REPORT 516-4

FIELD STRENGTH RESULTING FROM SEVERAL ELECTROMAGNETIC FIELDS

(Question 44/10, Study Programme 44A/10)

(1970-1978-1982-1986-1990)

Studies have been carried out in Italy [CCIR, 1966-69] and in Hungary [CCIR, 1978-82] on the composition of several stable electromagnetic fields at the same point.

1. Field strength resulting from two stable electromagnetic fields

If two fields of different frequencies are considered at a point in space:

$$E_1 = A \cos \omega t \tag{1}$$

$$E_2 = B \cos [(\omega + \Delta\omega)t + \varphi] \tag{2}$$

where A, B, ω, $\Delta\omega$ and φ are constant in time, and if it is assumed that both fields are polarized in the same direction, the instantaneous amplitude of the vector representing the resultant field is:

$$E = \sqrt{A^2 + B^2 + 2AB \cos (\Delta\omega t + \varphi)} \tag{3}$$

The mean value of E in the period $T = 2\pi/\Delta\omega$ is:

$$E_R = \frac{1}{T} \int_{t_0}^{t_0 + T} E(t)\, dt = Af\ (A/B) \tag{4}$$

The $\Delta\omega$ frequency component of E for the same period is:

$$E_{\Delta\omega} = \left(\frac{2}{T}\right) \int_{t_0}^{t_0 + T} E(t) \cos (\Delta\omega t + \varphi)\, dt \tag{5}$$

If the values A, B, E_R and $E_{\Delta\omega}$ (dB(μV/m)) are designated by E_1, E_2, $(E_1 + \Delta R)$ and $(E_2 + \Delta E)$ respectively and assuming that $E_1 \geqslant E_2$, a graph can be drawn of the values of ΔR, as indicated by a field measuring device, and of ΔE as a function of $(E_1 - E_2)$, and the curves shown in Fig. 1 (continuous line) and Fig. 2 are obtained.

The dotted line shown in Fig. 1 is obtained by calculating the r.m.s. of the amplitudes of the two fields:

$$E_R = \sqrt{A^2 + B^2} \tag{6}$$

The values of the first curve (continuous line) in Fig. 1 are always lower than those of the second curve, for each value of $(E_1 - E_2)$. The maximum difference is 0.9 dB for $E_1 = E_2$.

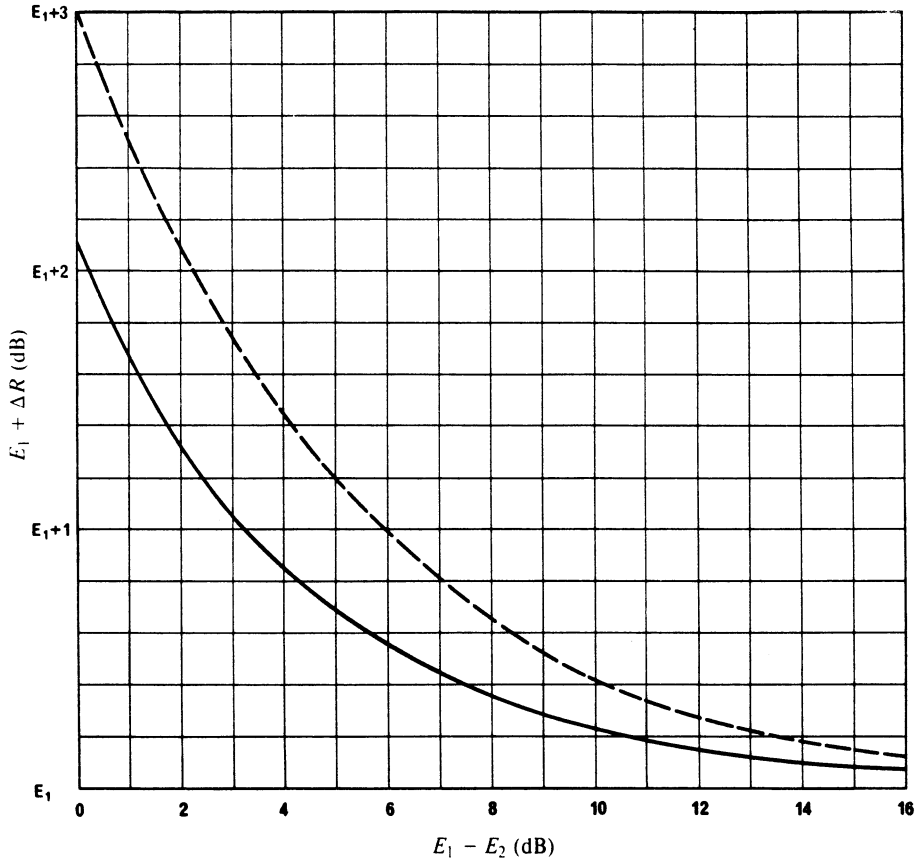

FIGURE 1 – *Resultant ($E_1 + \Delta R$) of two stable electromagnetic fields ($E_1 > E_2$)*

——— : value indicated by a field measuring device

— — : value calculated by adding the powers of the two signals

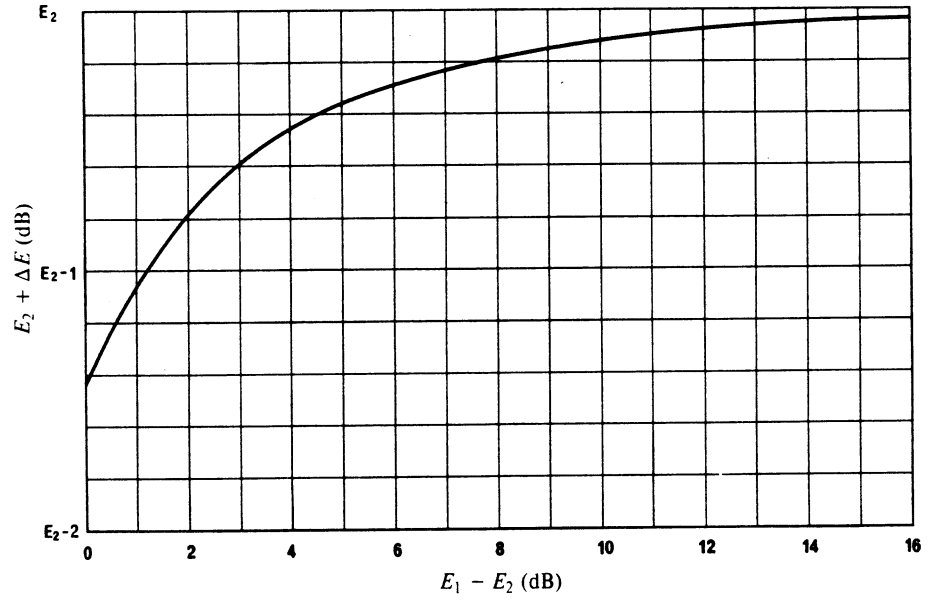

FIGURE 2 – *($E_2 + \Delta E$) component in the resultant of two stable electromagnetic fields ($E_1 > E_2$)*

2. Field resulting from three stable fields

Let:

$E_1 = A \cos \omega t$
$E_2 = B \cos [(\omega + \Delta\omega_1)t + \varphi_1]$
$E_3 = C \cos [(\omega + \Delta\omega_2)t + \varphi_2]$

be three fields (with the same assumptions as before).

If the values A, B, C, the mean value and amplitude of the components of the vector representing the resultant (dB(μV/m)) are designated by E_1, E_2, E_3, $(E_1 + \Delta R)$, $(E_2 + \Delta E_1)$ and $(E_3 + \Delta E_2)$ respectively and assuming that $E_1 \geqslant E_2$ and $E_1 \geqslant E_3$, graphs can be drawn in which the curves give the values of ΔR and ΔE_1, ΔE_2 as a function of $(E_1 - E_2)$ and $(E_1 - E_3)$.

The results are shown in Figs. 3 and 4.

It can be seen, for example, that when $E_1 = 63$ dB, $E_2 = 62$ dB and $E_3 = 60$ dB, then $\Delta R = 2.8$ dB, $\Delta E_1 = 3.7$ dB and $\Delta E_2 = 3$ dB.

For information concerning the measurement of ΔE, ΔE_1 and ΔE_2, refer to Report 273.

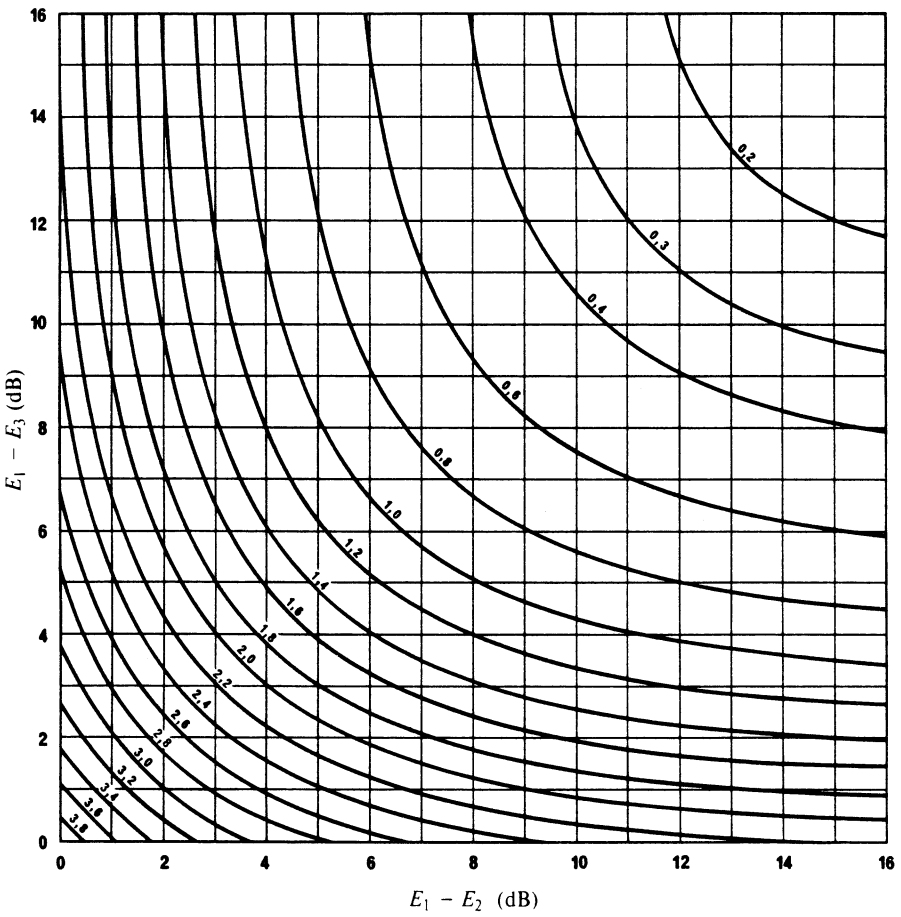

FIGURE 3 – *Family of curves $(E_1 + \Delta R)$ resulting from three stable electromagnetic fields $(E_1 > E_2, E_1 > E_3)$*

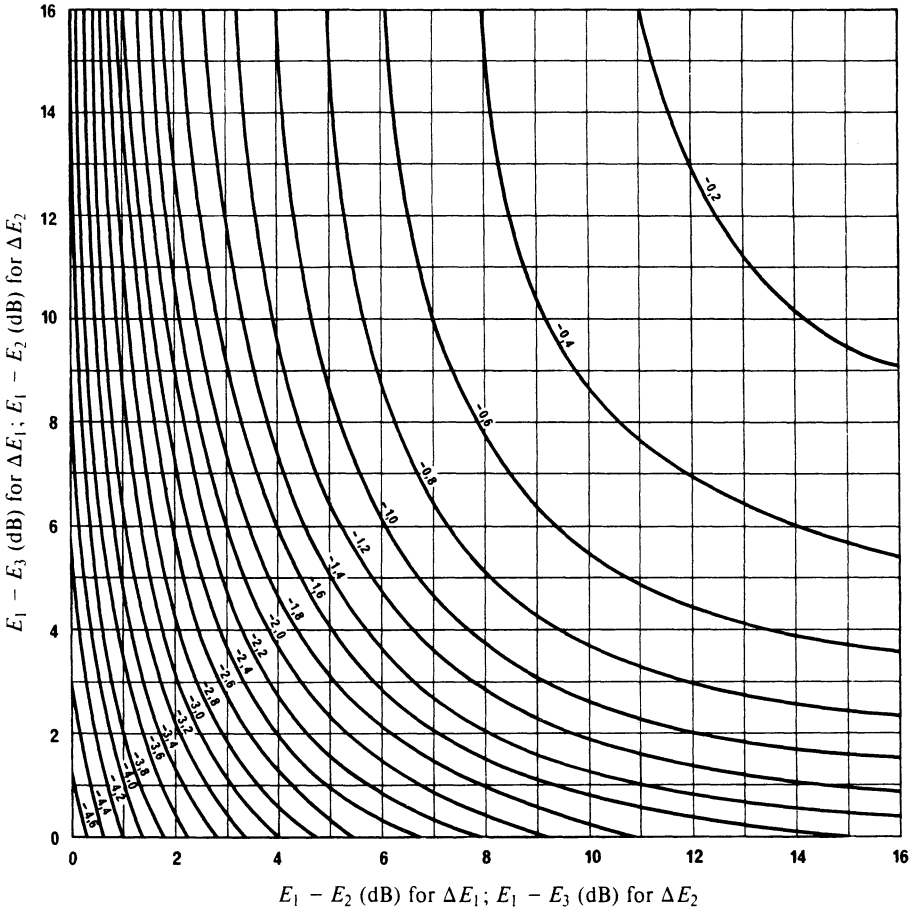

FIGURE 4 – *Family of curves ($E_2 + \Delta E_1$) and ($E_3 + \Delta E_2$) in the resultant of three stable electromagnetic fields*

3. Median field strengths resulting from synchronized HF transmitters

According to investigations carried out in the USSR [CCIR, 1986-90] in connection with the determination of the signal/interference ratio for planning purposes in the case of the synchronized operation of two radio stations which set up median field-strengths E_1 and E_2 at a receiving point, the median level of the aggregate signal may be obtained by adding values of ΔE_s to the larger of E_1 and E_2, in accordance with the following table:

Absolute value of difference $\lvert E_1 - E_2 \rvert$ (dB)	0	1	2	3	4	5	6	7
ΔE_s, dB	4	3.7	3.3	2.8	2.2	1.8	1.4	1.1

For a difference $\lvert E_1 - E_2 \rvert$, equal to 8 dB or more, the real increase is less than 1 dB and is practically equivalent to the arithmetical addition of the powers of the incoming signals. The values of ΔE_s which are given correspond to the total standard deviation of slow fades i.e. 6 dB.

4. Experimental results

Measurements of field strength carried out at the RAI monitoring centre at Monza and at the Hungarian monitoring station at Tárnok have led to the following deductions:

- considering two or three amplitude-modulation emissions in band 6 (MF) on the same channel;
- assuming a difference of at least a few hertz between the carrier frequencies, and
- assuming that the signals at the reception point are stable,

it may be assumed that the measured value of the resultant field is, with an approximation of 0.2 dB, that which is deduced from the continuous lines in Figs. 1 to 4 respectively.

REFERENCES

CCIR Documents

[1966-69]: X/56 (Italy).

[1978-82]: 1/143, 10/198 (Hungary (People's Republic of)).

[1986-90]: 10/253 (USSR).

BIBLIOGRAPHY

FENTON, L.F. [1960] - *The sum of log-normal probability distributions in scatter transmission systems,* IRE Trans, CS-8.