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Electromagnetic Interference from Substations in Central Region of Saudi Arabia

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ABSTRACT. Corona and gap type discharges occurring at high voltage hardware generate appreciable electromagnetic interference (EMI). This work is concerned with the level of interference generated at substations located in the Central Region of Saudi Arabia. The contribution of substation hardware to the overall power system EMI was found by measuring the EMI frequency spectrum under a power line near and away from the substation. Two areas in the central region namely Riyadh and Qassim, were considered. Some differences were observed between the substations in the two areas. The results of these measurements are analysed in the paper.

Corona and gap type discharges occurring on power system apparatus can cause severe electromagnetic interference (EMI) to nearby communication and control systems. Substations being an integral part of the power network, if not properly installed, can generate great deal of interference as found by Nelson and Schlinger (1976). Several studies were previously reported concerning the interference from power systems in general. These include studies by Newell (1967, 1968), Janischewskyj and Al Arainy (1981), Gary (1981) and Al Arainy *et al.* (1986). However, none of the previous studies discussed specifically the contribution of substations towards the overall EMI level of the system hardware. EMI from substations in the central region of Saudi Arabia was studied as part of a two years research program sponsored by King Abdul Aziz City for Science and Technology (KACST) to investigate the EMI from power system components located in the Central Region of the Kingdom of Saudi Arabia. This region includes two main power networks serving Riyadh and Qassim areas. This paper deals with the contributions of the substations to the overall level of EMI generated by power system components. Such a contribution was determined by comparing the interference level measured near and away from the substation under the same power line. Several measurements were done in this fashion for a number of substations in both areas. The results of these measurements are presented and discussed in the paper.

Results and Analysis

The measurements were performed according to the procedures and specification recommended by CISPR (1982). Quasi peak detectors were used to measure the interference level. Two instruments conforming to CISPR specifications were utilized. Anritsu Model ML-428A was used for frequency range of 0.1−30 MHz, whereas Anritsu Model ML-518A was used for frequency range of 25-520 MHz. A loop antena was used with model ML-428A whereas a dipole antena was used with model ML-518A. The measurement results will be presented separately for both areas.

Riyadh Area Substations

Figure 1 shows the EMI spectra measured for transmission lines of three voltage classes in Riyadh area. These measurements were carried out under the transmission lines at a height of 2m above ground at locations which were near and away from the substations. As can be seen from this figure, for each voltage class, the EMI levels at the two locations are similar. The difference between EMI values for a given frequency lies within the statistical variation characteristic of the power line interference. This indicates that these substations do not contribute in any significant manner towards the overall EMI level for the power lines. Many other measurements done in the same fashion for various substations in Riyadh area showed results which were similar to the above. Thus, these results suggest the absence of any appreciable EMI sources such as corona and specifically gap type discharges in the Riyadh area substations. This may be due to absence of rust and loose connections which lead to gap type of discharges in the hardware of these substations. However, this conclusion may not be valid for the future since with the passage of time, the possibility of the formation of rust and loose connections increases. Such conditions (rust and loose connections, etc.) are the "nests" for gap type discharges which can cause severe EMI. Since the distribution in Riyadh City employs underground cables, it was not possible to investigate the impact of substations on the EMI levels of distribution lines.

Qassim Area Substations

At present, Qassim area has only one class of transmission voltage *i.e.* 132 kV. However, most of the distribution in this area is by the overhead lines operating at

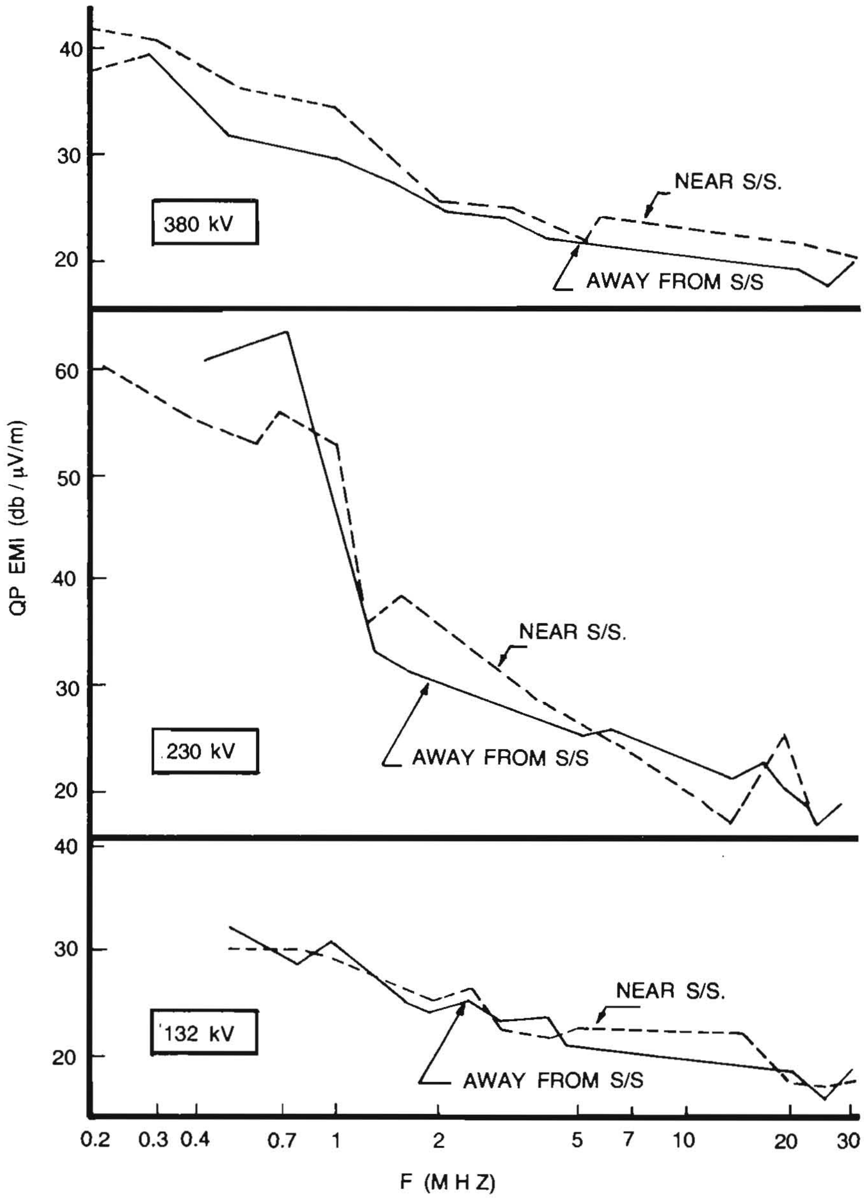

Fig. 1. Typical EMI spectra for Riyadh area transmission lines. "Near" and "Away" mean less than 200 m and more than 2000 m, respectively.

33 kV. Therefore, there are several 132/133 kV substations employing overhead power lines for both voltage levels. Figure 2 shows EMI spectra for one circuit of a 132 kV line measured near and away from Al-Rass substation. It is clear from this figure that the spectrum measured near the substation is nearly flat for the

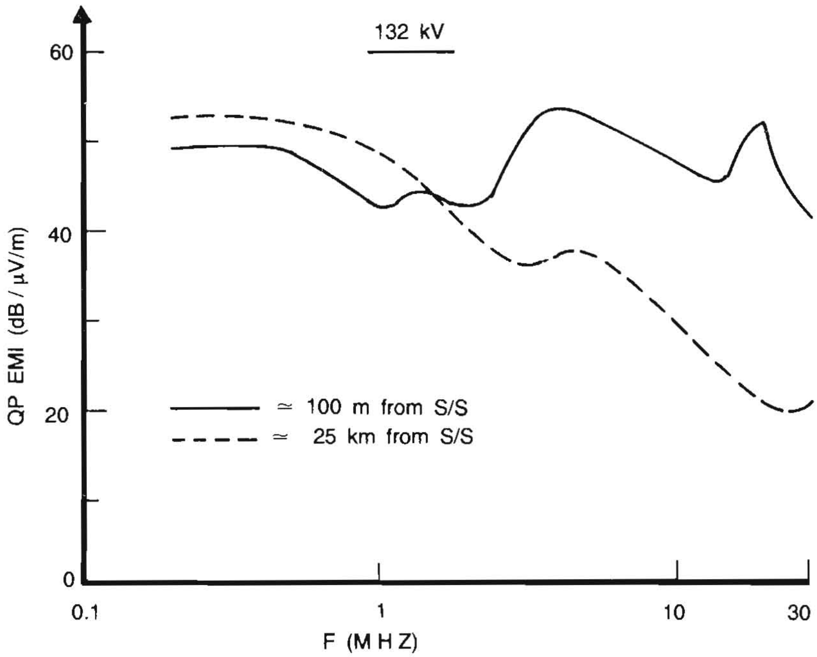

Fig. 2. EMI frequency spectra measured under 132 kV line near and away from Al-Rass substation in the frequency range of 0.2 to 30 MHz.

frequency range of $0.2 < F < 30$ MHz. However, the spectrum measured on the same line at a location which is 25 km away from the substation decays with frequency. The spectrum measured near the substation is characteristic of gap type discharges whereas the spectrum measured at 25 km distance is typical of corona discharges. This line exhibited EMI over the entire frequency range of 0.01 to 520 MHz when measurements were made near the substation as shown in Fig. 3. Such a frequency spectrum is usually associated with gap type discharges rather than corona. The reason for this is the fact that compared to corona current pulses, the gap type discharges introduce current pulses which have small rise and tail times and relatively larger amplitude as found by Al Arainy (1982). Thus, it is clear that this substation has gap type discharge sources. Such sources are caused by rust, loose connections, etc. and inject broad band noise into the transmission lines. When this noise propagates on the transmission lines it is attenuated. The attenuation coefficient depends upon frequency and increases rapidly as the frequency is increased. Consequently, most of the higher frequency components are attenuated rapidly. Thus, the measurements made on the line 25 km away from the substation do not contain noise generated at the substation specifically for frequencies above 10 MHz. In such a case, the EMI is primarily due to the conductor corona. Consequently, the EMI spectrum decays with frequency.

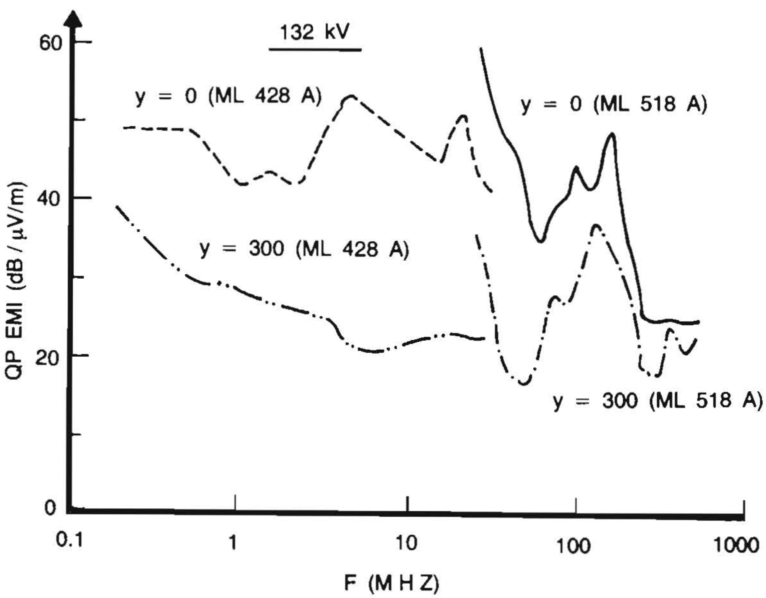

Fig. 3. EMI frequency spectra measured under 132 kV line near the Al-Rass substation over the frequency range of 0.2 to 520 MHz. y is lateral distance from the line.

Several other measurements made in Qassim area exhibited flat frequency spectra when measurements were made near substations. For example, Fig. 4 shows EMI on another 132 kV line. These measurements were carried out under mid span at about 200 m distance from the Qassim central power station in Unaiza. This figure clearly shows that near the substation there is appreciable noise up to a frequency of 70 MHz. Since corona related interference is only significant up to 5 to 10 MHz, this high frequency noise is assumed to have originated somewhere in the substation by gap type discharges.

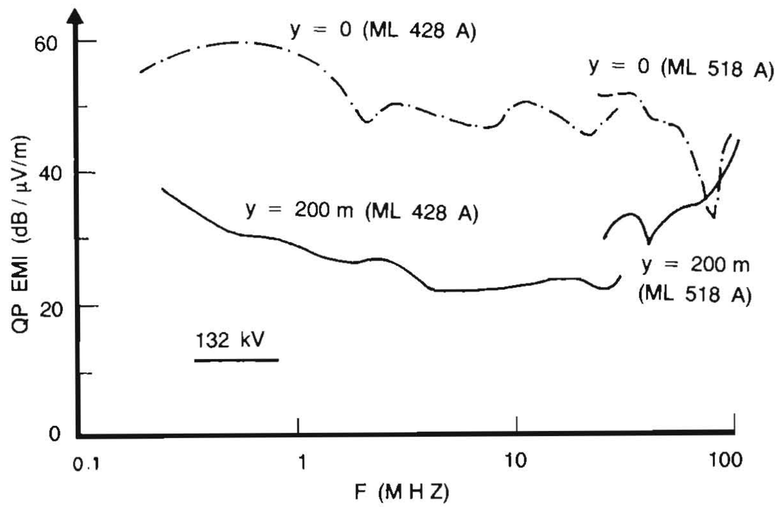

Fig. 4. EMI frequency spectra measured under 132 kV line near Qassim Central Power Station.

For 33 kV distribution lines, it was observed that EMI spectrum measured near the substation was somewhat different from the spectrum that was measured away from the substation. However, the difference in the EMI spectra for these two cases (*i.e.* near and away from the substation) was not too significant. For example, Fig. 5 shows frequency spectra for a 33 kV line measured at about 100m and 3000m from a substation. This figure also shows the ambient noise level measured at each frequency. It is clear from this figure that near the substation, there is about 9 to 10 dB noise at 30 MHz. However, this attenuates very rapidly and the line does not exhibit any interference at 30 MHz when measurements are carried out at a point along the line which is only 3000m away from the substation.

For many substations, EMI measurements were carried out for different outgoing distribution lines. Generally, the spectra measured near the substations were consistent. Figure 6 shows EMI spectra for different outgoing lines from the Mithnab substation. It is interesting to note that all of these lines exhibit some interference at 30 MHz. Since in Qassim area, the ambient noise level at 30 MHz is in the range of 18 to 23 dB, the power line EMI is a few dB higher than the ambient

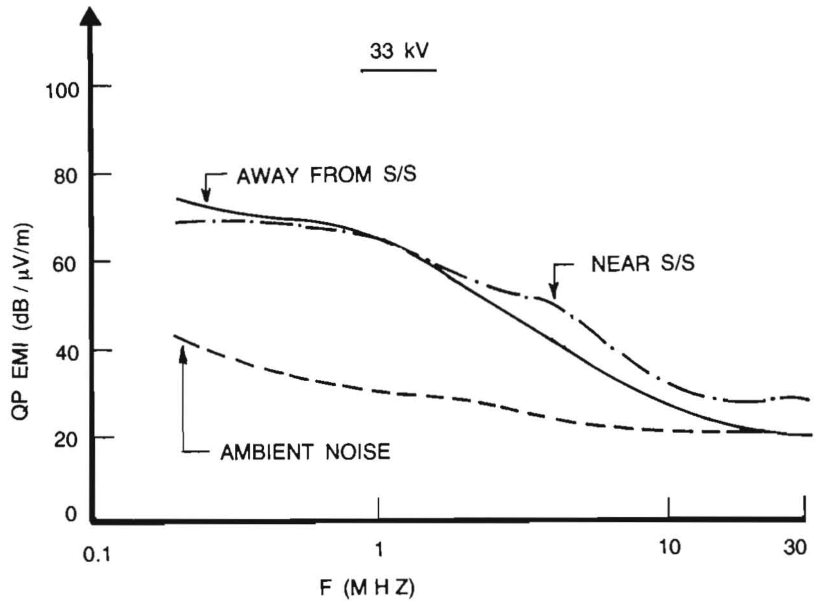

Fig. 5. EMI characteristics for a 33 kV distribution line in Qassim area.

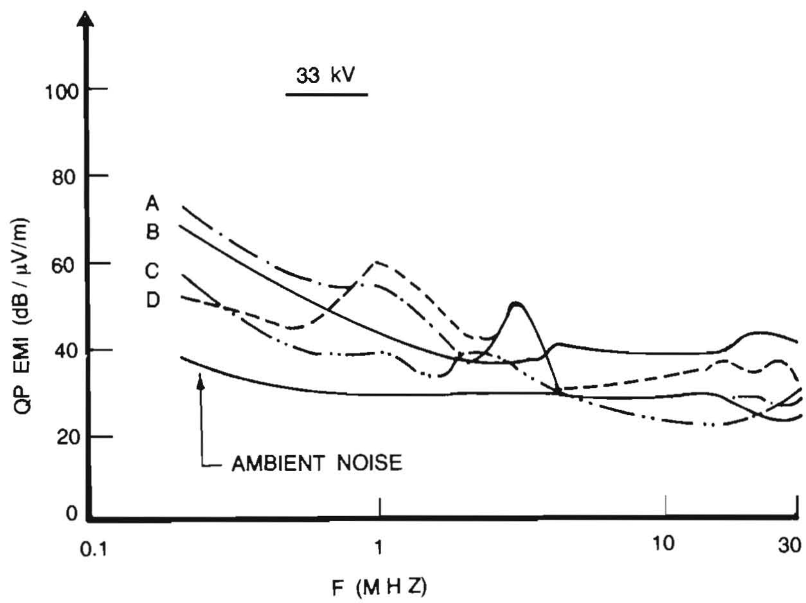

Fig. 6. EMI characteristics of several 33 kV lines outgoing from Al-Mithnab substation.

noise. However, the spectra of these lines decay with frequency and none of the lines shows flat spectra observed for some 132 kV lines (Figs. 2 to 4). Thus, it appears from these results for Qassim area substations, there are no gap type discharges on the 33 kV side. Such discharges tend to increase the interference level of the line for measurements made near the substations. Thus, substations contribute significant levels of EMI specifically at higher frequencies (F $\approx$10 MHz) for points along the lines which are located near the substations. However, as one moves away from the substations, the interference generated at the substations is attenuated and the contribution of substations towards the overall EMI level decreases. For locations which are more than a few kilometers away from the substations, the EMI levels will be primarily due to transmission or distribution line.

Conclusions

This paper shows that the substations can introduce broadband noise into power system components. In the Central Region of Saudi Arabia, Riyadh area substations contribute very little towards the overall EMI from the power lines. However, the Qassim area substations generate appreciable EMI at high frequencies especially on the transmission side. The reasons behind the different behaviour of the two areas may be due to the different design and construction practices used. By passage of time, it is possible that EMI due to gap type discharges from the substations investigated is increased due to further formation of rust and loose connections. However, by proper monitoring and maintenance these problems can be minimised.

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References

Al-Arainy, A.A. (1982) *Laboratory analysis of gap discharges on power lines,* Ph.D. thesis, University of Toronto, Toronto, Canada.

Al-Arainy, A.A., Malik, N.H. and **Abdul-Aal, L.N.,** (1986) *Electromagnetic interference from power lines located in Central Region of Saudi Arabia,* Final Report for KACST project AR-6-38, Riyadh, Saudi Arabia.

CISPR Publication 18-1 (1982) *Radio interference characteristics of overhead power lines and high voltage equipment,* Geneva, Switzerland.

Gary, C. (1981) Radio interference produced by insulator strings: Limit values ad string design, CIGRE Paper S22-81.

Janischewskyj, W. and **Al-Arainy, A.A.** (1981) Corona Characteristics of Simulated Rain", *IEEE Trans.* **PAS-100**(2): 539-551.

Nelson, W.R. and **Schlinger, W.R.** (1976) Construction practices for the elimination and mitigation of RI and TVI sources from overhead power lines, *IEEE Tutorial Courses* # 76 CH1163-5-PWR, pp. 20-33.

Newell, H.H. (1976) Corona and RI cause by particles on or near EHV conductor: I-Fair weather, *IEEE Trans.* **PAS-86:** 1375-1383.

Newell, H.H. (1968) Corona and RI caused by particles on or near EHV conductor: II-Foul weather, *IEEE Trans.* **PAS-87:** 919.

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التشويش الكهرومغناطيسي المنبعث من المحطات الكهربائية الفرعية في المنطقة الوسطى من المملكة العربية السعودية

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ينبعث تشويشا كهرومغناطيسي من مكونات نظام الجهد الفائق نتيجة لما يحدث فيها أو على مقربة منها من تفريغات تاجية وتفريغات كاملة في فجوات هوائية متناهية الصغر. يتناول هذا البحث مستويات التشويش المولدة في المحطة الكهربائية الفرعية الموجودة ضمن شبكة كهرباء المنطقة الوسطى من المملكة.

وقد أمكن معرفة إسهام تلك المحطات لمستوى التشويش المنبعث من الشبكة الكهربائية الكلية بقياس مستويات الطيف تحت خطوط النقل بالقرب من المحطات ومقارنتها بتلك المستويات في أماكن بعيدة عن المحطات (تحت نفس الخط). أختيرت منطقتي القصيم والرياض لهذه الدراسة حيث وجد أن هناك فرق في النتائج بين تلك المحطتين. وبتحليل النتائج أمكن توخى مصادر التشويش في تلك المحطات والأسباب المؤدية إلى تباين مستويات التشويش بين تلك المنطقتين.