Brüel & Kjær application notes

# Using RASTI to Determine Speech Privacy

The Speech Transmission Analyzer Type 3361 is normally used to measure the intelligibility of the spoken word. This Application Brief describes how the Type 3361 can be used to measure the opposite speech unintelligibility, or speech privacy. This application can be used in open-plan office space to reduce the interruptions and decreased efficiency caused by unintentional eavesdropping; another application is for security purposes.

## Introduction

There has been great interest in speech privacy for many years. Cavanaugh et al have described how Articulation Index (AI), average transmission loss and background noise are used to calculate privacy[1]. However, Sound Transmission Class (STC) is still the most widely used privacy measurement method even though it has been shown that STC is not a very good predictor for privacy.

The factors that influence speech intelligibility and therefore speech privacy are signal-to-noise ratio, reverberation, and reflection. The two methods used now, AI and STC, are based on signal-to-noise ratio whereas the RASTI method takes all factors into account[2]. RASTI also measures speech intelligibility according to IEC Std.268[3].

## Theory

The RASTI method is based upon a measure of the Modulation Transfer Function (MTF) and gives a numeric result between 0 and 1 (Fig. 1), with the range of interest for speech privacy between 0 and 0,3. The test signal used is modulated pink noise. For low RASTI values the resultant modulation will be very low, equal or less than the modulation of the background noise. However, this measurement problem can be solved by using elevated signal levels.

The modulation transfer function can be expressed as

$$m(f) = \frac{1}{\sqrt{1+\left(2\pi \frac{FT}{13{,}8}\right)^2}} \times \frac{1}{1+10^{-\frac{S}{N}\frac{1}{10}}}$$

where the first term is the reverberation part (dependent on the modulation frequency) and the second term is the noise part, which is independent of the modulation frequency. When the signal-to-noise ratio (S/N) is greater than 15 dB, the second term equals 1, meaning that only the first term is measured. S/N greater than or equal to 15 dB is obtained by using elevated levels.

The second term, corresponding to reference levels, is calculated from measurements of background noise $L_N$ and the elevated signal level $L_{S+N}$ using the following formula.

$$S/N = \frac{10^{L_{S+N}/10} - 10^{L_N/10}}{10^{L_N/10}}$$

A typical RASTI measurement procedure is shown in Fig. 2. RASTI is calculated from the nine modulation reduction factors as follows:

$$X_i = 10 \log [m_i/(1 - m_i)]$$

where $X_i$ is the apparent signal-to-noise ratio corresponding to the measured modulation reduction factor $m_i$.

The $X_i$ values are truncated at $X_i = \pm 15$ dB such that

$$\text{if } X_i > +15 \text{ dB then } X_i = +15 \text{ dB}$$
$$\text{if } X_i < -15 \text{ dB then } X_i = -15 \text{ dB}$$

The arithmetic mean of these 9 $X_i$ values is obtained and normalized to yield an index which ranges from 0 to 1.

$$\text{RASTI value} = (\overline{X}_i + 15)/30$$

## Measurements

A typical measurement setup is shown in Fig.3. The measurements were carried out in an office building.

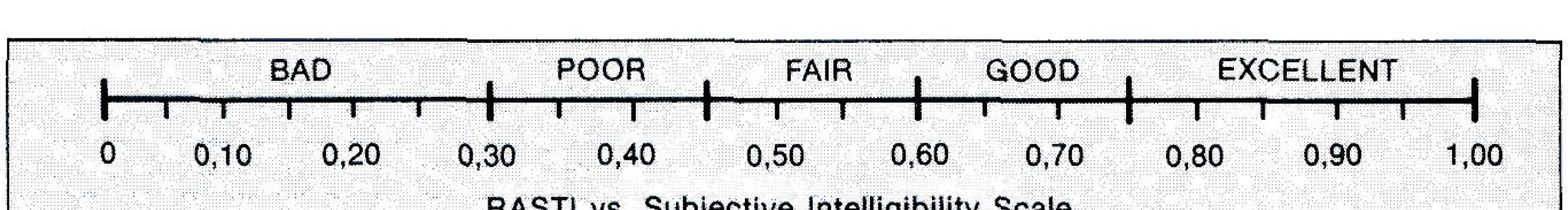


*Fig. 1. The RASTI Scale for Speech Intelligibility*

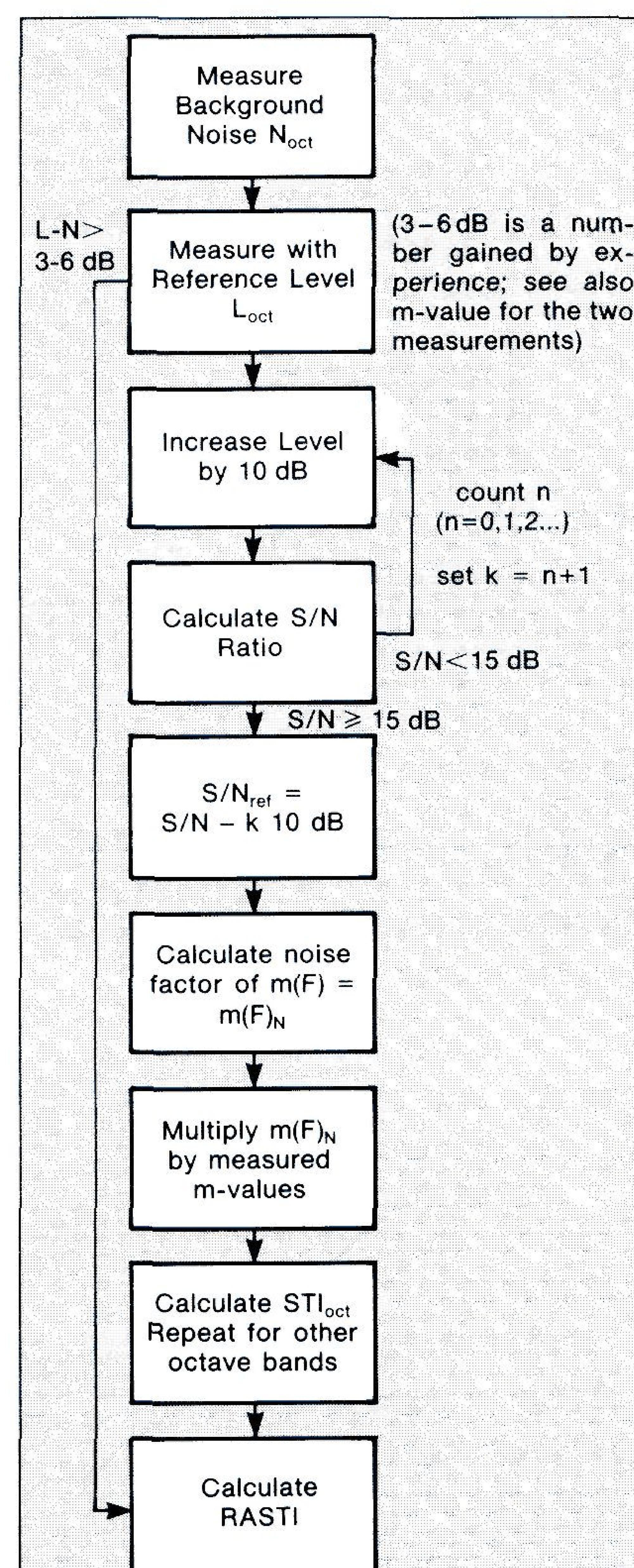


*Fig. 2. RASTI Flowchart*

The partition between two workspaces was 1/2 inch gypsum board on a steel frame with 3 inches of mineral wool in the center.

To make measurements in this situation, it was necessary to raise the signal level by 30 dB. Since this is not possible with the Transmitter Type 4225, an external speaker was used (Sound Source Type 4224). This source was calibrated by placing a microphone on the calibration attachment supplied with the Type 4224[4]. In this case, the levels measured were

| | |
|---|---|
| 500 Hz | 80,4 dB |
| 2000 Hz | 73,0 dB |
| Level Difference | –7,4 dB |

The measurement results are shown in Table 1.

These results show that a measurement using a reference level in this situation will overestimate the RASTI value, while the method described in this Application Brief gives a more accurate result. The largest difference between the two measurement procedures is in the 2000 Hz octave band; the MTF is shown in Fig. 4. Note that the m-values of the background noise are higher than the m-values from the measurement with "REF" level.

| | "REF" | "REF + 30 dB corrected" |
|---|---|---|
| STI (500 Hz) | 0,53 | 0,50 |
| STI (2 kHz) | 0,12 | 0,02 |
| RASTI | 0,30 | 0,23 |

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*Table. 1. Measurement results "REF" is the result obtained using the Type 4225 adjusted to the RASTI reference level. "REF" + 30 dB, corrected" is the result obtained from the measurement with the elevated level and then calculated to correspond to the standard level*

# Conclusion

It has been shown how elevated levels can be used for privacy measurements at the low end of the RASTI scale which otherwise would have been impossible. A calculation procedure to relate the results to "Ref" level is provided. Calibration information for the B & K Sound Source Type 4224 is supplied.


[1]Cavanaugh, W.J., *et al.* "Speech Privacy in Buildings", *Journal of the Acoustical Society of America,* vol. 34 no. 4, 1962.

[2]Type 3361 RASTI Product Data sheet, Brüel & Kjaer

[3]IEC Std.268-16, The Objective Rating of Speech Intelligibility in Auditoria by the RASTI Method

[4]Type 4224 Instruction Manual, Brüel & Kjaer


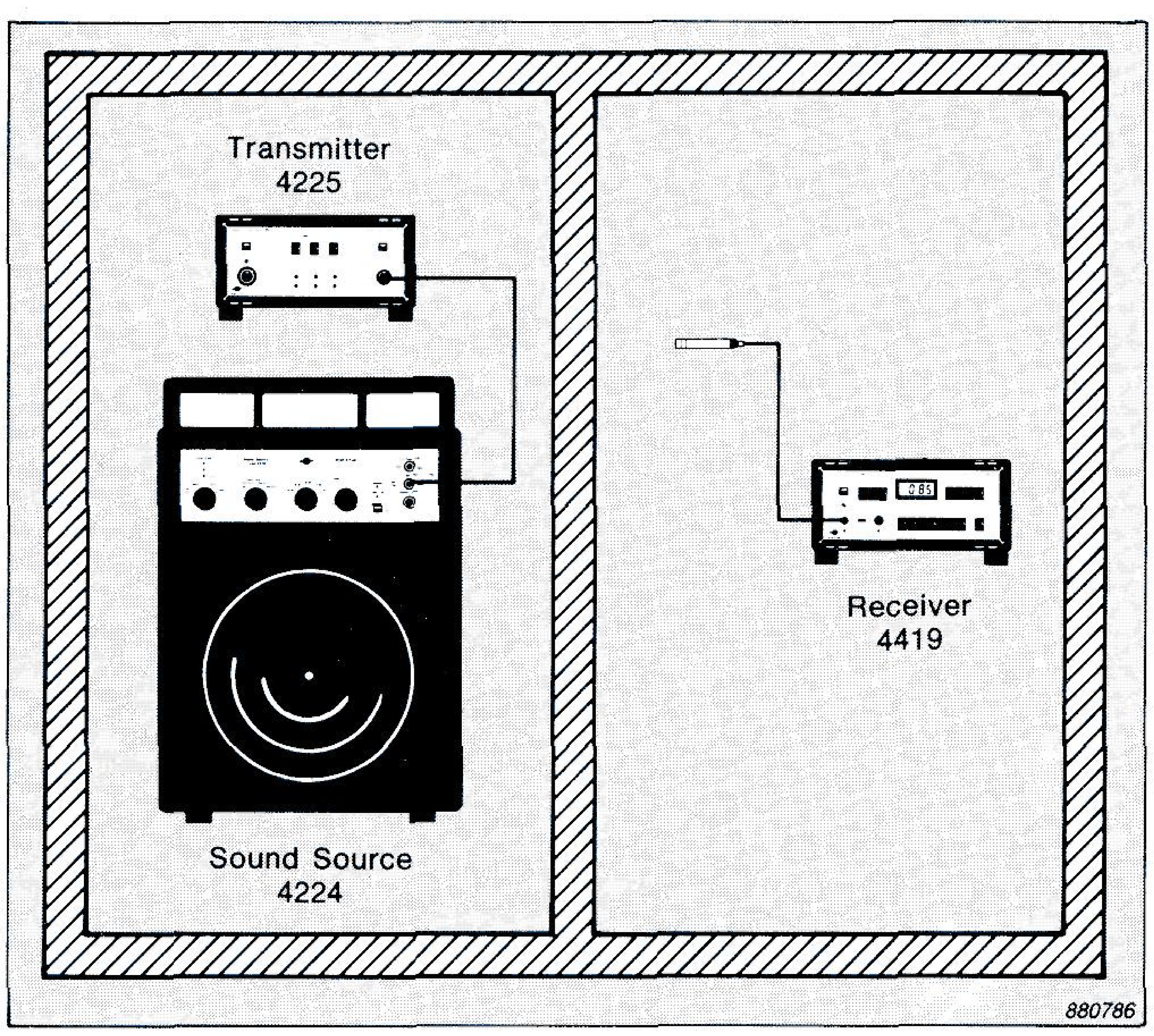


*Fig. 3. Measurement Setup*

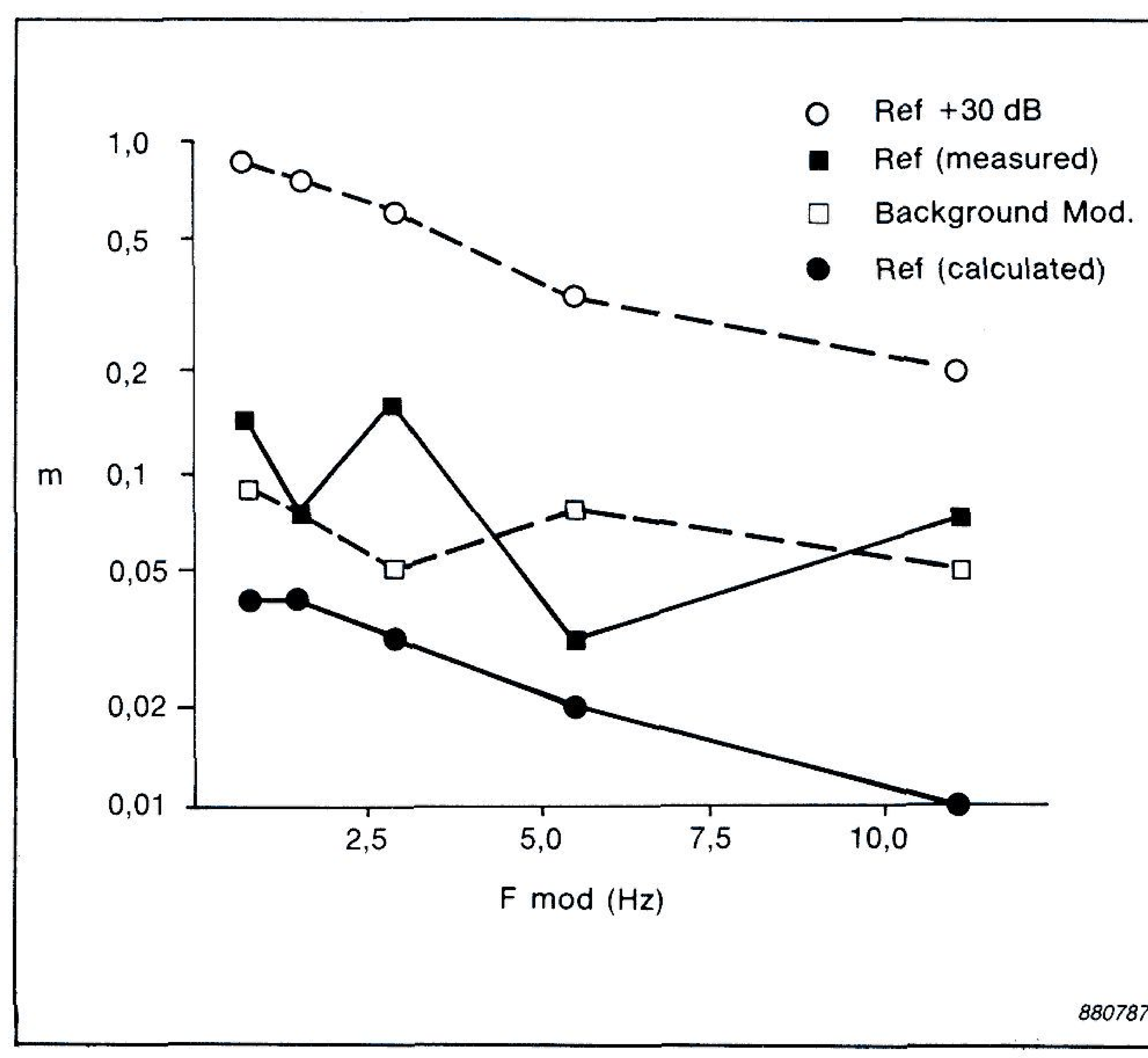


*Fig. 4. The measured Modulation Transfer Function*


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