CLAIMS

What is claimed is:

1. An acoustic feedback canceling module comprising:

a conversion module (106) configured to convert an input audio signal (101) to the frequency domain;

a detection module (108) configured to detect and estimate howling frequency candidates, the detection based on a howling to noise ratio (HNR~~).~~), wherein the howling frequency is calculated based on determining a peak magnitude for an FFT bin norm and the FFT norms for the FFT bins immediately before and after the peak magnitude FFT bin and choosing these bins as candidates for the estimated howling frequency;

a filter design module (110) configured to provide filter coefficients for the adaptive design for removal of the estimated howling frequency; and

a filter (112) placed in line with the audio input signal to remove the estimated howling frequency.

2. The feedback canceling module of claim 1 wherein the howling to noise ratio (HNR) comprises a ratio between the power of a candidate frequency and the power of a noise floor.

3. The feedback canceling module of claim 2 wherein both the noise floor and the HNR are smoothed by a first order smoother.

4. The feedback canceling module of claim 1, 2 or 3 wherein FFT norms are accumulated and averaged.

5. The feedback canceling module of claim 2 wherein the howling detection criteria is at least one of a) the HNR is larger than the HNR threshold; HNR is increasing; and there must be at least one HNR jump in N_HIT runs meeting a threshold criteria.

~~6. The feedback canceling module of claim 1 wherein the howling frequency is calculated based determining a peak magnitude for an FFT bin norm and the FFT norms for the FFT bins immediately before and after the peak magnitude FFT bin.~~

~~7~~6. The feedback canceling module of any preceding claim ~~1~~ wherein the estimated howling frequency is based on a comparison of successive frames.

7. The feedback canceling module of any preceding claim wherein the howling frequency estimation is based on a bin increment from a howling frequency

candidate bin, the bin increment based on FFT norms around an FFT bin determined to have the maximum power.

8. A method for suppressing unwanted howling sounds comprising:
receiving microphone signals;
converting (306) the microphone signals to the frequency domain;
detecting and estimating howling frequencies (324) in the frequency domain based on a howling to noise ratio (HNR), wherein the howling frequency is calculated based on determining a peak magnitude for an FFT bin norm and the FFT norms for the FFT bins immediately before and after the peak magnitude FFT bin and choosing these bins as candidates for the estimated howling frequency;
adaptively designing a notch filter for the howling frequency; and
removing the howling frequency from the input signal.

9. The method recited in claim 8 wherein the howling detection is based on a howling to noise ratio (HNR) which comprises a ratio between the power of a candidate frequency and the power of a noise floor.

10. The method recited in claim 9 wherein both the noise floor and the HNR are smoothed by a first order smoother.

11. The method recited in claim 10 wherein the howling detection criteria is at least one of a) the HNR is larger than the HNR threshold; HNR is increasing; and there must be at least one HNR jump in N_HIT runs meeting a threshold criteria.

12. The method recited in claim 11 wherein 3 FFT norms around the howling frequency bin are interpolated.

13. The method recited in any of claims 8 to 12 wherein FFT norms are accumulated and averaged.

14. The method recited in any of claims 8 to 13 wherein the howling frequency estimation is based on a bin increment from a howling frequency candidate bin, the bin increment based on FFT norms around an FFT bin determined to have the maximum power.

~~14.~~15. An audio system with an integrated notch-filter based howling suppression system comprising:
a microphone;
a conversion module (106) configured to convert an input audio signal (101) to the frequency domain;

a detection module (108) configured to detect and estimate howling frequency candidates, the detection based on a howling to noise ratio (HNR). wherein the howling frequency is calculated based determining a peak magnitude for an FFT bin norm and the FFT norms for the FFT bins immediately before and after the peak magnitude FFT bin and choosing these bins as candidates for the estimated howling frequency;

a filter design module (110) configured to provide filter coefficients for the adaptive design for removal of the estimated howling frequency; and

a bank of adjustable notch filters (112) placed in line with the audio input signal to remove the estimated howling frequency.

15.16. The audio system as recited in claim 1415, wherein the bank of adjustable notch filters include at least one IIR filter.

16.17. The audio system as recited in claim 14 15 or 16 wherein the howling detection is based on a howling to noise ratio (HNR) which comprises a ratio between the power of a candidate frequency and the power of a noise floor.