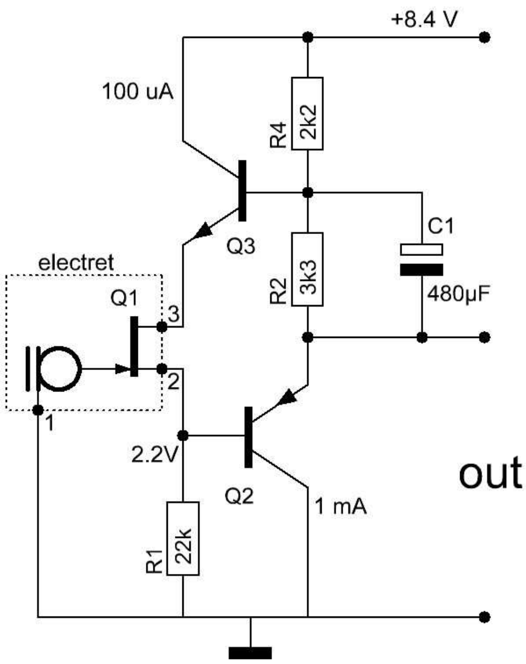
Bootstrapped Electret

Preface

In the document: '*Condenser microphone pre-amp with bootstrapped op amp*' on this site, bootstrapping is defended to eliminate non linear parasitic junction capacitances to avoid distortion. This robust solution is rather costly and prolix.
Investigating B&K-microphones, I came to a much easier design which could work fine but requires more pre-investigation in case of electrets. In particular the diverge of the parameters of the built-in FET Q1 plays tricks.

Choices of components

The (values of) the parasitic capacitances of Q1 are unknown but less important because of the bootstrapping. However, the DC between drain and source should be large enough to keep the FET saturated. With the small FET's used in electret microphones, the knee voltage will vary from 0.2 to 0.8 volt and the saturation current from 50 to 500 µA. **The values of the components in the rest of the circuit are determined by these parameters!**



Let us assume the current through Q1 is 100 µA. The collector-base voltage of Q2 should be at least 2 volt to keep away from its knee voltage so that R1 should be >22 kΩ. (Q2 is a small PNP transistor.) U32, being the drain-source voltage of Q1, should also be >2 volt, so that with R2 = 3k3 the current through Q2 should be larger than 1 mA. So the battery voltage becomes ≥ 8.4 volt.
How this voltage is obtained from the phantom voltage of the mixing console is left to the reader.

The bootstrap

The source of Q1 'follows' the gate (more or less) Q2 acts as an emitter follower so that the AC output voltage follows the AC gate voltage.
Q3 also acts as an emitter follower so that the drain of Q1 eventually follows the gate. This means that the AC-voltage across the parasitic capacitance between gate and source as the AC-voltage across this between drain and gate will be kept naught.
The capacitance of C1 must be very large to avoid distortion (Douglas Self).

Conclusively

This circuit will operate with less distortion than that in the document: '*Meet-microfoon'* (in Dutch) but it is rather sensitive to the parameters of the built-in FET of the electret. The robust but elaborate design in '*Condenser microphone pre-amp with bootstrapped op amp*' provides by far the best results.

Distortion

The resistor across a condenser microphone capsule (in general) to bias the electronic circuit behind it, determines the distortion at the low audio frequencies! With this design the 'bias resistor' is constituted by the leakage resistor between gate and source of the little FET. (Be aware that the housing of the electret (connection 1) should be connected to ground.) Depending on the electret's construction and the used FET, this 'bias' resistor could vary from 1 to 100 GΩ.

In Fig.5 of the article '*Electrically Manifested Distortion of Condenser Microphones in Audio Circuits'* AES Vol.48 no 6 2000 June, of Holger Pastillé the distortion is shown at levels of 140 dB!

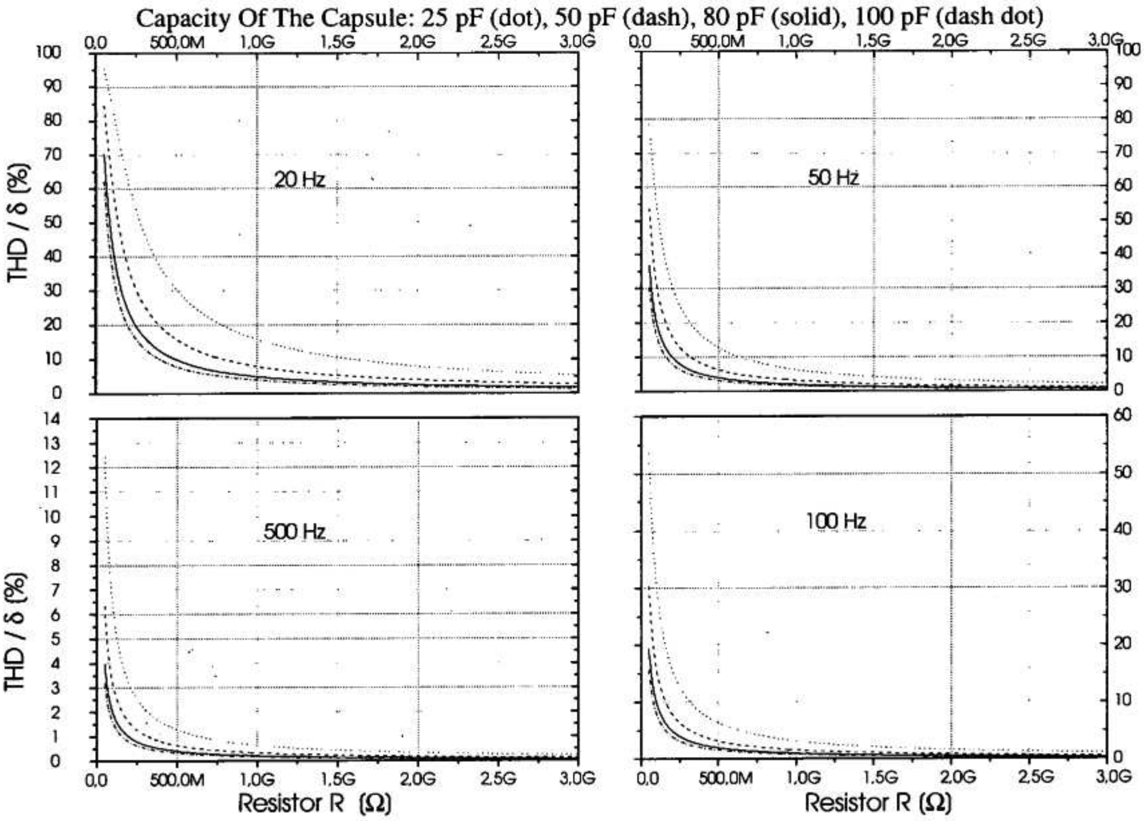


Fig. 5. Normalized nonlinearity versus resistance for four frequencies.

6 CONCLUDING REMARKS

It has been shown analytically that modern studio microphones with an input resistance of 3 GΩ and a small capsule capacitance have less than 0.5% electrically manifested distortion at even the highest sound pressure levels found in studios. For the reasons given (the acoustical-mechanical distortions of the capsule color the result), verification by measurement is not possible. All other sources of distortions ("clipping" and acoustical-mechanical behavior) produce higher distortions.

The low resistance of a traditional tube circuit design (in the area of 100 MΩ) can create distortions. If a natural recording is desired, it is suggested that for levels higher than speech or moderate music, microphones with a FET or a modern tube circuit design be used rather than a traditional vacuum tube circuit. Measuring microphones with a non-tube amplifier (input resistance approximately 20 GΩ) are practically free from electrically manifested distortions, that is, in the worst case the THD of a ½-in (12.7-mm) microphone at 10 Hz is less than 0.003%.

It should, of course, be remembered that the electrically manifested distortions are only one contribution to the nonlinearities of a microphone. Other causes, such as mechanical properties of the membrane, air damping, and the stiffness of the cavity, are of greater influence.