12/5/2017

EE492

Final Report

By Dec1702B

ABOUT US

We are a senior design team formed in the term Spring 2017. Our team is composed by four members:

- Team Leader: Robert Cohoon
- Key Concept Holder: Abdelmagieed Ibrahim
- Web Master: Jinan Li
- Communication Leader: Chang Sun

We have been working over one year on our senior design project and got close cooperation through our team work.

The team leader, Robert mainly in charge of controlling the timeline of our whole project and setting mission tests for our weekly activities.

The key concept holder, Abdelmagieed, mainly take charge in the whole technical control on our whole project, including the critical thinking for every content under our project.

The web master, Jinan, mainly responsible for our web page construction and a part of contents under our project, assisting the key concept holder on expertise of our design project.

The communication leader, Chang, mainly take in charge of struggling the time arrangement of every group meeting, meeting with clients and mentors, as well as writing meeting records and documents for the senior design project.

ABOUT THE PROJECT

Our senior design project is on power system. We are asked by the company Muscatine Power & Water (MPW), our client, to give a diagnose to an old transmission line built by them in 1960s. The transmission line is numbered as Transmission Line 98, which is located in the city Muscatine, Iowa. Hence our senior design project is defined as: New construction or re-conductoring the Transmission Line 98?

In this project, we first have to determine whether to re-conductor or re-build the transmission line. If re-building the transmission line, we need to figure out all the components we needed for the new Line 98 and finally define the new route for Line 98.

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1. INTRODUCTION

1.1 PROJECT STATEMENT

Analyze the systematic and economic viability for re-conductoring or new constructing of existing Transmission Line 98 to meet growing load demand of 89kV.

1.2 PURPOSE

The current transmission line does not the growing load needs, if the line is not improved, some customers will not have power.

1.3 GOALS

1. Deliver a viable, robust, and complete design for each option.

2. Learn from being involved in a major design process.

3. Learn about and research power systems topics that we do not know, but need for the project.

1.4 DELIVERABLES

In order to meet the goals outlined in the introduction, the project give these specification:

- Create economic plan with a cost benefit analysis of four type of conductors (T2, ACSR, AAAC, and ACSS).
- Create sag/tension charts for each conductor.
- Construction plane. (next semester deliverable)
- List of equipment required for construction.
- Structure design with material list
- Propose reconductoring line 98 and have an engineering analysis plane done.
- Pole loading with different conductor.
- Budget report.

1.5 ASSESSMENT OF PROPOSED METHODS

- Type of conductors:
    - AAAC (All Aluminum-Alloy Conductor.)
    - ACSR (Aluminum Conductor. Steel Reinforced)
    - ACSS (Aluminum Conductor, Steel Supported.)
    - Motion resistant conductor
    - T-2
    - ACSR/T-2(Aluminum Conductor Steel-Reinforced Concentric-Lay-Stranded Twisted Pair)
    - AAC/T-2 (All-Aluminum 1350 Conductor Concentric-Lay-Stranded Twisted Pair)

- Poles and materials
    - Select new poles based on the type of conductor.
    - Location of poles (not equal distance).
    - Material and equipment required for installing poles and conductor.

1.6 PROJECT REQUIREMENTS/SEPECIFICATIONS

1.6.1 FUNCTIONAL

The technical requirement:

- The new line must at least supply 89 MVA.

1.6.2 NON-FUNCTIONAL

- Consideration of new locations for poles in case of changed surrounding environment.
- Different properties of pole.
- Economic analysis based on different conductor.

1.6.3 STANDARDS

- For types of conductors we are using National Electric Code (NEC).
- For types of poles we are using IEEE.

1.7 CHALLENGES

The biggest challenge is going to be choosing the proper type of poles and where to place them for each type of conductor. Another significant challenge will be based on the distribution line that shares the poles with the transmission line and whether or not there will need to be new poles for that line. There are some construction constraints with the pole locations that will need to be solved based on the terrain conditions in some areas.

1.8 TIMELINES

1.8.1 FIRST SEMSTER

Week	1	2	3	4	5	6	7	8
Research	Research on conductor types							
	Read through materials given by client							
	Research on poles							
	Research on calculation methods							
Analysis of materials		Analyze materials from the client						
			Develop different combinations of conductor and methods					
			Fit in parameters into calculation formula					
					Calculate the costs according to research and materials			
Evaluation						Evaluate combinations and finalize a plan		

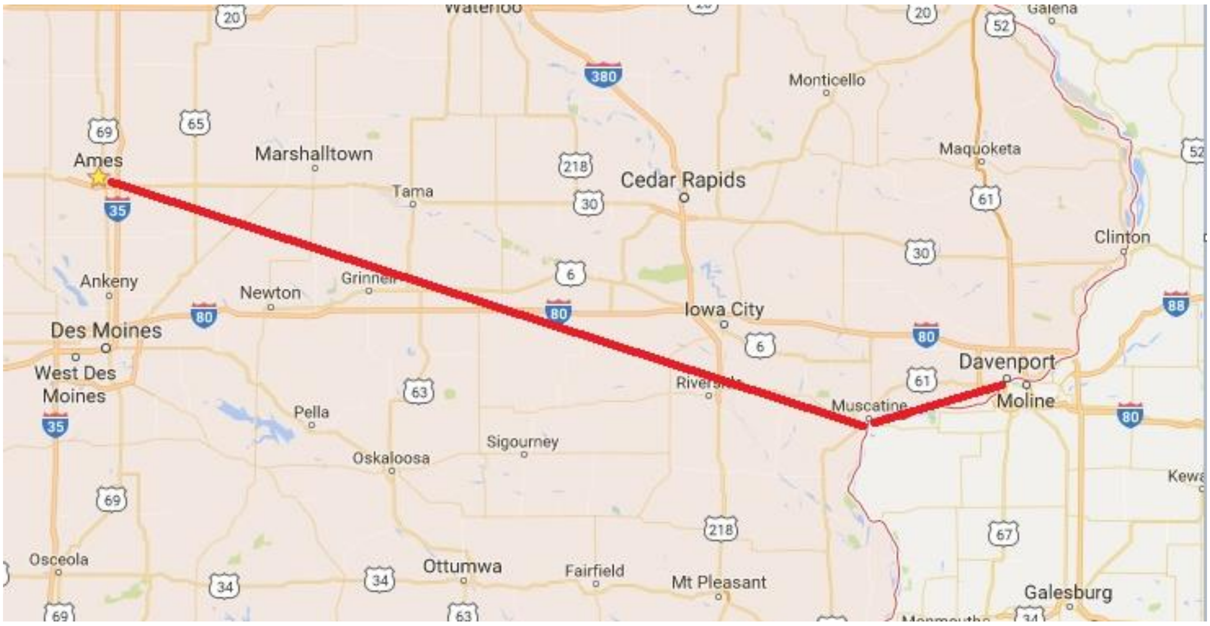
1.8.2 SECOND SEMESTER

Week	1	2	3	4	5	6	7	8
Design	Carry out the actual design for all combinations							
			Develop the calculated parameters for all combinations					
			Calculate the economic budgets to all combinations					
					Construction notations according to Musctine situation			

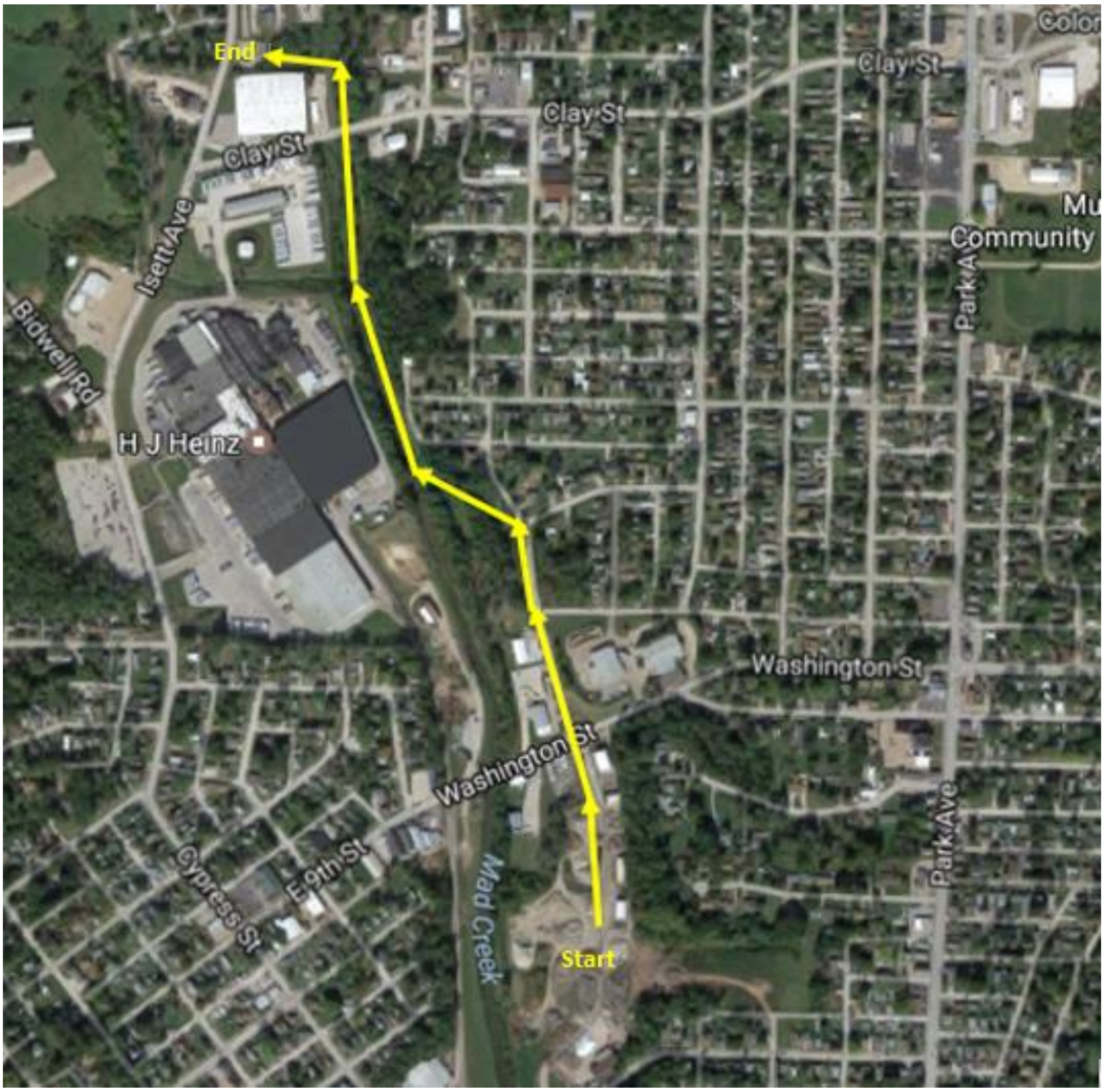
Week	9	10	11	12	13	14	15	16
Communicate	Communicate with client and adjust construction plan							
Document		Compose the construction plan into real document						
Presentation					Prepare a presentation			
								Present

2. PROJECT ANALYSIS

2.1 MAP OF MASCATINE RELATION TO AMES



2.2 MAP OF TRANSMISSION LINE 98



Problem statement:

- Total Length: 1.7 Miles
- Follows creek near residential/commercial area
- Difficult to access for maintenance
- Insufficient ampacity for growing load

Reconductor or rebuild a section of transmission Line 98 (1.7 Miles) to create ease of access for maintenance and upgrade conductors to meet growing load demand.

3. CONDUTOR ANALYSIS

3.1 PARAMETERS FOR DIFFERENT CONDUCTORS

3.1.1 AAAC

Code Word	Size (KCMIL)	Stranding	Diameter (ins.)		Weight Per 1000 Feet (lbs.)	Rated Strength (lbs.)	Resistance OHMS/1000ft.		Allowable Ampacity+ (Amps)	ACSR With Equivalent Diameter	
			Individual Wires	Complete Cable			DC @ 20°C	AC @ 75°C		Size	Stranding (Al/Stl)
Flint	740.8	37	.1415	.9900	690.8	24400	.0272	.0327	790	636.0	26/7

3.1.2 ACSR

Code Word	Size (AWG or KCMIL)	Stranding (Al/Stl)	Diameter (inches)			Weight Per 1000ft (lbs.)			Rated Strength (lbs.)	Resistance OHMS/1000ft.		Allowable Ampacity+ (Amps)
			AL	Steel	Complete Cable	AL	Steel	Total		DC @ 20°C	AC @ 75°C	
Kingbird	636.0	18/1	.1880	.1880	.9400	597.2	93.6	690.8	15700	.0270	.0332	773
Swift	636.0	36/1	.1329	.1329	.9300	596.0	47.0	643.0	13690	.0271	.0334	769
Rook	636.0	24/7	.1628	.1085	.9770	600.0	219.2	819.2	22600	.0268	.0330	784
Grosbeak	636.0	26/7	.1564	.1216	.9900	600.0	275.2	875.2	25200	.0267	.0328	789
Scoter	636.0	30/7	.1456	.1456	1.0190	600.0	395.0	995.0	30400	.0256	.0325	798
Egret	636.0	30/19	.1456	.0874	1.0190	600.0	386.0	987.0	31500	.0266	.0326	798

ACSR 636 Grosbeak 26/7

Code Word	Size (KCMIL)	Stranding	Diameter (ins.)	Weight Per 1000 Feet (lbs.)	Rated Strength (lbs.)	Resistance OHMS/1000ft.		Ampacity at 75 C
						DC@20	AC@75	
Grosbeak	636	26/7	0.991	874	25200	0.0267	0.0328	789

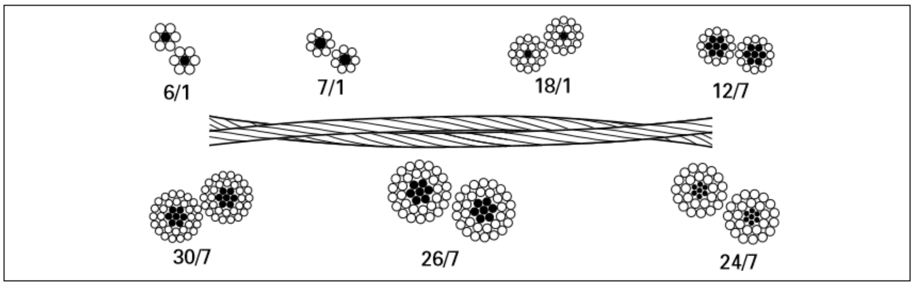
3.1.3 ACSS

Code Word	**Size (KCMIL)**	**Stranding**	**Diameter (ins.)**		**Weight Per 1000 Feet (lbs.)**	**Rated Strength (lbs.)**	**Resistance OHMS/1000ft.**		**Ampacity at 200C**
			Individual Wires	**Complete Cable**			**DC @ 20°C**	**AC @ 75°C**	
Partridge	266.8	26/7	0.2363	0.642	366.8	8880	0.0619	0.0761	812
Junco	266.8	30/7	0.2829	0.660	417.4	11700	0.0615	0.0756	822

3.1.4 MOTION RESISTENT

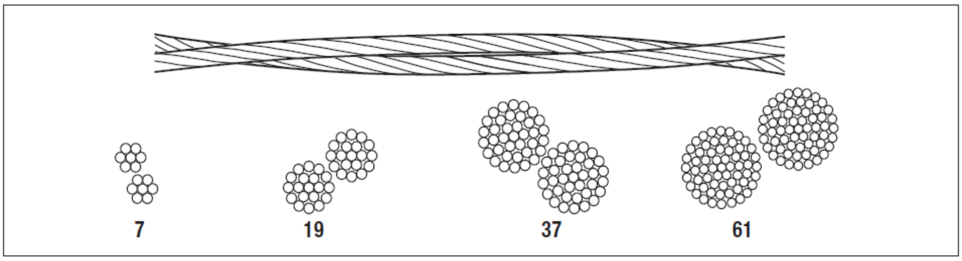
Code Word	Size(AWG)	Area(sq.inches)		Steel stranding	Conductor ellipse dimeters (inches)		Weight per 1000 ft (Lbs.)	R/1000 ft		Rated Strength	Ampacity
		Al	total		major	minor		DC@ 20C	AC@ 75C		
Linnet/MR	795	0.6247	0.7264	7x0.136	1.302	0.879	1093	0.0213	0.0263	31500	908

3.1.5 ACSR/T-2(Aluminum Conductor Steel-Reinforced Concentric-Lay-Stranded Twisted Pair)



Code Word	Size (KCMIL)	Diameter (ins.)	Weight Per 1000 Feet (lbs.)	Rated Strength (lbs.)		Resistance OHMS/1000ft.	Ampacity at 75 C
Ostrich	600	1.114	825	24400	.0283	.0348	790
Merlin	672	1.119	730	17400	0.0255	.0315	830

3.1.6 AAC/T-2



Code Word	Size (KCMIL)	Diameter (ins.)	Weight Per 1000 Feet (lbs.)	Rated Strength (lbs.)	Resistance OHMS/1000ft.		Ampacity at 75 C
Tulip	672.8	1.089	631	12800	.0257	.0317	820
Daffodil	700	1.111	656	14200	.0247	.0305	840

3.2 ANALYSIS OF CONDUCTORS

According to our research on 6 types of conductors, we have found that conductor ACSR 636 Grosbeak 26/7 has the best features for re-construction of Line 98.

Comparison between All Types of Conductors

Type of Conductors	Code Word	Size (KCMIL)	Diameter (ins.)	Weight Per 1k Feet (lbs.)	Seg (ft.)	Rated Strength (lbs.)
AAC-T2	Tulip	672.8	1.089	631.0	1.0344	12800
	Daffodil	700.0	1.111	656.0	1.0112	14200
ACSR-T2	Ostrich	600.0	1.114	825.0	0.8391	24400
	Merlin	672.0	1.119	730.0	0.9403	17400
AAAC	Flint	740.8	0.990	690.8	2.8311	24400
ACSR	Kingbird	636.0	0.940	690.8	3.4683	15700
	Swift	636.0	0.930	643.0	3.4683	13690
	Rook	636.0	0.977	819.2	3.4683	22600
	Grosbeak	636.0	0.990	875.2	3.4683	25200
	Scoter	636.0	1.019	995.0	3.4683	30400
	Egret	636.0	1.019	987.0	3.4683	31500
ACSS	Partridge	266.8	0.642	366.8	3.3615	8880
	Junco	266.8	0.660	417.4	3.3615	11700

Type of Conductors	Code Word	Impedance (Ω/mile)	Resistance OHMS/1kft.		Ampacity at 75 ℃
			AC at 20 ℃	DC at 75 ℃	
AAC-T2	Tulip	0.1674 + 5.5238i	0.0257	0.0317	820
	Daffodil	0.1576 + 5.3478i	0.0247	0.0305	840
ACSR-T2	Ostrich	0.1663 + 5.4864i	0.0348	0.0348	790
	Merlin	0.1542 + 5.2375i	0.0255	0.0315	830
AAAC	Flint	0.1727 + 5.5968i	0.0272	0.0327	790
ACSR	Kingbird	0.1732 + 5.5476i	0.0270	0.0332	773
	Swift	0.1732 + 5.5477i	0.0271	0.0334	769
	Rook	0.1732 + 5.5478i	0.0268	0.033	784
	Grosbeak	0.1732 + 5.5479i	0.0267	0.0328	789
	Scoter	0.1732 + 5.5480i	0.0256	0.0325	798
	Egret	0.1732 + 5.5481i	0.0266	0.0326	798
ACSS	Partridge	0.1695 + 5.5476i	0.0619	0.0761	812
	Junco	0.1695 + 5.5477i	0.0615	0.0756	822

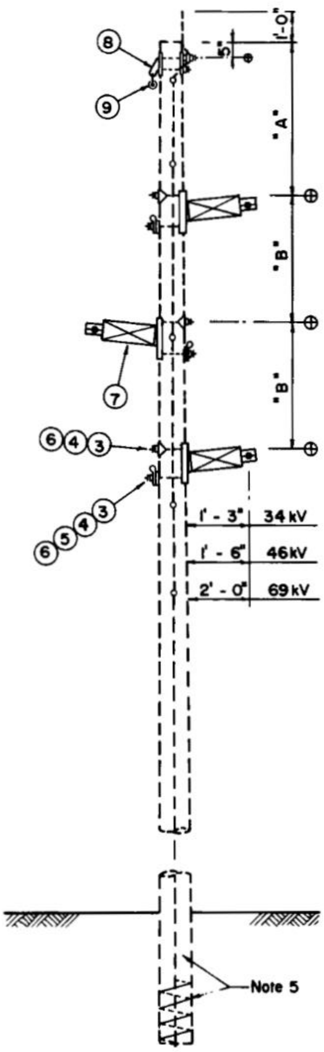
4. POLE ANALYSIS

4.1 POLE INTRODUCTION

There are two configurations of poles: A & B, the structures of A and B is shown in the figures:

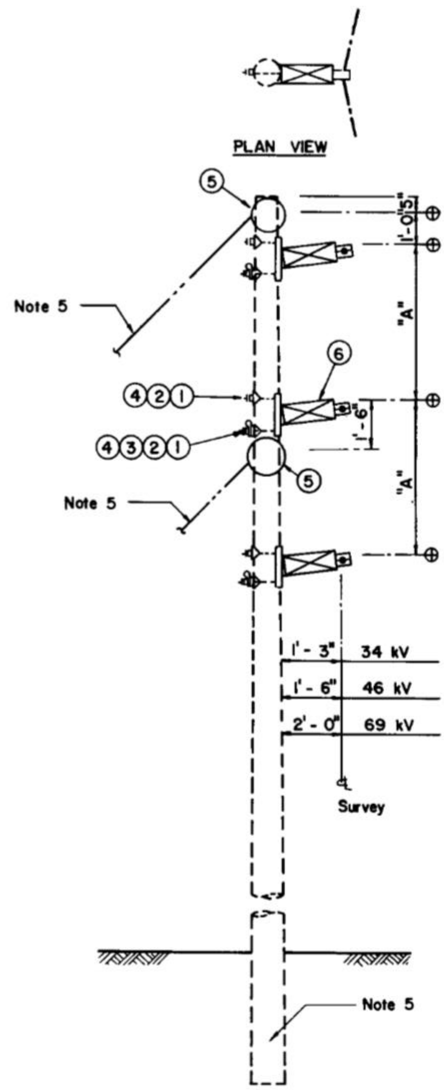
Characteristics of A:

- Reduced line impedance
- Horizontal clearance increased



Characteristics of B:

- Higher line impedance
- Better clearance
- Ease of maintenance



4.2 POLE ANALYSIS

4.2.1 POLE CHOICE FOR ACSR 636 GROSBEAK

Poles	Span (feet) pole to pole	Sag (feet)
1 -2	376.7	3.4177
2- 3	283.2	1.8897
3 - 4	187	0.8239
4 - 5	142..7	0.4798
5- 6	289.9	1.9802
6 - 7	273.1	1.7964
7 - 8	274.3	1.8095
8 - 9	261.8	1.6508
9 - 10	338.5	2.7597
10- 11	220.9	1.1753
11- 12	293.1	2.0691
12 -13	285.4	1.9618
13- 14	288.4	2.0033
14- 15	379.4	3.4669
15 -16	236.1	1.3426
16 - 17	299.5	2.1604
17 - 18	401.1	3.8748
18 -19	193.3	0.8999
19 -20	315.3	2.3944
20 -21	291.4	2.0452

- Pole 15, 16, 17 should be 10 ft longer than standard, only poles 13 & 14 on private land.

Pole choice: 18 Southern Yellow Pine 75ft class 1, 3 for 85 ft class 1.

- Max Vertical Loads on cross arms is 7422.845lb-ft.

  In our case, OCF = 1.9, Lphase = 4 ft

4.2.2 POLE CHOICE FOR ACSR 363 ORIOLE

Span (feet)	Sag (feet)
376.7	2.9181
283.2	1.6493
187	0.7191
142..7	0.4188
289.9	1.7283
273.1	1.5337
274.3	1.5450
261.8	1.4095
338.5	2.3563
220.9	1.0035
293.1	1.7666
285.4	1.6750
288.4	1.7104
379.4	2.9601
236.1	1.1463
299.5	1.1463
401.1	3.3084
193.3	0.7684
315.3	2.0444
291.4	1.7462

Max Vertical Loads for distribution line on cross arms is 5961.25 lb-ft

In our case, OCF = 1.9, Lphase = 4 ft

- Sag must not exceed 7% of the vertical clearance. thus, the distance from ground to lower point of the distribution line conductor must be at least 47.2626 ft.

5. SAMPLE CALCULATION

5.1 ROW WIDTH

TABLE 5-3
TYPICAL RIGHT-OF-WAY WIDTHS

	Nominal Line-to-Line Voltage in kV				
	69	115	138	161	230
ROW Width, ft.	75-100	100	100-150	100-150	125-200

Maximum Span as Limited by Galloping

Galloping, sometimes called dancing, is a phenomenon where the transmission line conductors vibrate with very large amplitudes. This movement of conductors may result in: (1) contact between phase conductors or between phase conductors and overhead ground wires, resulting in electrical outages and conductor burning, (2) conductor failure at support point due to the violent stress caused by galloping, (3) possible structure damage, and (4) excessive conductor sag due to the overstressing of conductors.

Galloping Considerations in the Design of Transmission Lines

In areas where galloping is either historically known to occur or is expected, designers should indicate design measures that will minimize galloping and galloping problems, especially conductor contacts. The primary tool for assuring absence of conductor contacts is to superimpose Lissajous ellipses over a scaled diagram of the structure to indicate the theoretical path of a galloping conductor. See Figures 6-3 and 6-4. To avoid contact between phase conductors or between phase conductors and overhead ground wires, none of the conductor ellipses should touch one another. However, if galloping is expected to be infrequent and of minimal severity, there may be situations where allowing ellipses to overlap may be the favored design choice when economics are considered.

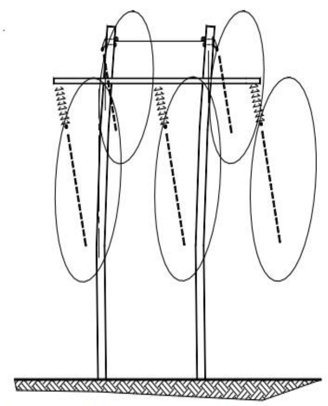


FIGURE 6-4: SINGLE LOOP GALLOPING ANALYSIS

Where:

p_c = wind load per unit length on iced conductor in lbs/ft. Assume a 2 psf wind

w_c = weight per unit length of conductor plus 1/2 in. of radial ice, lbs/ft

L = span length in feet

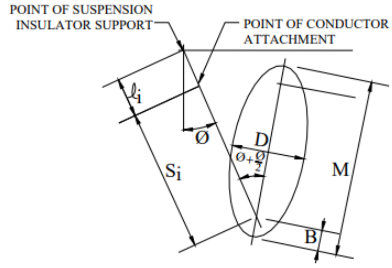
M = major axis of Lissajous ellipses in feet

S_i = final sag of conductor with 1/2 in. of radial ice, no wind, at 32°F, in fee.

D = minor axis of Lissajous ellipses in feet

$B, Ø$ = as defined in figure above

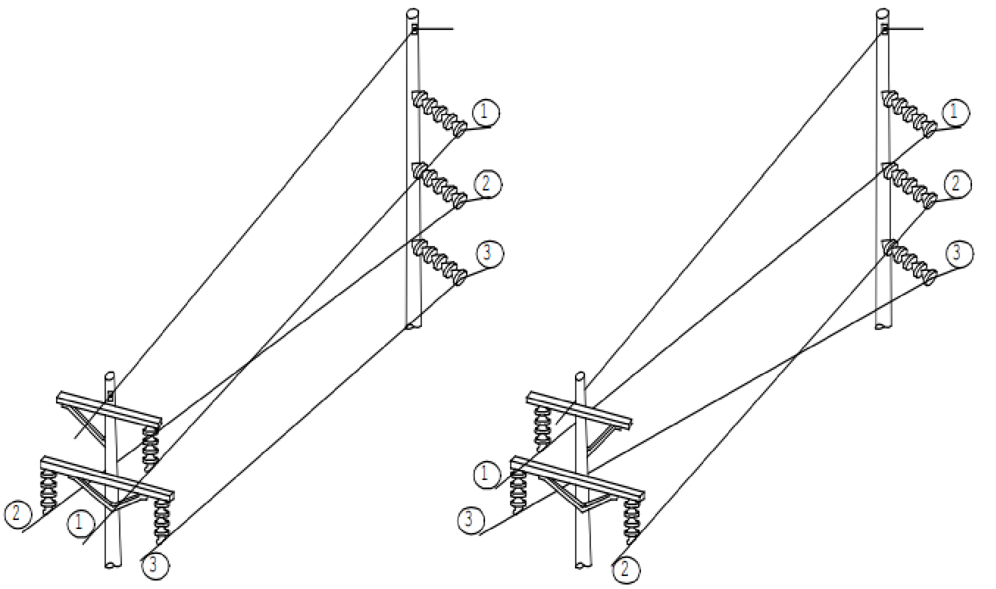
FIGURE 6-3: GUIDE FOR PREPARATION OF LISSAJOUS ELLIPSES



$$\phi = \tan^{-1}\left(\frac{p_c}{w_c}\right) \qquad \text{Eq. 6-6}$$

	Single Loop	Double Loop
Major Axis	$M = 1.25\,S_i + 1.0$ Eq. 6-7	$M = 1.0 + \sqrt{\frac{3a\left(L + \frac{8S_i^2}{3L} - 2a\right)}{8}}$ Eq. 6-8 where $a = \sqrt{\left(\frac{L}{2}\right)^2 + S_i^2}$
Distance 'B'	$B = 0.25\,S_i$ Eq. 6-9	$B = 0.2M$ Eq. 6-10
Minor Axis	$D = 0.4M$ Eq. 6-11	$D = 2\sqrt{M - 1.0}$ Eq. 6-12

5.2 CLEARANCE



Conductor contacts in spans changing from cross arm to vertical type construction may be reduced by proper phase arrangement and by limiting span lengths. Limiting span lengths well below the average span lengths is particularly important in areas where ice and sleet conditions can be expected to occur.

5.3 UNDERBUILD

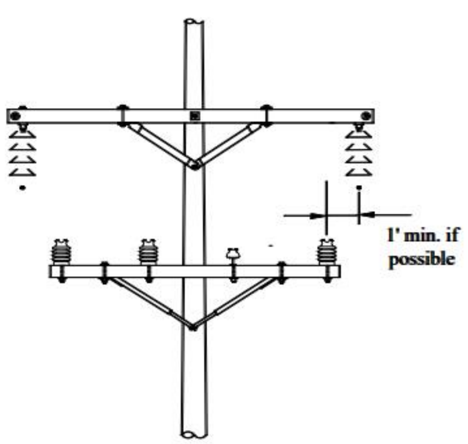


FIGURE 16-1:
HORIZONTAL SEPARATION REQUIREMENTS BETWEEN TRANSMISSION AND UNDERBUILD

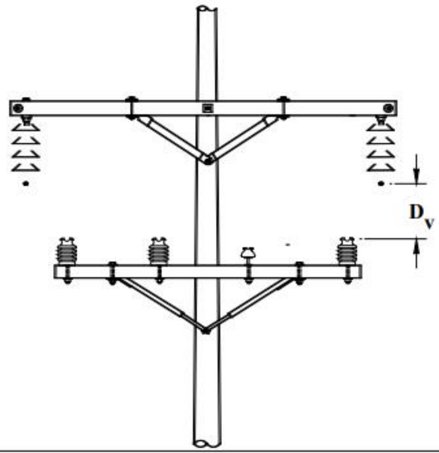
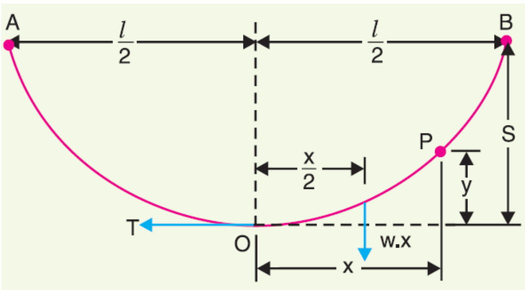


FIGURE 16-2:
VERTICAL SEPARATION REQUIREMENTS AT STRUCTURE FOR UNDERBUILD

Horizontal Separation.

The horizontal separation at the support between the lowest transmission conductor(s) and the highest distribution conductor(s) or neutral should be at least 1 foot if possible as illustrated in Figures above.

5.4 CALCULATION OF SAG



Let,

- l = length of the conductor span
- w = weight per unit length of the conductor
- T = tension in the conductor

Consider a point P on the conductor. Considering the lowest point O as the origin, let the coordinates of point P be x and y. Assume the curvature is so small that the curved length is equal to its horizontal projection (i.e. OP = x). The forces acting on the conductor portion OP are:

- the weight w.x acting at a distance x/2 from the point O
- the tension T acting at the point O

Equating the moments of the two forces about point O, we get,

$$T.y = w.x * x/2$$

$$\text{or, } y = w.x^2 / 2T$$

The maximum sag (dip) is represented by the value of y at either of the support points. At support point A,

$$x = l/2 \text{ and } y = S \text{ (sag)}$$

$$\text{therefore, sag } S = w(l/2)^2 / 2T$$

$$\text{therefore, sag } \mathbf{S = w.l^2/8T}$$

6. NEW R OUTE MAP

7. BUDGET

We are supposed to get a budget for our senior design projects, but unfortunately we did not have any luck for getting the price from the sellers. We are continuing working on the budget.

We are given an approximate budget limit by our client for 1.8 million dollars.

8. CONCLUSION

According to the research and the analysis above, we have designed a new route for Transmission Line 98, finished the re-build of the transmission line. Compared to our project plan, we have achieved most of the goals but the economic budget.

9. REFERENCE

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