Upper limit of measurement microphones

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Nearly all the measurement microphones used in sound level meters use the principle of a capacitance formed by a fixed back plate and a parallel thin diaphragm that is free to move in response to the incident sound wave. The air between them forms the dielectric and the basic equation is:

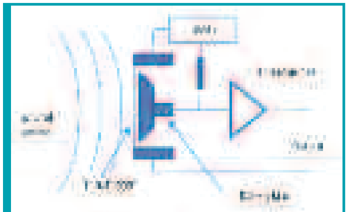
$$c \quad k.\frac{A}{d}$$

Where C is the capacitance, k is the dielectric constant, A is the overlap area of the parallel plates and d is the distance between them. So it can be seen that the capacitance is inversely proportional to the distance between the plates. If this capacitor is charged via a fixed resistor the relationship between the capacitance, charge and voltage will follow the basic equation of:

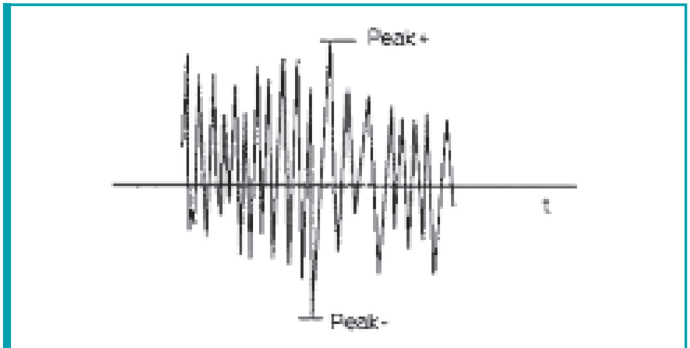
$$c \quad \frac{Q}{V}$$

Where C is the capacitance in Farads, Q is the charge in coulombs and V is the voltage. For measurement microphones this polarising voltage was almost universally set at +200v and if follows that for a 20pF microphone capsule the charge held in the microphone will be 4 nano Coulombs. As the diaphragm is depressed by a positive sound wave it will move closer to the fixed back plate and result in an increase in the capacitance and a fall in the voltage across it; similarly a negative sound wave will result in a reduction in the capacitance and an increase in the voltage. It follows therefore that with an externally polarised microphone there is a phase reversal with a negative peak voltage produced by a positive peak sound level. When pre-polarised (electret) measurement microphones were introduced the choice of a positive polarising voltage proved unfortunate as it was much easier to produce a negatively charged electret so we then get the opposite response of a positive going voltage for a positive sound wave and vice versa. As most sound level meter manufacturers only display the root-squared signal the sign of the peak is lost and so this is just an academic point for those making detailed investigation of peak signals.

These equations hold true for parallel plate capacitors but in a practical microphone the outer edge of the diaphragm is supported and cannot move and hence with increasing sound pressures the configuration will move away from the ideal parallel motion of the diaphragm and back plate. The relationship between sound pressure and the change in capacitance still holds true for low sound pressures but as the level increases so the change in capacitance will become non-linear and result in distortion of the signal. Most microphones have their upper limit specified as the point where this non-linear distortion reaches 3% and typical microphones then have a distortion level around 10% for sounds that are 6dB higher. If sound levels increase beyond the quoted upper limit the distortion will continue to increase until the diaphragm eventually hits the back plate and there it will stop and the microphone will be effectively short circuited. Although not to be recommended, there is a fair chance that the microphone will recover but there is a risk of damage caused by the shorting of the polarisation voltage or excessive negative displacement of the diaphragm.



Condenser microphone



Peak +ve and –ve

Basic physics limits the dynamic range of measurement microphones to around 125 dB; i.e. thermal noise to the distortion limit. The designer therefore has a choice of optimising them for measurement at low sound levels with a range of 15 to 140 dB or tip things in favour of high levels by shifting the range up to say 35 to 160 dB. The upper limit of a microphone is to a large extent directly linked to its sensitivity which is chiefly determined by its size and the tension on its diaphragm. Most sound level meters have half inch microphones with a sensitivity of around 50mV/Pa; to achieve this a thin diaphragm material is used that cannot take very high tension and as a result they are good at measuring low sound levels but have a 3% distortion limit at around 145dB peak. There are also significant numbers of half inch microphones having thicker high tension diaphragms that are not so good at low sound levels but are happy up to 160 dB. To go above these levels it is necessary use quarter inch microphones with examples measuring up to 194 dB. Beyond these levels the sound wave itself becomes non-linear and we move out of conventional acoustics.

The microphones themselves are quite good at dealing with high sound levels but they have to live close coupled to their preamplifier and consideration of this element of the measurement chain is for another day.

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