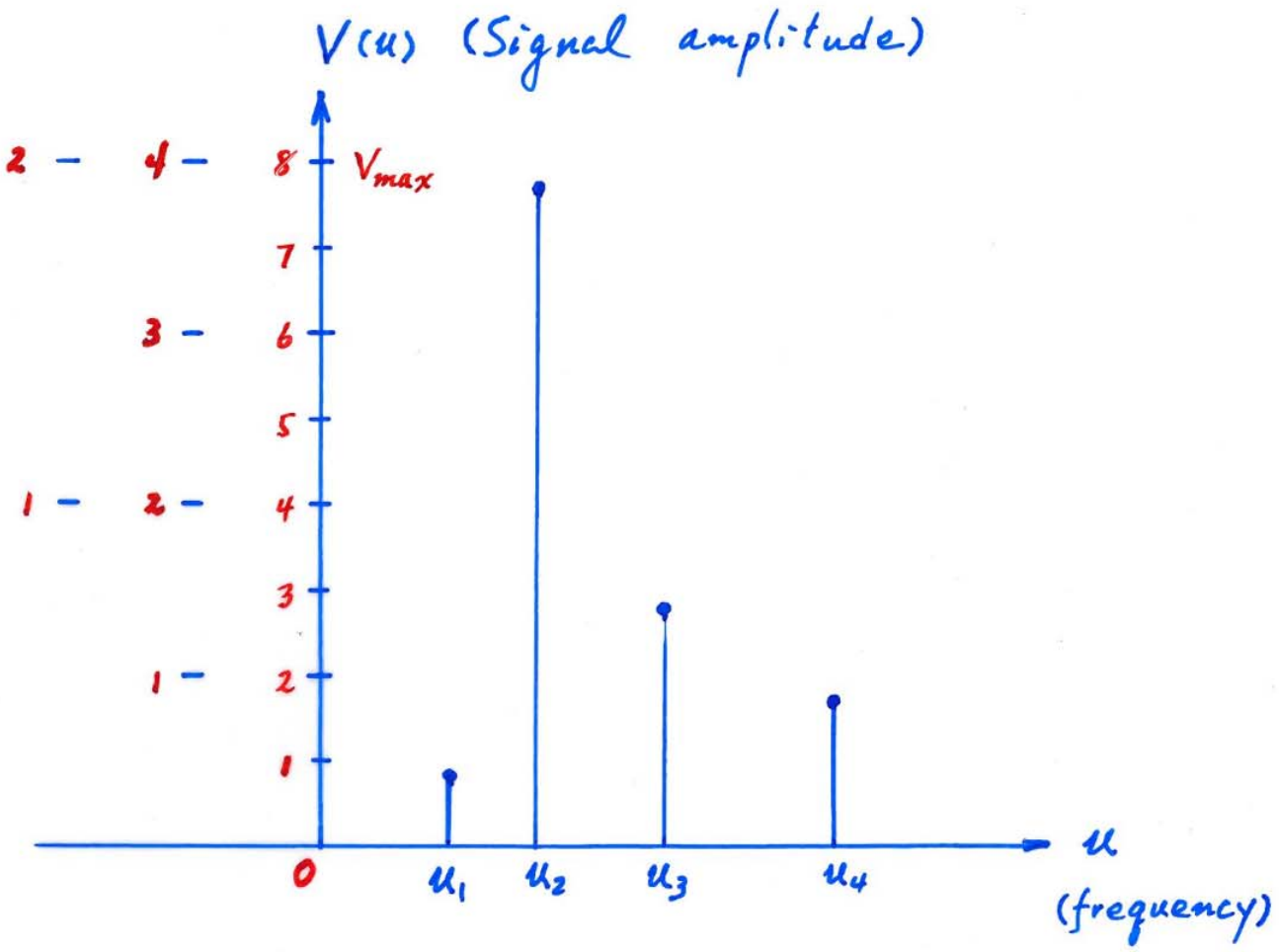
A closer look at SQNR



In general, k bits gives 2^k quantization levels,

2^{k-1} levels each for positive and negative,

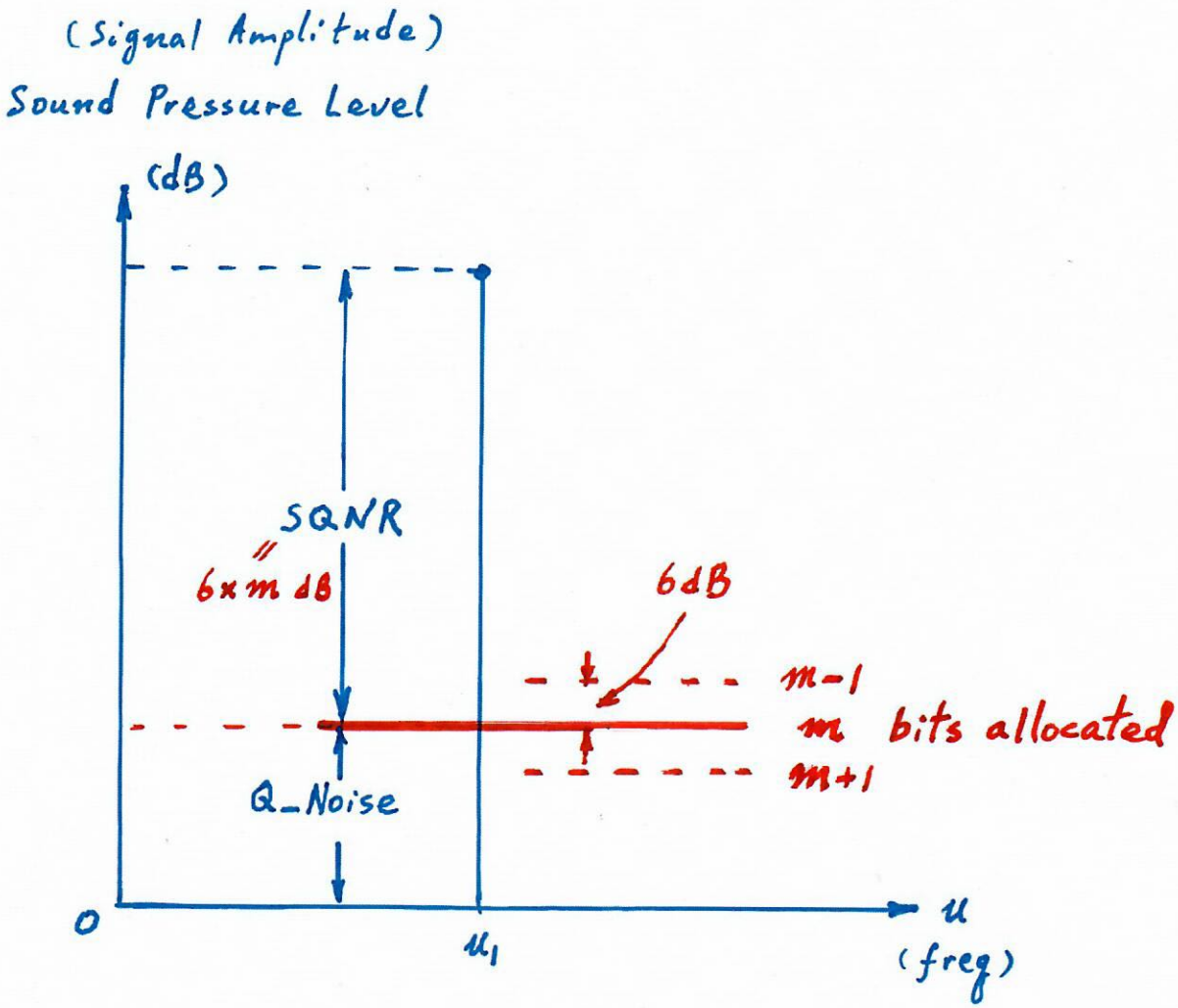
the quantization error is $[-\frac{1}{2}, \frac{1}{2}]$

$$SQNR = 20 \log_{10} \frac{V_{max}}{V_{noise}} = 20 \log_{10} \frac{2^{k-1}}{\frac{1}{2}} = 6 \times k \text{ dB}$$

Here, $k = 4$ $2^{k-1} = 8$ SQNR = 24 dB

or $k = 3$ $2^{k-1} = 4$ SQNR = 18 dB

or $k = 2$ $2^{k-1} = 2$ SQNR = 12 dB



An Illustration of SQNR and Quantization_Noise in Logarithmic scale (dB)

SQNR (dB) = Signal (dB) − Q_Noise (dB)

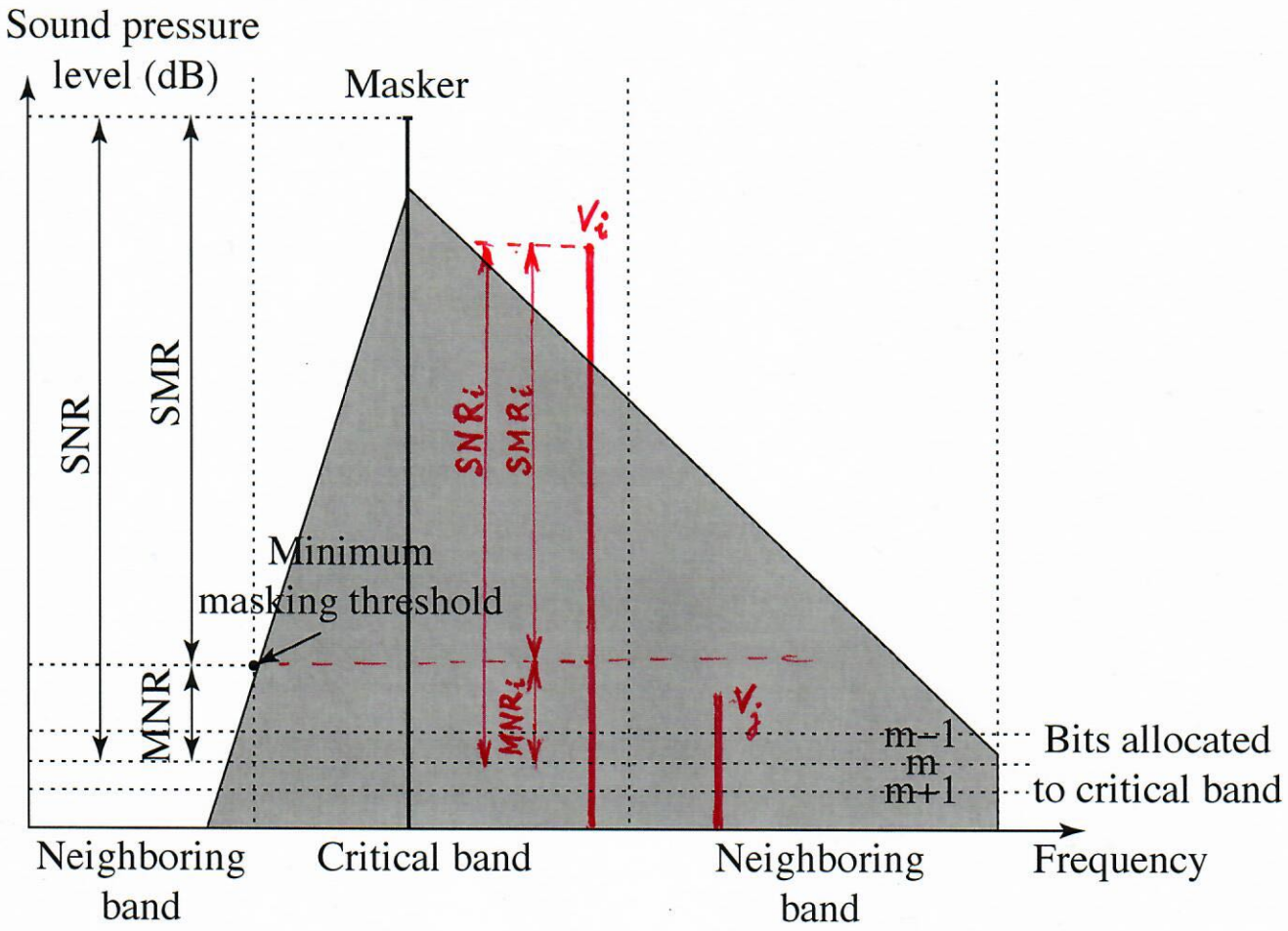


Figure 1: Mask-to-noise ratio and signal-to-mask ratio. A qualitative view of SNR, SMR and MNR, with one dominant masker and m bits allocated to a particular critical band.

Signal V_i : Minimum of $\frac{SMR_i}{6}$ bits needed

Signal V_j : Below masking threshold, no bit needed

Bit Allocation in MPEG Audio Compression

- The aim is to ensure that all quantization noise values are below the masking thresholds.

1. From the psychoacoustic model, calculate the *Signal-to-Mask Ratio (SMR)* in decibels (dBs) for each subband:

$$SMR = 20 \log_{10} \frac{Signal}{Minimum\_masking\_threshold}$$

   - This determines the quantization, i.e. the minimum number of bits that is needed, if available. The amount of a signal above the threshold, i.e. SMR, is the amount that needs to be coded. Signals that are below the threshold do not.

2. Calculate *Signal-to-(quantization)-Noise Ratio (SNR)* for all signals.

   - A lookup table provides an estimate of SNR assuming a given number of quantizer levels.

3. *Mask-to-(quantization)-Noise Ratio (MNR)* is defined as the difference, in dB (See Figure 1).

$$MNR = SNR - SMR$$

4. Iterate until no bits left to allocate:

- Allocate bits to the subband with the lowest MNR
- Look up new estimate of SNR for the subband allocated more bits, and re-calculate MNR

Note:

- The masking effect means we can raise the quantization noise floor around a strong sound because the noise will be masked off anyway. As indicated in Figure 1, adjusting the number of bits m allocated to a subband can move this floor up and down.
- To ensure that all the quantization noise values are inaudible, i.e., below the masking thresholds, so that all MNRs are ≥ 0, a minimum number of bits is needed. Otherwise, SNR could be too small, causing MNR to be < 0, and the quality of the compressed audio could be significantly affected.
- If more bits than the minimum are allowed from the budget, allocate them anyway so as to further increase SNR. For each additional bit, we get 6 dB better SNR.