FINAL REPORT

ASSESSMENT OF ELECTROMAGNETIC INTERFERENCE TO THE RADIO BASE STATION AT THE WDIV SITE

for

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1. Introduction

The Detroit Cellular Telephone Co. (DCTC) is scheduled to maintain one Radio Base Station (RBS) at a site located about 30.5 m (100 ft) north from the base of the WDIV TV station's 305 m (1000 ft) tall tower containing TV Channel 4 transmitting antenna on top; it is understood that there are other FM and UHF band transmitting antennas also located on the same tower. The receiver and transmitter of the RBS operate in the frequency ranges 825 - 835 MHz and 870 - 880 MHz, respectively. Due to the close proximity of the RBS to the above transmitting station, there has been some concern regarding the amount of possible interference to its performance caused by the radiation from the TV Channel 4 antenna and also from other electromagnetic interference (EMI) sources located either on the WDIV tower or elsewhere in its vicinity. The present report at first estimates the EMI signals in the vicinity of the RBS site and then discusses their possible impact on the RBS performance.

2. General Discussion

Theoretical estimation of the existing EMI signals in the RBS site area is very difficult, if not impossible. This is due to the fact that such an estimation requires precise knowledge of the nature of these sources, their radiation mechanisms, terrain conditions and the propagation environment; even with that knowledge the analysis is often very complicated.

We shall use the available knowledge of the TV Channel 4 transmitting antenna and make some appropriate assumptions to theoretically estimate the strength of the field at the RBS site originating from that antenna. The results will then be compared with those obtained from measurements carried out under another program [1]. This will establish the validity of theoretical as well as measured results. Subsequently, we shall use the results obtained from measurements only.

3. WDIV Tower and the TV Channel 4 Antenna

Figures 1 and 2 show the complete WDIV tower and the TV Channel 4 transmitting antenna on top of the tower, respectively. Several side mounted antennas operating in the FM and UHF frequency ranges are also scattered vertically along the same tower.

The TV Channel 4 antenna consists of standard [2,3] six bays of RCA batwing (superturnstile) antennas. Essentially, the antenna may be considered as a vertically oriented broadside array of six half-wavelength ($\lambda/2$) spaced elements, each element being a standard combination of two batwing antennas in the east-west and north-south directions [3]. The pattern of the antenna is assumed to be omni-directional in the horizontal plane, and directional in the vertical plane having its maximum approximately in the horizontal direction. It is also assumed that for null-filling purposes the vertical plane beam is tilted about five to six degrees below the horizon. The other appropriate information regarding the antenna are given in Table 1.

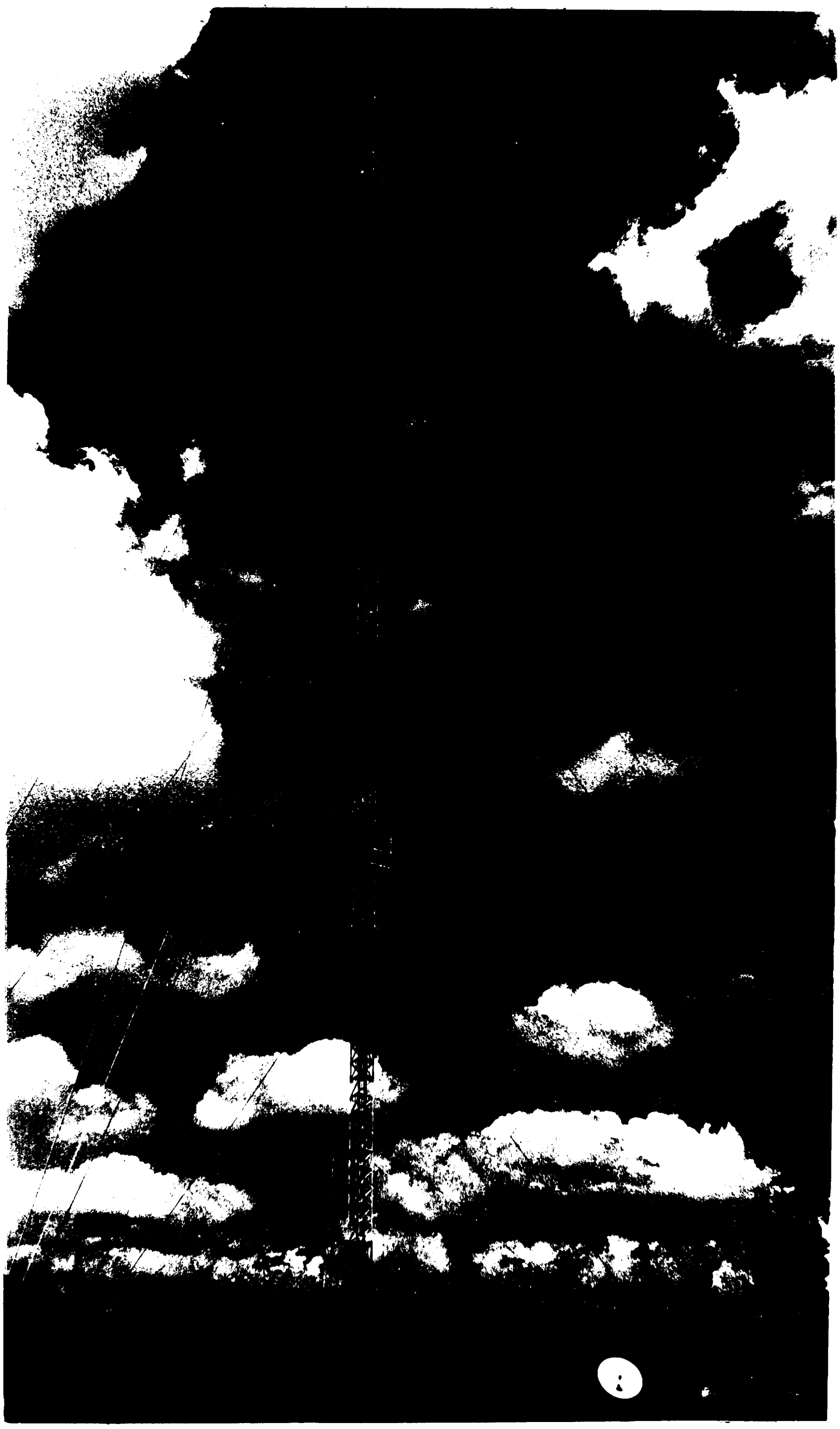

Fig. 1: The WDIV Tower.

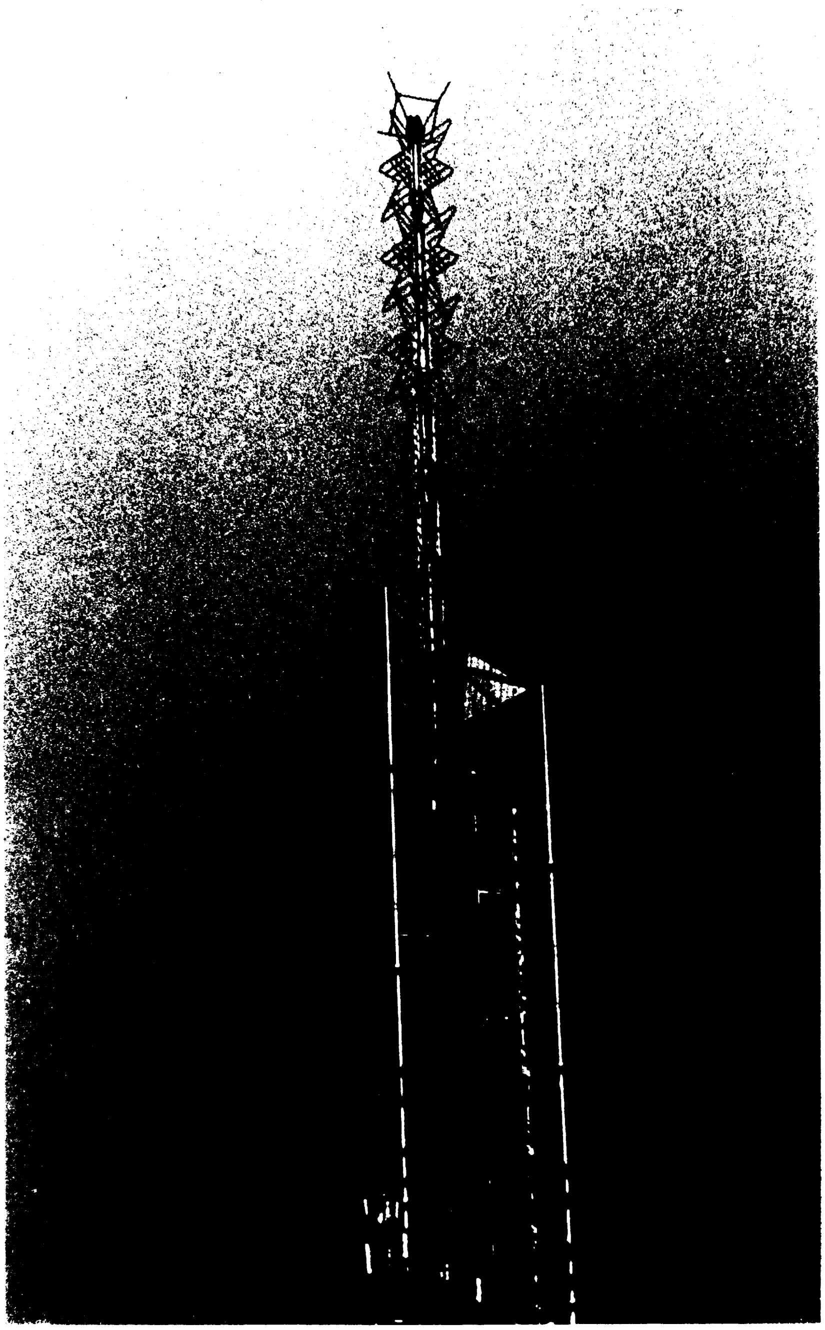

Fig. 2: The TV Channel 4 Transmitting Antenna.

Table 1

Some Information Appropriate for the TV Channel 4 Antenna

Frequency of Operation	:	66 - 72 MHz, for the purpose of calculation we shall assume that the frequency f = 70 MHz, wavelength λ = 4.3 m.
Antenna Type	:	RCA Batwing
Number of Bays	:	6
Effective Radiated Power	:	100 kW
Gain	:	5 (with respect to a $\lambda/2$-dipole
Harmonic Radiation	:	-80 dB (10^{-4} relative voltage)

4. Theoretical Considerations

Assuming that the gain of the antenna with respect to a $\lambda/2$-dipole is g_t and that it radiates a power of P_t, it can be shown that the electric field at a point $P(r,\theta)$ is approximately given by [3]

$$E = \frac{7\sqrt{P_t g_t}}{r} \frac{\sin(3\pi \sin(\theta - \alpha)}{6 \sin\left[\frac{\pi}{2} \sin(\theta - \alpha)\right]} (1 - |\Gamma|) \quad , \qquad (1)$$

where r = the distance of the field point P from the phase center of the antenna,

θ = the angle between the horizontal direction and the line joining the antenna phase center and the point P,

α = the beam tilt angle and

$|\Gamma|$ = the magnitude of the ground reflection coefficient.

In Eq. (1) it has been assumed that the antenna consists of six bays of $\lambda/2$-spaced horizontally polarized elements and is located above a plane earth. It is customary to quote the effective radiated power (P_{eff}) by the antenna instead of the actual power (P_t) radiated. The relationship between these two is given by

$$P_{eff} = P_t g_t \quad . \qquad (2)$$

In our present calculations the ground reflection may be ignored due to the vertical directivity of the antenna, and we shall use the following relationship for field calculations:

$$E \simeq \frac{7\sqrt{P_{eff}}}{r} \; \frac{\sin[3\pi \sin(\theta - \alpha)]}{6 \sin\left[\frac{\pi}{2} \sin(\theta - \alpha)\right]} \quad . \qquad (3)$$

Sample Calculation

Figure 3 shows the geometry of the problem where:

AB = H = tower height,

O is the phase center of the antenna,

P is the location of the field point, located at a height h above the ground,

r, θ parameters are as shown in Fig. 3.

AO = d_p is the distance of O from the top of the tower,

CP = d is the horizontal distance of P from the tower.

In the present case: λ = 4.3 m and H = 305 m, $d_p = 5\lambda/4 = 5.4$ m, d = 7.32 m.

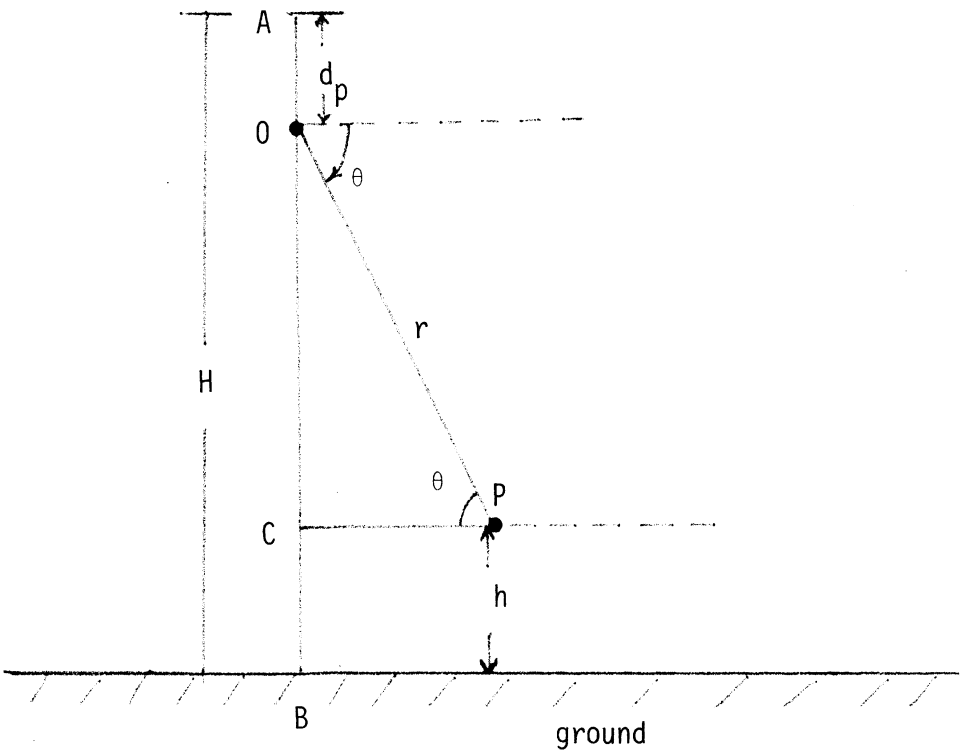

Fig. 3: Geometry of the problem. P is the Field Point.

Thus,

$$\theta \simeq 84^\circ \quad , r \simeq 294 \text{ m} \quad .$$

Assuming $\alpha \simeq 6$ degrees, we obtain from Eq. (3)

$$E = 7 \times \sqrt{100 \times 10^2} \times \frac{\sin(3\pi \sin 78^\circ)}{6 \frac{\pi}{2} \sin 78^\circ}$$

$$= \frac{7 \times 10^2 \times \sqrt{10}}{294} \times 0.0341$$

$$= 0.25 \text{ V/m} \quad .$$

Under the same conditions, the measured field strength [1] obtained on TV Channel 4 is 0.28 V/m which is within 12 percent of the theoretical value. This indicates that Eq. (3), although obtained under a number of assumptions, may be used to compute the desired field strengths provided the characteristics of the antenna are known, and also this establishes the validity of the measured results obtained in [1].

5. Measured Field Strengths

In another program [1], the strengths of various signals in the frequency range of about 0.05 to 1.0 GHz have been measured with the help of standard receiving antenna in combination with a spectrum analyzer and EMI receiver. Both horizontally and vertically polarized signals were measured. Measurements were carried out with the field point P located 30.5 m (100 ft) and 9.1 m (30 ft) from the base of the WDIV tower and at 7.3 m (24 ft) and 3.1 m (10 ft) above ground, respectively. In general, the measured field strengths were found to be insensitive to the present variations of the parameters d and h; also, in most cases the field strengths were found to be of the same order of magnitude for both horizontal and vertical polarizations. Table 2 gives the pertinent results for the various EMI signals obtained in the vicinity of the RBS site; more detailed information and discussion regarding these results may be found in [1].

Table 2

EMI Signals at the RBS Site Near the WDIV TV Channel 4 Antenna Tower

Frequency (MHz)	E (V/m)
57 (Channel 2)	0.32
69 (Channel 4)	0.28
92 (FM)	0.92
825-835	28.5×10^{-6}
871	167.9×10^{-6} (vertical polarization)
871	237.1×10^{-6} (horizontal polarization)
870-880	32.0×10^{-6}

Except for 871 MHz, all signals in Table 2 were of the same orders of magnitude for the horizontal and vertical polarization.

6. Impact on the RBS Performance

A search through the existing literature indicates that there exist no specific standards for the electromagnetic interference susceptibility of the RBS equipment to EMI signals. In the absence of such standards, we shall use the U.S. military standards set forth for various electronic equipment, and discussed in [4]. We quote here the following from [4]:

> "No malfunction, degradation of performance, or deviation from specified indication beyond those given in individual equipment specifications shall occur in the applicable frequency range when the test equipment is subjected to radiated fields as follows:

Frequency	Susceptibility-Level Sheltered	Susceptibility-Level Non-Sheltered
10 kHz - 1.9 MHz	10 V/m	1 V/m
2.0 MHz - 29.99 MHz	20 V/m	10 V/m
30 MHz - 1.9 GHz	50 V/m	10 V/m

> The above susceptibility limit be met for both horizontally and vertically polarized fields."

One of the most comprehensive electromagnetic compatibility or EMC requirements documents for telecommunications equipment is the "EMC Susceptibility Specifications" approved on February 1983 by the Danish Telecommunications Administration. A synopsis of the above document appeared in [5] which indicates that in the frequency range of 0.15 to 2300 MHz the susceptibility limit of the present RBS equipment be about 1 V/m.

Since the maximum EMI signal at the RBS site is below 1 V/m at any of the frequencies of concern, it may thus be concluded that according to presently available standards, the performance of the

RBS at the base of the WDIV tower will not be adversely affected by the EMI signals that exist there.

7. References

[1] J. E. Ferris, "Detroit Cellular Telephone Site Survey," DCT TR-001, JEF Consultant, Saline, MI, August 1984.

[2] H. Jasik, "Antenna Engineering Handbook", McGraw-Hill Book Co., New York, pp. 23-8-23-11, 1961.

[3] G. W. Bartlett, "National Association of Broadcasters Engineering Handbook," Sixth Edition, National Association of Broadcasters, 1771 N. Street, N.W., Washington, DC 20036, 1975.

[4] J. S. Hill and D.R.J. White, "EMI Specifications, Standards, and Regulations," Don White Consultants, Inc., Germantown, Maryland, pp. A5.131-132, 1975.

[5] R. W. Brewer, "Standards and Regulations," EMC Technology, Vol. 3, No. 4, pp. 30-31, October-December 1984.