MEASUREMENTS OF RADIO NOISE IN THE DELHI AREA—PART I

by

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ABSTRACT

Measurements of radio noise levels were carried out at several field locations (which also included industrial areas), in and around the city of Delhi (28° 35′N, 77°5′E) by an objective method using a portable equipment (Noise and Field Intensity meter—model NF-105 manufactured by the Empire Devices Products Corp., New York). Noise level values for the frequency band 150 Kc/s to 21 Mc/s were obtained during the month of July (1958), when the atmospheric levels usually have maximum values during this period of the year. Tables of Noise levels are given both in field strength values in microvolts/metre per Kc. bandwidth as well as in Noise Power in db above kTB. The results obtained indicate that the noise grade figures for this area need revision.

Introduction

Knowledge of the radio noise level obtaining in various radio channels in a given area is a necessary prerequisite for planning and establishment of communication service in that area, for selection of suitable channel and for evaluation of minimum signal strengths required for providing satisfactory service. A comprehensive information of the noise levels through the entire radio frequency spectrum is thus of vital importance to the Defence Services.

Studies of radio-noise levels have been in progress, ([1,2,3,4]) both in Great Britain and United States, for a number of years. Considerable amount of data has been collected from extensive measurements of noise levels at a number of stations scattered over the globe and predictions of world wide noise levels have been published. However, the method of interpreting the earlier predictions were not entirely clear partly due to different methods of measurement employed by different workers which made correlation rather difficult. Also measurements are often vitiated by the presence of man-made noise or by lack of sensitivity in the equipment. This state of affairs exists even today.

Attempts are being made by various agencies, notably C.C.I.R. (International Radio Consultative Committee) to standardise the methods of measurements and systematise the presentation of data by choosing parameter that will minimise the difficulty of interpretation. The measurements are confined to the frequency Band 10 Kc/s to 100 Mc/s.

Characteristics of Radio Noise—External radio noise is now understood to be mainly of three types : namely, atmospheric, manmade and galactic. Each type has different characteristics. The present report is concerned with the first two types only.

Atmospheric noise consists in general of short pulses with random recurrence superimposed upon a background of random noise. If these short time variations of instantaneous noise power are averaged over a period of several minutes, this average power level is found to be relatively constant during a given hour, the variations seldom exceeding two or three db, except during sunrise or sunset, or during a local storm. The basic parameter used is, therefore, the median value of the average power during a period of one hour—called the hourly value. These hourly values vary with

(1) the time of the day

(2) frequency and location of thunderstorms

(3) the frequency of the radio wave

(4) Geographical locations

and (5) topography.

Man-made noise arises from various sources such as, industrial machinery, electric power transmission lines, automobile ignition system—medical and other electrical apparatus. Thus its characteristics may vary over a wide range. Its level, however, decreases with increasing frequency owing in part to radiated spectrum and partly because of propagation.

It was considered desirable that the Radar and Electronics Research Unit at the Defence Science Laboratory undertake a programme of work on measurements of Radio Noise Levels at various frequencies with a view to provide important data for optimum performance of the Service Electronic equipments as well as to co-operate with other organisations to pool the data for purpose of correlation. The present work describes the initiation of this programme in as mush as it describes the equipment used, manner of the presentation of data in forms accepted today and their interrelation. Measurements were confined to the areas in and around the city of Delhi/New Delhi in the first instance and were carried out during the month of July 1958 under cloudy weather conditions.

An objective method was adopted for measurements of radio noise levels employing direct reading and portable equipment. The readings were then reduced to noise field intensities in μ *V/m/Kc* bandwidth and to noise powers above the thermal noise level (in kTB) as recommended in C.C.I.R. report No. 65.[2]

Experimental set up and method of Measurement

Measurements of radio noise levels were carried out at several field locations in and around Delhi (28°35′N, 77°5′E). These included highly industrial areas where manmade noise levels would predominate as well as those outside the city limits where the random atmospheric noise would be the main contributory factor.

The equipment used is the Noise and Field Intensity Meter—model NF—105 manufactured by the Empire Devices Products Corp., New York. This is a portable equipment with the following main features:—

(*a*) *Receiving Antenna*

A vertical 41″ collapsible rod is used as the receiving antenna. The antenna impedance is matched to the input impedance of the receiver through matching devices at various frequency bands.

(b) *Calibrating Source*

An impulse generator, producing extremely short pulses at variable repetition rates, constitutes the standard noise source. The impulse noise spectrum is flat from 10 Kc/s to 1000 Mc/s. In the present studies the pulse repetition rate of the impulse source is kept at 1000 c/s. With the standard attenuator provided, impulse signal can be fed at various levels to the input of the receiver for estimating the level of unknown noise level by the substitution method.

(c) *Output Meter Circuits*

For measurements of peak levels the meter time constant is made large by using a discharge resistor of 50 megohms. The discharge time is further increased by applying the 50 megohm in the grid circuit of one half of a double triode with negative feed back so that it operates as a resistance "magnifier" or a pulse stretcher. Under these conditions of time constant the output meter was found to faithfully reproduce pulse peaks of lower repetition rate. The double triode also operates, simultaneously, as a bridge type vacuum tube voltmeter circuit.

(d) *Method of Measurements*

In the present measurements, the visual substitution method was adopted. The antenna was connected to the input receptical of the receiver and the instrument was tuned to the desired frequency within a clear channel. By adjusting the signal input attenuator, which is provided, and by controlling the I/F gain, a reference reading was obtained on the output meter. When the received noise signal was fluctuating, the reference reading was taken corresponding to the highest reading. The antenna was then disconnected and the output of the impulse generator level was adjusted with the impulse level attenuator to get the same reference reading on the output db meter. The correction factors, on account of the finite bandwidth of the receiver and the correction factor for obtaining the conditions of loss-less antenna, which were provided, were added to the impulse generator level to get the received noise level in db above 1$\mu V/Mc$. This is the received level from a loss-less antenna across an impedance of 50 ohms. Table 1 gives the measured values of noise levels expressed in db above 1 $\mu V/Mc$, as well as, in $\mu V/Kc$ for various locations and frequencies of operation. These noise levels are then reduced to (1) noise field strength in $\mu V/m/Kc$ and (2) noise powers above kTB as given in the following section.

Results

(a) Table II gives the values of noise field strengths per meter per Kc for the various locations and frequencies. These values were calculated from the noise levels in db above 1 $\mu V/Kc$ given in Table I by using the relation for a loss-less isotropic antenna,

$$E_r = \epsilon \frac{\lambda}{\pi} \sqrt{\frac{R_a}{480}} \quad \ldots \quad (1)$$

where E_r =received noise level in V/Kc across an input impedance of R_a ohms.

TABLE I

Measured Values of Noise Level in db Above 1 μV/Mc and in μV/Kc

Frequency	1		2		3		4		5	
	db	*μV/Kc*	*db*	*μV/Kc*	*db*	*μV/Kc*	*db*	*μV/Kc*	*db*	*μV/Kc*
150 Kc/s	110	316	123	1410	126	2000	125	1780	113	447
400 Kc/s	104·5	168	..	..	115·5	597	110·5	336	113·5	472
750 Kc/s	96	63·2	100	100	117	708	119	891	110	316
1 Mc/s	103·5	150	102·5	133	112·5	423	109·5	297	104·5	168
3 Mc/s	89	28·2	..	..	104	158	106	200	103	141
5 Mc/s	89·5	29·7	88·5	26·5	107·5	237	99·5	94	100·5	105
10 Mc/s	84	15·8	83	14·1	101	112	87	22·4	78	7·94
15 Mc/s	67	2·2	80	10	109	282	92	39·8	81	11·2
21 Mc/s	75	5·6	75	5·6	93	44·7	85	17·8	75	5·6

TABLE I—*contd.*

Frequency	6		7		8		9		10	
	db	$\mu V/Kc$	*db*	$\mu V/Kc$	*db*	$\mu V/Kc$	*db*	$\mu V/Kc$	*db*	$\mu V/Kc$
150 Kc/s	134	5010	100	100	120	1000	123	1410	105	178
400 Kc/s	116·5	665	95·5	59·7	121·5	1200	125·5	1880	103·5	150
750 Kc/s	122	1260	100	100	119	891	124	1580	104	158
1 Mc/s	114·5	530	101·5	120	115·5	597	122·5	1330	104·5	168
3 Mc/s	111	355	89	28·2	108	251	123	1410	101	112
5 Mc/s	102·5	133	89·5	29·7	108·5	265	115·5	597	95·5	59·7
10 Mc/s	106	200	78	7·94	90	31·6	100	100	88	25·1
15 Mc/s	104	158	81	11·2	97	70·8	81	11·2	74	5
21 Mc/s	105	178	75	5·6	80	10	69	2·82	62	1·26

LOCATION

1. N.P.L. Workshop
2. N.P.L. Front Pond
3. Connaught Place (Hindustan Times)
4. Connaught Place (Inner Circle)
5. Najafgarh Road
6. Fountain
7. University of Delhi
8. Delhi Gate
9. Safdarjung Airport
10. Ridge

TABLE II

Field Strength in μV/m/Kc using Equation (1)

Frequency	1	2	3	4	5	6	7	8	9	10
150 Kc/s	1·538	6·861	9·731	8·662	2·174	24·39	0·4867	4·866	6·861	0·8662
400 Kc/s	2·178	..	7·747	4·359	6·124	8·628	0·7747	15·59	24·44	1·946
750 Kc/s	1·535	2·432	17·22	21·68	7·543	30·62	2·433	21·68	38·44	3·844
1Mc/s	4·866	4·347	13·72	9·636	5·450	17·22	3·893	19·36	43·15	5·443
3 Mc/s	2·743	..	15·38	19·42	13·72	34·53	2·745	24·43	137·2	10·9
5 Mc/s	4·817	4·298	38·46	15·24	17·03	21·57	4·817	42·87	96·83	9·683
10 Mc/s	5·140	4·574	36·39	7·261	2·576	64·88	2·576	10·29	32·43	8·147
15 Mc/s	1·070	4·866	137·1	19·37	5·450	76·90	5·462	34·45	5·462	2·439
21 Mc/s	3·815	3·815	30·45	12·10	3·815	121·0	3·815	6·817	1·921	0·8584

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ϵ = noise field strength in $\mu V/m/Kc$

λ = wavelength in meters.

The relation (1) has been obtained from the well-known fundamental equation of a receiving antenna,—.

$$i_a = \frac{\sqrt{R_a G_a}.\lambda \; \cos\psi \; \varepsilon}{Z_{aa} \; \pi \sqrt{120}} \quad .. \quad .. \quad .. \quad (2)$$

For maximum power delivered to the receiver from a lossless isotropic antenna, when $\psi = 0$, $Z_{aa}=2R_a$ & $Ga = 1$ equation (2) reduces to

$$i^2_a R_a = \frac{\lambda^2 \varepsilon^2}{480\pi^2} = \frac{E^2_r}{R_a} \quad .. \quad .. \quad (3)$$

from which relation (1) follows.

(b) The values of noise powers given in table (III) were calculated from the noise levels given in table (I) by using the relationship

$$F_a = 10 \log_{10} \frac{E_r{}^2}{R_a kTB} \quad .. \quad .. \quad .. \quad (4)$$

where F_a = Noise power in db above kTB

E_r = Noise levels in $\mu V/Kc$ across input impedance R_a, given in Table I.

k = Boltzman constant

T = Temp. in abs. deg.

B = Bandwidth in c/s

(c) C.C.I.R. report No. 65[2] gives relationship between the noise powers in db above kTB and noise field strength in db above 1 $\mu V/m/Kc$ which is as follows:—

$$E_n = F_a - 65{\cdot}5 + 20 \log_{10} f_{mc} \quad .. \quad .. \quad .. \quad (5)$$

where E_n = rms field strength in db above $1/\mu V/m/Kc$

f_{mc} = frequency in Mc/s

The above relation assumes the effective height of the antenna, h_e, to be related to the radiation resistance, R_a, as

$$\frac{h^2_e}{R_a} = \frac{\lambda^2}{160\pi^2} \quad .. \quad .. \quad .. \quad .. \quad (6)$$

[National Bureau of Standards (U.S.A.) Circular No. 557][1].

The values of noise field strength in $\mu V/m/Kc$, corresponding to the noise level of table I, are computed from the noise powers given in table III by using the above relationship (5) and are shown in Table IV.

It will be seen from a comparison that the values in tables II & IV both of which give the values of noise field strength in $\mu V/m/Kc$ derived from the same data, are of the same order of magnitude. However, there is constant difference of about 10% in the two values. This can be explained by the fact that

TABLE III

Noise Power F_a in db above k B

Frequency	1	2	3	4	5	6	7	8	9	10
150 Kc/s	87	100	103	102	90	111	77	97	100	82
400 Kc/s	81·5	..	92·5	87·5	90·5	93·5	72·5	98·5	102·5	80·5
750 Kc/s	73	77	94	96	87	99	77	96	101	81
1 Mc/s	80·5	79·5	89·5	86·5	81·5	91·5	78·5	92·5	99·5	81·5
3 Mc/s	66	..	81	83	80	88	66	85	100	78
5 Mc/s	66·5	65·5	84·5	76·5	77·5	79·5	66·5	85·5	92·5	72·5
10 Mc/s	61	60	78	64	55	83	55	67	77	65
15 Mc/s	44	57	86	69	58	81	58	74	58	51
21 Mc/s	52	52	70	62	52	82	52	57	46	39

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TABLE IV

Noise Field Strength in uV/m/Kc using Equation (5)

Frequency	1	2	3	4	5	6	7	8	9	10
150 Kc/s	1·782	7·964	11·25	10·02	2·519	28·26	0·5637	5·637	7·945	1·002
400 Kc/s	2·524	..	8·956	5·036	7·114	10·05	0·8956	17·86	28·32	2·25
750 Kc/s	1·778	2·818	19·95	25·12	8·915	35·57	2·818	25·12	44·67	4·467
1 Mc/s	5·623	5·012	15·85	11·22	6·310	19·95	4·467	22·39	50·12	6·310
3 Mc/s	3·177	..	17·86	22·5	15·92	40·00	3·177	28·31	159·2	12·65
5 Mc/s	5·623	5·012	44·67	17·78	19·95	25·12	5·623	50·12	112·2	11·22
10 Mc/s	5·957	5·309	42·19	8·414	2·985	74·99	2·985	11·89	37·58	9·441
15 Mc/s	1·262	5·636	158·9	22·45	6·325	89·35	6·325	39·91	6·325	2·826
21 Mc/s	4·438	4·438	35·26	14·04	4·438	140·4	4·438	7·893	2·224	0·9935

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in deriving relationship (1) the ratio of the square of the effective height of the antenna to the radiation resistance has been taken to be:[5]

$$\frac{h^2_e}{R_a} = \frac{\lambda^2}{120\pi^2} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

It is seen from (6) and (7) that the effective height of the antenna used in the relation (5) is $\frac{\sqrt{3}}{2}$ times the corresponding ratio in (1). Therefore, the values of field strength computed by using the relation (1) would be $\frac{\sqrt{3}}{2}$ times the corresponding values computed by using the relation (5). This explains the apparent difference of about 10% in the field strength values presented in Table II and IV.

Discussion

It is seen from Table II (or IV) that the measured values of the Noise Field Strength vary from a minimum of 0·48 to a maximum of 143·5 $\mu V/m/Kc$ at various frequencies as well as locations. As has been stated earlier, these values include both the atmospheric as well as manmade noise. A closer examination, however, would reveal the fact that the locations chosen group themselves into three broad categories—(1) those where the values are rather high throughout the frequency range as in columns 3, 6, 8 and 9 which indicate proximity to industrial sources. Location 3 corresponds to the Hindustan Times Press operated by large D.C. motors. Location 6, Chandni Chowk Area is also cluttered up with a large number of D.C. installations as well as a few radio repair shops in the interior. In contrast to these, locations 1, 2, 7 and 10 which are at the National Physical Laboratory, Delhi University and the Ridge are fairly removed from industrial installations and show smaller values of the noise field strengths, which are due mainly to the atmospheric contributions. A comparison of these values with those predicted from the C.C.I.R. charts is given in the following table V.

TABLE V

Frequency	0800—1200 Hrs. Time Block			1200—1600 Hrs. Time Block		
	Predicted value from Ref. 2	Measured values as per Table II Col. 1 *	Measured values as per Ref. 4	Predicted value from Ref. 2	Measured values as per Table II Col. 7 *	Measured Values as per Ref. 4
150 Kc/s	+2·0	+3·78	..	+21·0	—6·256	..
400 Kc/s	—23·0	+6·78	..	+3·0	—2·218	..
750 Kc/s	—37·5	+3·78	..	—7·5	+7·72	..
1 Mc/s	—41·0	+13·74	..	—10·0	+11·8	..
3 Mc/s	—42·0	+8·756	+1·2	—15·0	+8·77	+4·0
5 Mc/s	—25·0	+13·66	+0·3	—12·0	+13·6	+3·4
10Mc/s	—19·0	+14·2	—3·2	—8·0	+8·2	+2·0
15 Mc/s	—20·0	+0·58	..	—13·0	+14·75	..

NOTE:—All values are in *db* above 1 $\mu V/m/Kc$.

* The values are 20 $\log_{10}$ ε, where 'ε' is value given in Table II.

It will be seen that except for the frequency of 150 *Kc/s*, the values of radio noise levels predicted from the C.C.I.R. charts are very much smaller than the observed values for the same time blocks. Further the measured values for either time blocks are more or less of the same order of magnitude whereas the predicted values show wide variations. Ghosh and Mitra[4] have reported values of noise level at Delhi as obtained from subjective measurements. Their values reduced to 1 *kc* bandwidth are given in column 3 of table V for these frequencies. These are about 15 *db* higher than the predicted values for 1200—1600 hrs. and 25 *db* higher in 0800—1200 time block. The difference between the values reported in this investigation and those of column 3, arises from the fact that whereas Ghosh & Mitra have employed a subjective method with statistical correlation factor to obtain a mean value the present work reports only the peak values of noise levels. However, the trend of the measured values points to the obvious conclusion that noise grades require revision for this area as suggested. Since paucity of the sufficient data may be responsible for this state of affairs, further measurements are in progress and will form subject of later communications.

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