890123456789012345678901234567890123456789  
 =====

```

C <++++> Cards punched by support routine on 29-Feb-08 15.24.27 <++++>
C LINE CONSTANTS
C $ERASE
C $UNITS, 60., 60.
C BRANCH IN__AOUT__AIN__BOUT__BIN__COUT__C
C METRIC
C 10.333 0.10418 4 1.197 1. 55. 35. 18. 0.0
C 20.333 0.10418 4 1.197 28. 60.8 40.8 18. 0.0
C 30.333 0.10418 4 1.197 55. 55. 35. 18. 0.0
C 0 0.5 2.4 4 0.385 15. 81. 61. 0.0 0.0
  
```

```

C 0 0.5 2.4 4 0.385 42. 81. 61. 0.0 0.0
C BLANK CARD ENDING CONDUCTOR CARDS
C 100. 60. 111111 111111 0 20.3 44
$VINTAGE, 1
1IN__AOUT__A 2.71665557E+00 1.51395469E+01 5.66909987E+01
2IN__BOUT__B 1.73414980E+00 4.60941126E+00 -6.78394003E+00
3IN__COUT__C 2.90197664E+00 1.49987705E+01 5.77972369E+01
1.64075348E+00 3.65083164E+00 -2.34234185E+00
1.73766625E+00 4.60644445E+00 -6.76824125E+00
2.72357373E+00 1.51338568E+01 5.67241673E+01
$VINTAGE, -1,
===== < End of LUNIT7 punched cards as flushed by $PUNCH request >=====
Blank card terminating frequency cards. |BLANK CARD ENDING FREQUENCY CARDS
Blank card ending "LINE CONSTANTS" cases. |BLANK CARD ENDING LINE CONSTANT
Total case timing (CP, I/O, tot), sec: 0.656 0.000 0.656

```

# Weather Effects

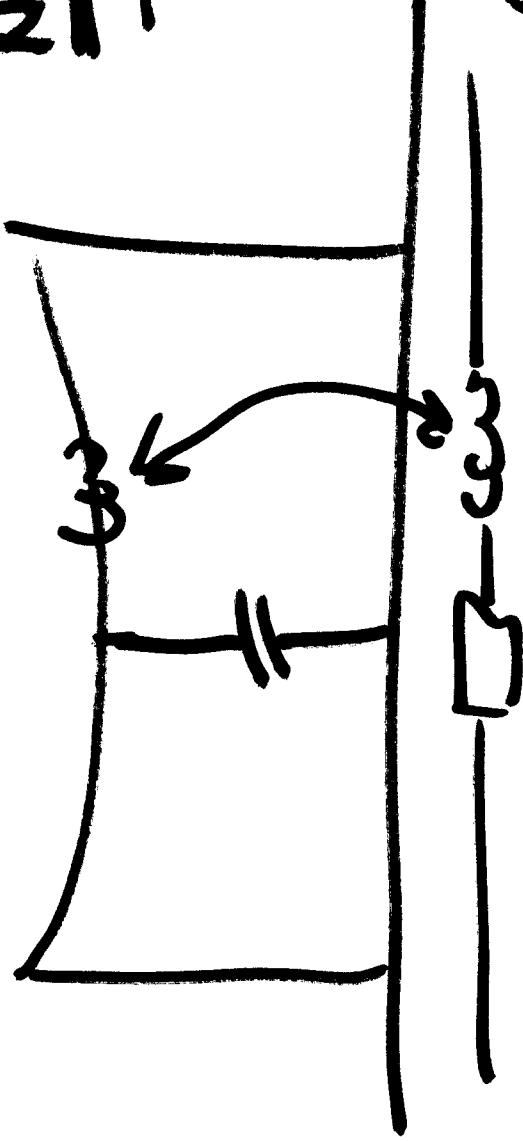
- Rain, run-off, pooling
- Operating Temp:  $-40^{\circ}\text{F} \rightarrow 180^{\circ}\text{F}$



$P$  (0mm.m) - is not constant  
- varies seasonally or w/ precipitation

# NESE

- Clearances
- Open field
- Roads / Ave
- Bldgs.



$C_{gd}$ : decrease w/ height  $\left[ C \propto \ln \frac{r}{D} \right]$

$\Rightarrow$  Lucky to get within 5-10% of actual line parameters.