—ノート—

バンドメータ校正のための占有周波数帯幅の実用標準について

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A Practical Standard of Occupied Bandwidth for Testing of Band-Meter

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In calibrating the occupied bandwidth meter, a simple calibration method, utilizing the reference signal which is the calculated bandwidth of AM or FM signal, which can be easily generated with a standard signal generator, is effective in practical use. This paper describes the principle of this method and the necessary conditions of the reference signal mentioned above.

This is the abstraet of the paper which is inserted into Electronics and Communications in Japan [1] by the author.

The band meter [2] for measurement of the occupied bandwidth as defined in the International Telecommunication Convention [3] is an important instrument for the regulation and operation of radio stations. In calibrating the band meter, the divisional calibrating method which is to measure the characteristic of each part of the equipment has been adopted, but this method is impractical and complicaed. Therefore, an effective and accurate way of calibration of the band meter should be the over-all calibration method. This paper describes a new simple method of over-all calibration utilizing the reference signal which is the calculated bandwidth of AM or FM signal.

AM method: The ratio of sidebsnd power to total power of an AM signal which is modulated with a sinusoidal wave is written

$$A = \frac{m^2/2}{1+(m^2/2)} = \frac{m^2}{2+m^2} \tag{1}$$

where m is the modulation factor of AM signal. This relation is plotted in Fig. 1, and we can find the calibrating points from this figure. As an example, the power ratio of the signal modulated with 14.21% by 1KHz is 1%.

Therefore, the occupied bandwidth is 2KHz. Error of the power ratio is given by

$$\frac{\Delta A}{A} = \frac{4}{2+m^2} \cdot \frac{\Delta m}{m} \doteqdot 2\frac{\Delta m}{m} \tag{2}$$

If the signal contains some distortions or residual FM components, the power ratios are, respectively:

$$A' = \frac{\sum_{n=1}^{\infty}(m_n^2/2)}{1+\sum_{n=1}^{\infty}(m_n^2/2)} \doteqdot A(1+k^2) \tag{3}$$

$$A'' \doteqdot \frac{\left\{J_1(\beta)+\frac{m}{2}J_0(\beta)\right\}^2+\left\{-J_1(\beta)+\frac{m}{2}J_0(\beta)\right\}^2}{J_0^2+\left\{J_1(\beta)+\frac{m}{2}J_0(\beta)\right\}^2+\left\{-J_1(\beta)+\frac{m}{2}J_1(\beta)\right\}^2} \tag{4}$$

where k is the distortion factor, β is the residul FM index, and $J_n(\beta)$ is the Bessel function of the first kind n-th order with argument β.

FM method: The ratio of sideband (from sideband number n=1 to n=N) power to total power of a FM signal which is modulated with a sinusoidal wave, is written

$$B = \frac{\sum_{n=-N}^{N}J_n^2(\beta)}{\sum_{n=-\infty}^{\infty}J_n^2(\beta)} = \sum_{n=0}^{N}k_n J_n^2(\beta) \tag{5}$$

where $k_0=1$, $k_n=2, n=1,2,3,\cdots\cdots$. In the case of N=3, this relation is shown in Fig. 2. This curve may be used for determining the occupied bandwidth.

For example, as the modulation index is 2.4 for the power ratio B=99%, it will be seen that the occupied bandwidth is equal to 2N times the
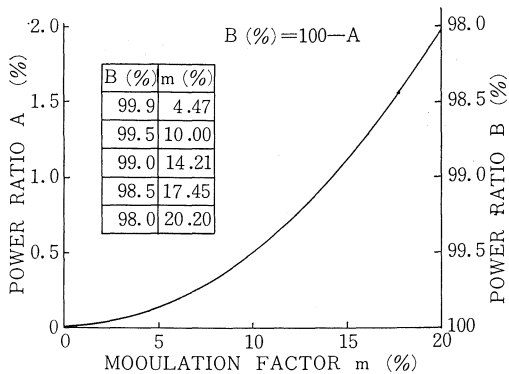
Fig. 1 Relation between power ratio and modulation factor

Fig. 2 Relation between power ratio and FM index (N=3)

modulation frequency. The power ratio error is given by

$$\frac{\Delta B}{\Delta \beta} = 2\sum_{n=-N}^{N} J_n(\beta)J'_n(\beta) = -2\,J_N(\beta)J_{N+1}(\beta) \qquad (6)$$

In the case where some distortions or residual AM components are contained, the power ratios are as follows,

$$B' \doteqdot \frac{\sum_{n=-N}^{N} J_n^2(\beta) + \dfrac{\beta'^2}{2} \sum_{n=2}^{N} \{J_{n-2}(\beta)+J_{n+2}(\beta)\}^2}{1+\dfrac{\beta'^2}{2}} \qquad (7)$$

$$B'' \doteqdot \frac{\sum_{n=-N}^{N} J_n^2(\beta) + 2\left(\dfrac{m}{\beta}\right)^2 \sum_{n=1}^{N} n^2 J_n^2(\beta)}{1+\dfrac{m^2}{2}} \qquad (8)$$

where β' is the FM index of the 2nd harmonic.

From these equations, we can find the necessary conditions of the signal source generating the standard occupied bandwidth. In order to test the method of calibration as mentioned above,
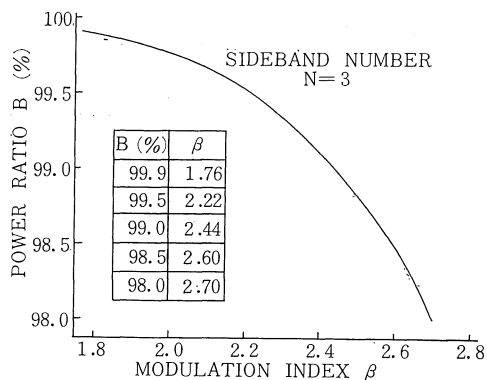
some kinds of band meters were calibrated by the standard occupied bandwidth. The results of calibration were successful and satisfactory.

This standard occupied bandwidth can be easily actualized with the standard signal generator, meeting the necessary conditions described above.

Therefore, this method of calibration is suitable for practical use.

(1) Electronics & Communications in Japan, vol.54, p. 83, Mar.1971, and The Transactions of the institute of Electronics and Comm unication Engineers of Japan, (japanese) vol. 54-c, no. 3, p. 209, Mar. 1971.
(2) CCIR Document, 128E, London, 1953.
(3) Radio Regulations, 90 Art. 1, Atlantic-city, 1947 and Geneva, 1959.