ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 2, Issue 6, June 2013

Radio Interferences Performances in 750KV Transmission Line & 400KV Transmission Line of HVAC Transmission system by MATLAB program

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Abstract— This paper presents the methodologies for the radio interference measurements of electrical system in transmission lines, its effect, level, rules and design criteria describes that. This paper also shown that 750kV and 400kV transmission lines radio interference results through MATLAB software general program.

Keywords: Over head high voltage transmission line (HVAC), Radio interference (RI).

Introduction: Corona loss has investigated since the year 1900.The research was accelerated after 1945 and again after 1955.After 1970 the phenomena like RI (Radio Interference), TVI (Television Interference), AN (Audible Noise) have received more attention. [4]

The overhead EHV AC and HVDC lines generate radio interference (disturbance) TV interference and Audible Noise in neighboring zone. The disturbance reduces with distance as the distance of the Receiver from the overhead line increases. Radio, TV communication is by electromagnetic Waves through air. The corona and sparking on power line generate unwanted radio frequency waves results in Radio Interference and also called Radio Noise and to a small extent TV Interference. Audible Noise is due to Vibrations in air caused by corona and wind induced vibrations in conductor. [3]

Limits of these disturbances at the edge of Right Of Way (ROW) are specified by National Codes and Standards-

The design of line conductors, accessories, hardware, insulators and clearances are dictated by these limits. Hence the cost of transmission line increases by lower limits of these disturbances. Shown Table 1:-

Type of Disturbance/ Interference	**Frequency Range**	**Principal cause**	**Limit of Disturbance at edge of ROW**
Radio Noise (RN)	3kHz to 30kHz	Corona, Spark Harmonics	Urban area 42dB Rural area 34dB
TV Interference	30MHz to 300MHz	Spark	
Audible Noise*	20Hz to 20kHz	Corona, Spark	52dB

*In Substations AN is also caused by Transformer/Reactor Humming, Cooling Fans, Ventilation System, Air Conditioners.[4]

Radio Interference: -Definitions according to (IEEE) - Degradation in reception of radio frequency signals. Any unwanted disturbance within radio frequency band. Corona discharge radiates electromagnetic waves in radio frequency band. Corona is a principal cause of Radio Interference or Radio Noise from overhead transmission lines. Radio frequency interference (RFI) has been a consideration for hams from the beginning. [4]

Radio Noise Level: - The radio noise level is an empirical formula relating most important line and atmospheric parameters. The important quantities involved in the empirical formula are [1]:

- **I.** Conductor radius, r, or diameter d=2r;
- **II.** Maximum surface voltage gradient on conductor, Em;
- **III.** Aerial distance from conductor to the point where RI is to evaluated, D;
- **IV.** Other factors, such as frequency and climatic conditions.

For up to 4 conductors in bundle, the basic formula is:

RI (K) = 0.035Em (k) +1200r-33log (D (k)/20)-30 dB

Where RI is evaluated and k=1, 2, 3.

There are several limitations on the use of this formula. It follows when [1]

A. The values of Em and d are in centimeter units; Em in kV/cm, r.m.s.;
B. The aerial distance D(k) is in meters and d(k)> 20 m;
C. The frequency is 0.5 MHz;
D. The number of sub-conductors N in the bundle is less or equal to 4.This is true of lines up to 765kV;
E. The ratio of bundle spacing B between sub-conductors to the conductor diameter lies between 12 and 20;
F. The weather condition is average fair weather;
G. The RI level has a dispersion of $\pm$ 6 dB.

Rules for addition of RI Levels of all phases: There are two adding rules are given in:-[1]

I. **Rules for Adding of RI levels of 3-phases Single-circuit line: -** Calculated the RI level due to each phase at the measuring point , the rules for the total RI level of a 3-phase single-circuit line are follows:

a. If one of the RI level is at least 3dB higher than the rest, then this is the RI level of the line.

b. Otherwise the RI level of line is

RI= (Average of the two highest+3)/2 dB

c. At 1MHz, the RI level is 6dB lower.

d. For evaluating the RI level in rain, add 17dB. [1]

II. **Rules for Addition of RI levels for a double-circuit: -** The rules apply for adding RI level of phase conductors in a double circuit line only. That rules as are:

a. The RI level in dB calculated by the RI (k) formula to micro volt/meter (μV/m) by the relation.

$$RI\mu V/m = 10\text{^} (RIdB /20)$$

b. A double circuit line, there are two phase-conductors belong to each phase.

Let RI_{A1} and RI_{A2} be the RI values in $\mu V/m$ at any point M on ground to phase A which can be evaluated individually by the RI (k) formula in dB and converted $\mu V/m$ according to equation $RI_{\mu V/m}$ .then the resulting RI value in $\mu V/m$ to the two conductors of phase A is given the quadratic addition equation is are :

$$RI_A = \sqrt{(RI_{A1}{}^2 + RI_{A2}{}^2)} \quad , \mu V/m$$

Similarly,

$$RI_B = \sqrt{(RI_{B1}{}^2 + RI_{B2}{}^2)} \quad , \mu V/m$$

$$RI_C = \sqrt{(RI_{C1}{}^2 + RI_{C2}{}^2)} \quad , \mu V/m$$

Where, M=Measuring point

c. The reason for quadratic addition is based upon the property that the pulses causing the noise from any one phase are time – correlated from its two conductors so that energies or powers are added arithmetically in the noise meter circuitry. If there are N identical noise sources which are correlated in the time, that is they occur on the same conductor or different conductors energized by the same voltage, then the resulting meter reading in $\mu V/m$ is for N non-identical but time – correlated sources, since this represents a quantity that is proportional to the energy or power(in a unit bandwidth).[1]

RI (N) =$\sqrt{N}$ $\times$(RI due to each source acting individually).

$$[\boldsymbol{RI}(\boldsymbol{N})]^2 = \mathbf{N}\times(\boldsymbol{RI})^2,$$

If all sources are identical

$$[\boldsymbol{RI}(\boldsymbol{N})]^2 = (\mathbf{RI_1}^2 + \mathbf{RI_2}^2 + \mathbf{RI_3}^2 + \cdots + \mathbf{RI_N}^2)$$

For 1MHz level, deduct 6dB from above equation.

RI Design Criterion for EHV-AC LINE:-

RI design criterion is dependent on the broadcast signal strength and acceptable *'Signal to Noise Ratio'* (SNR). The corona noise produced by the line must be sufficiently low so that the customer located adjacent to the line route may receive acceptable broadcast signal. Following are the influencing factor there are [4]:

1. **SNR Ratio-**SNR ratio should be sufficiently high for receiving broadcast radio reception.
2. **The Broadcast Radio Signal Strengths-** These are measured along the line route at the edge of ROW.
3. **Type of Radio Reception Services, e. g.** Type B-Service has a contour with strength of 500 $\mu V/m$ (54dB). Type B may be broadcast for 50% of day-of-night time.
4. **Population Density-** Population density along the route. Acceptable RI is low for heavily populated areas.

RI condition for Fair weather, Bad weather and Heavy rains: From practically on actual lines it is observed that.

$RI_F < RI_B < RI$
Where,
RI_F =RI for fair weather.
RI_B=RI for bad weather.
RI_R =RI for heavy rains.

Effects of RI from EHV-AC Lines-

I. Bad weather effects – RI during rains is higher due to corona pulses occurring during rain – drops falling on conductor surface. RI upper limit is reached during heavy rains.

II. Effect of number of sub-conductors in bundle- Increased number of sub-conductors in the bundle reduces the surface voltage stress. With same cross-sections area, as that of a single conductor, the RI level of an AC line is reduced with increased number of sub-conductors [1].

Radio Interferences Performance Analysis in Transmission Lines & Its Results:

The deference two transmission lines are used following two input data's for radio interference performance and obtained from HVAC transmission system. The input data described below:

1. **First Transmission Lines input data-** 750KV transmission line are used , its number of bundle conductor 4, bundle spacing is 0.4572meter, bundle sub-conductor is 0.015meter and is the distance from the outer phase at the ground is 15meter [2].
2. **Second Transmission Lines input data-** 400KV transmission line are also used and its 2 number of bundle conductor, bundle spacing , bundle sub-conductor and distance from the outer phase at the ground same as 750kV transmission line 1st problem.

Result Table-2 as based on above input data by MATLAB Performance:

Output Contents	750kV Transmission Line	400kV Transmission Line
Horizontal span in meter (Sag) in meter	15.14	11.96
Average height in meter Hav	18.0477	12.9864
Bundle Radius in meter	0.161645	0.2286
Eq. radius in meter	0.082813	0.0852612
Mid Center Voltage in kV/m	1838.45	1682.51
Mid Outer Voltage in kV/m	1754.1	1602.78
Corona Inception Gradient Voltage	1999.45	1988.13

Radio Interference RI1 in dB	47.5738	45.2922
Radio Interference RI2 in dB	44.4779	42.1932
Radio Interference RI3 in dB	36.7307	34.8799
Average Radio Interference	47.52585	45.2427

1st case- 750KV transmission line radio interference & its average radio interference shown above table. It's considered 47.5dB at 0.5MHz and 41.5dB at 1MHz.Since there is a $\pm$6dB in the formula. Also, the value of 41dB at 1MHz approximate is meant only for preliminary estimates. Other such as S/N ratio will have to be considered in final decision [2].

The width of R-O-W based on a line corridor extending to 15meter from outer phase is 2(15+15) =60meters.

2ndcase- 400KV transmission line radio interference &its average radio interference are also shown above table. Therefore, RI level of line is 45.2427dB at 0.5MHz and 39.2427dB at 1MHz.

Since the limit is 40dB at the edge of R-O-W. The line corridor be made equal to 2(Sag+15) =54meters.

Conclusion

It is concluded that in transmission lines radio interference dose not depends on the lines length and the power transmitted by line. Radio interference depends on receiving end voltage, sag, number of bundle conductor, bundle spacing, bundle sub-conductor and distance from of the outer phase from the ground. In this paper average radio interference has been calculated for 750kV and 400kV lines using MATLAB programming and results are shown in Table-2. These results are helpful for transmission line design and planning as it gives the information of noise pollution in the environment and nature effects. This program is also helpful for sub-station design and planning. Calculation of radio interference through MATLAB programming is economical and less time consuming method.

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