

ERRATA

SPECIFICATION NO 2068194A

Front page, line 5, Heading (57) *for at read of*

Page 1, line 22, *for X₂ and X₁ read Z₂ and Z₁*

Page 1, lines 35 to 52, *delete whole lines insert*

$$Z_1 = R - \frac{j}{\omega c}, Z_2 = R + j\omega L$$

$$\text{Thus } Z = \frac{Z_1 Z_2}{Z_1 + Z_2}$$

$$= \frac{\left(R - \frac{j}{\omega c} \right) \left(R + j\omega L \right)}{\left(R - \frac{j}{\omega c} \right) + \left(R + j\omega L \right)}$$

$$= \frac{R^2 + \frac{L}{c} + Rj \left(\omega L - \frac{1}{\omega c} \right)}{2R + j \left(\omega L - \frac{1}{\omega c} \right)}$$

$$\text{Let } \omega L = \frac{1}{\omega c} \text{ ie, define } \omega = \frac{1}{\sqrt{LC}}$$

and let $Z=R$

$$\Rightarrow R = \frac{R^2 + \frac{L}{c}}{2R}$$

$$\Rightarrow C = \frac{L}{R^2}$$

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(56) Documents cited

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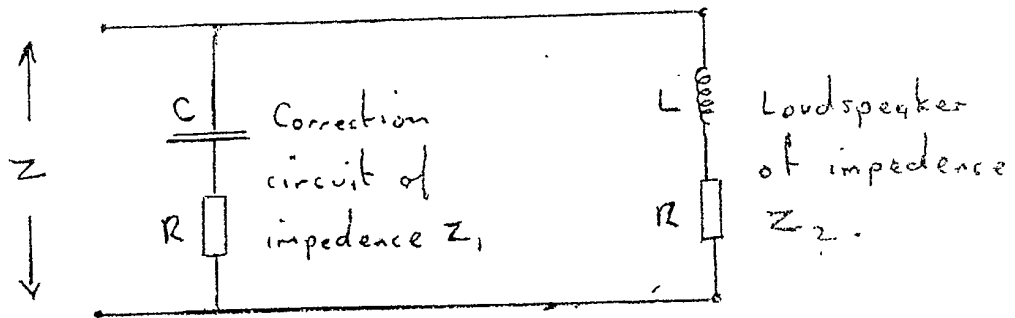
Co Durham

(54) **Loudspeaker circuits**

(57) The invention consists of a filter to be connected in parallel with loudspeaker drive-units whose purpose is to minimise the impedance variation at the filter and drive-unit combination. This also modifies the electro-mechanical damping of the unit.

The filter comprises two elements, one resistive and equal in value to the resistance of the drive-unit. In series with this there is a reactance whose value is determined by the relationship $C = L/R^2$ where L (or C) is the mean reactance of the drive unit and C (or L) is the corresponding value of the filter reactance. The values may be within the range -50% to + 100% of those stated.

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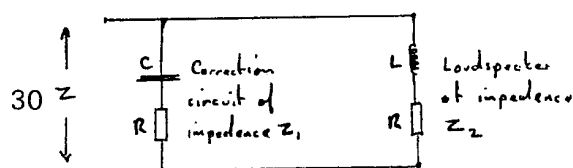
SPECIFICATION

A circuit for minimising the impedance variation of loudspeakers

The design of filter networks for loudspeakers is complicated by the impedance variation of the drive units. It has been found that this can be minimised by the inclusion in the filter of an RC network in parallel with inductive loads or an LR circuit parallel to capacitive loads. The design and use of such networks in loudspeaker crossovers is the subject of this patent application.

Theoretical Basis

Let the loudspeaker drive unit be represented by a fixed inductance, L and a fixed resistance, R connected in series. An impedance correction circuit of capacitance C and resistance equal to R is connected in parallel. These have complex impedances Z_1 and Z_2 respectively. The total impedance, as seen by the rest of the filter network, is Z.



$$Z_1 = R - j/wc, \quad Z_2 = R + jwL$$

$$\text{Thus } Z = Z_1 Z_2 / Z_1 + Z_2$$

$$= (R - j/wc)(R + jwL) / (R - j/wc) + (R + jwL)$$

$$= R^2 + L/C + Rj(wL - 1/wc)/2R + j(wL - 1/wc)$$

Let $WL = 1/wc$ ie. define $w = 1/\sqrt{LC}$ and let $Z = R$

$$\rightarrow R = R^2 + L/C/2R$$

$$\rightarrow C = L/R^2$$

This gives the relation between C, L and R for $Z = R$ at one particular frequency. We now show that this relation is valid for all frequencies.

$$\text{If } C = L/R^2$$

$$\rightarrow Z = 2R^2 + Rj(wL - 1/wc)/2R + j(wL - 1/wc) = Z_3/Z_4$$

$$\text{Arg } Z_3 = R(wL - 1/wc)/ZR^2 = WL - 1/wc/2R$$

$$\text{Arg } Z_4 = wL - 1/wc/ZR$$

$$\rightarrow \text{Arg } Z_3 = \text{Arg } Z_4$$

$$\text{Now Arg } Z = \text{Arg } Z_3 - \text{Arg } Z_4 = 0$$

$$\rightarrow Z = R \quad \forall w$$

Practical Application

Impedance variations in moving coil loudspeaker drive units result from two courses. One is the variation produced by motion of the diaphragm, the other is the variation caused by the inductance of the coil. The former is predominant at resonances, particularly in the lower frequency range of the unit. The latter causes an impedance rise at higher frequencies. It is this latter rise which can be controlled by including a correction circuit designed on the basis described above. The value of the inductance used in the calculation to find the correcting capacitance should thus be found from impedance measurement of the drive unit in the upper region of its frequency response.

For electrostatic units, the capacitance should be measured in its low frequency region and this used to calculate a value for the correcting inductance.

Embodiment

A trial was made on the base unit used in an FF3 mkII produced by Environmental Sound Ltd. The inductance of the base/mid-range unit at 10kHz was found to be approximately 0.2 mH. The d.c. resistance was 6.5 Ω .

$$\text{Hence } C = L/R^2 = 0.2 \text{ mH}/42.5$$

$$\rightarrow 4\mu\text{F} < C < 5\mu\text{F}$$

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A capacitor of 4 μF in series with a resistor of 6.8 Ω was tried in parallel with the unit. This resulted in an impedance curve with a slight peak at ~2kHz but substantially flat in the range 100 Hz to 10kHz.

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The unit and associated correction network were later incorporated in a half section crossover designed in the conventional manner.

CLAIMS

1. The Inventor claims the monopoly on all sound reproduction systems characterised by the inclusion of the described filter in parallel electrical connection with loudspeaker drive unit(s).

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the filter is to comprise of two elements in series electric connection. One element is resistive and has a value approximately equal to the resistance of the drive unit or the equivalent value when units are used in combina-

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- tion. In series there is a reactance whose value is to approximate to the value determined by the relationship $C = L/R^2$ where L (or C) is the means reactance of the drive unit(s) and C (or L) is the corresponding filter reactance. Approximate is used in these cases to mean within a range of -50% to + 100% of the stated value.
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