スピーカを知ろう

Right understanding of loudspeakers



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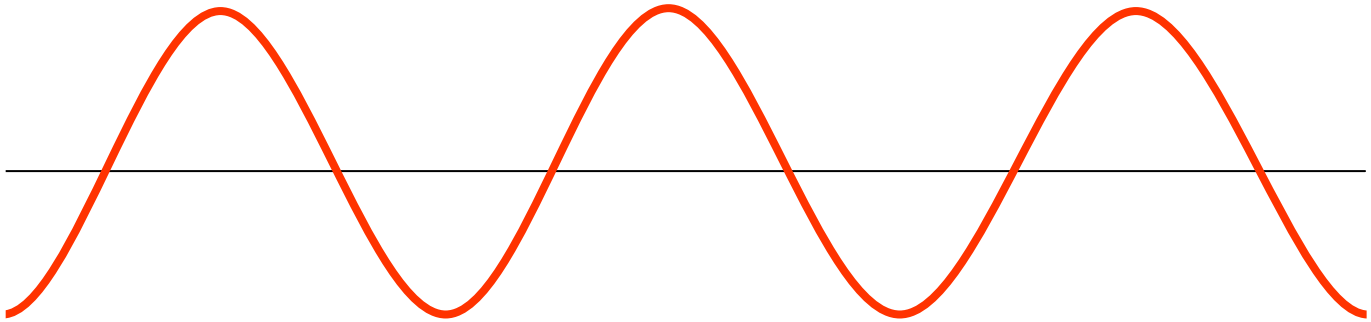
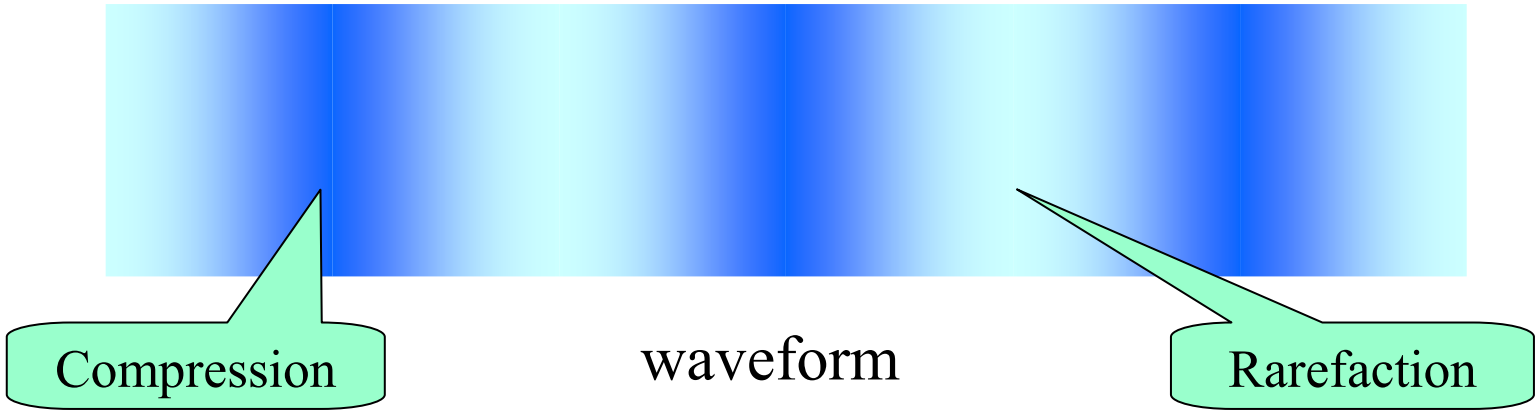
Contents

1. What is loudspeaker?
2. Loudspeaker types
    - Drivers
    - Cabinets
3. Detail of moving coil direct radiator
4. Detail of horn speaker
5. Multi-way system
6. How to design vented box

What is sound wave?



signal



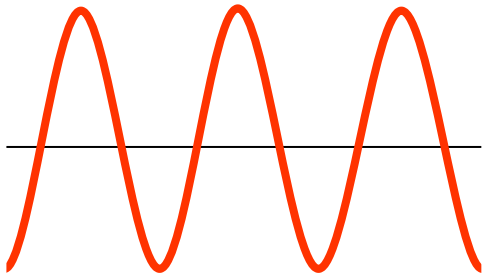
Sound＝Pressure＝Air vibration

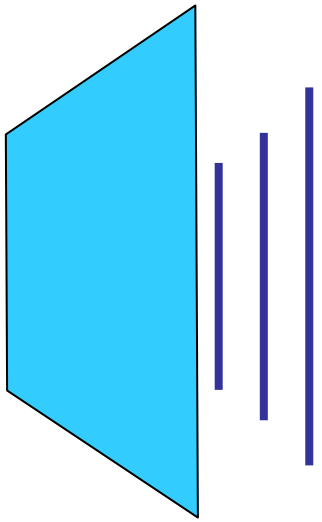
What is loudspeaker?

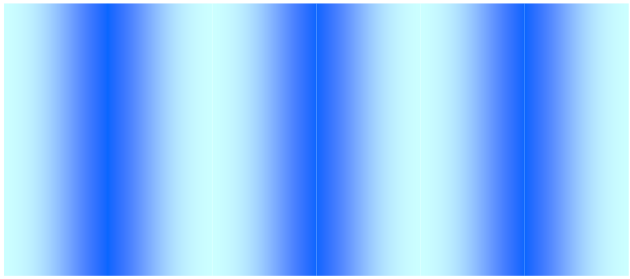
Electric signal

Translate

Air vibration

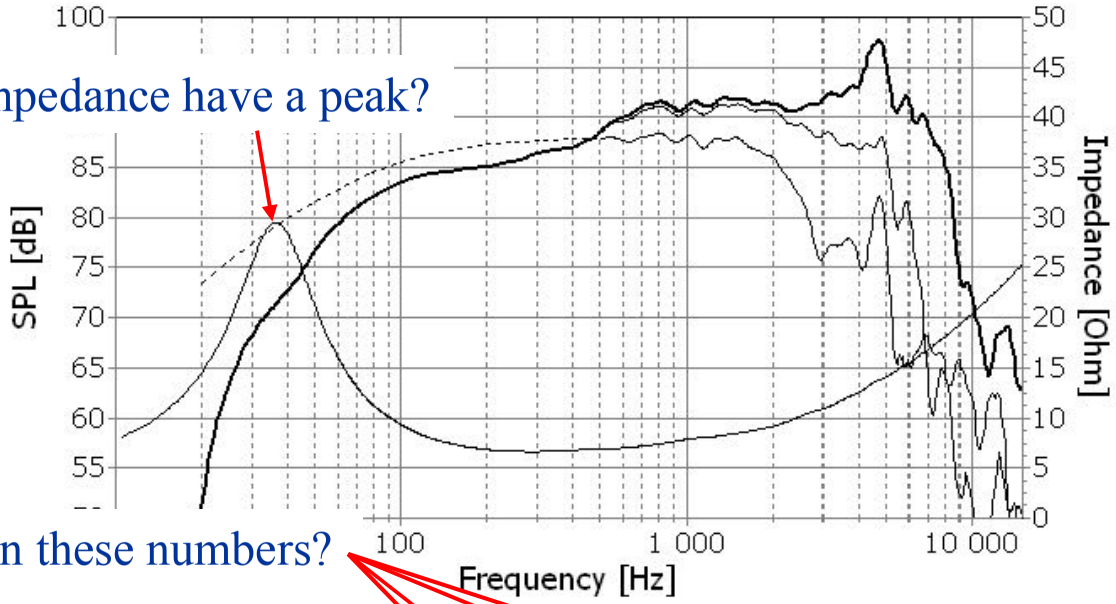






Can you understand these specifications?

Why impedance have a peak?



What mean these numbers?

Nominal Impedance	8 Ohms	Voice Coil Resistance	5.9 Ohms
Recommended Frequency Range	45 - 3000 Hz	Voice Coil Inductance	0.67 mH
Short Term Power Handling *	250 W	Force Factor	7.2 N/A
Long Term Power Handling *	80 W	Free Air Resonance	37 Hz
Characteristic Sensitivity (2,83V, 1m)	88.5 dB	Moving Mass	14.0 g
Voice Coil Diameter	39 mm	Air Load Mass In IEC Baffle	0.92 g
Voice Coil Height	18 mm	Suspension Compliance	1.3 mm/N
Air Gap Height	6 mm	Suspension Mechanical Resistance	2.20 Ns/m
Linear Coil Travel (p-p)	12 mm	Effective Piston Area	136 cm²
Maximum Coil Travel (p-p)	22 mm	VAS	32 Litres
Magnetic Gap Flux Density	1.0 T	QMS	1.58
Magnet Weight	0.64 kg	QES	0.39
Total Weight	1.91 kg	QTS	0.32

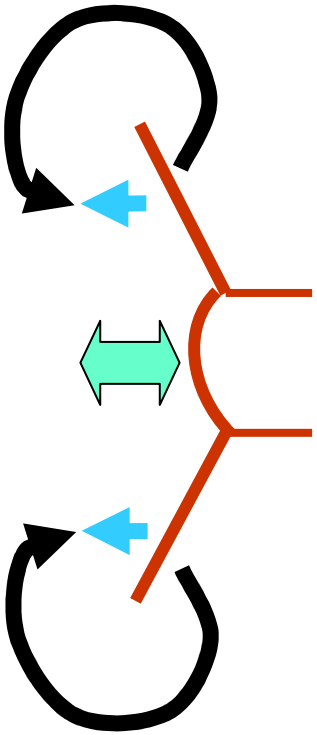
*http://www.seas.no/

スピーカの分類　Loudspeaker types

Classification	Types
駆動方式 Driving system	・導電型　**Dynamic** ・電磁型　**Magnetic** ・圧電型　**Piezoelectric** ・静電型　**Electrostatic** ・イオン型　**Plasma arc**
振動板形状 Diaphragm shape	・コーン型　**Cone type** ・ドーム型　**Dome type** ・平面型　**Flat panel type** ・リボン型　**Ribbon type**
放射方式 Radiation type	・直接放射型　**Direct radiator** ・ホーン型　**Horn speaker**

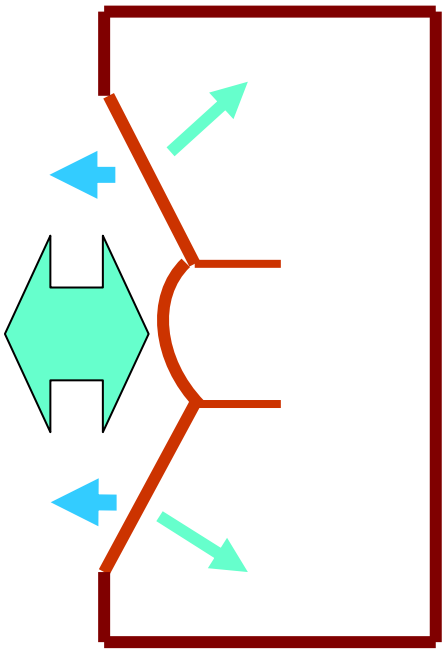
キャビネットの役割
How enclosure works?

キャビネットが無いと
without enclosure



cancel both side sounds

キャビネットに付けると
with enclosure

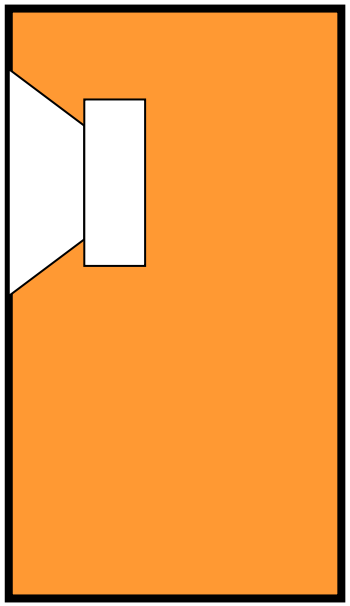


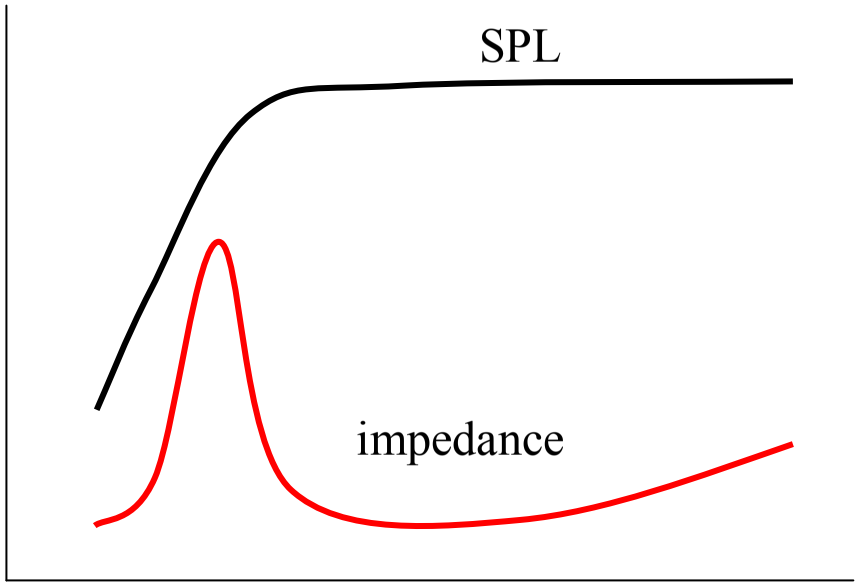
no cancelation and more bass

キャビネット形式　Enclosure types

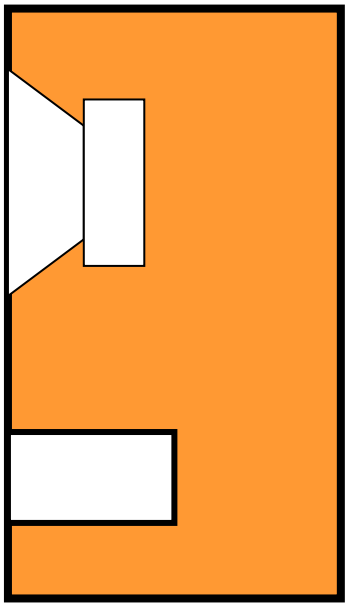
Classification	Types
低音放射方式 System designs （Low frequency reproduction ）	・密閉型　**Sealed box** ・バスレフ型　**Vented box** ・パッシブラジエータ型　**Passive radiator** ・バックロードホーン型　**Back loaded horn**
形状 Styles	・ブックシェルフ　**Book shelf** ・フロア型　**Floor standing** ・トールボーイ型　**Tall boy**

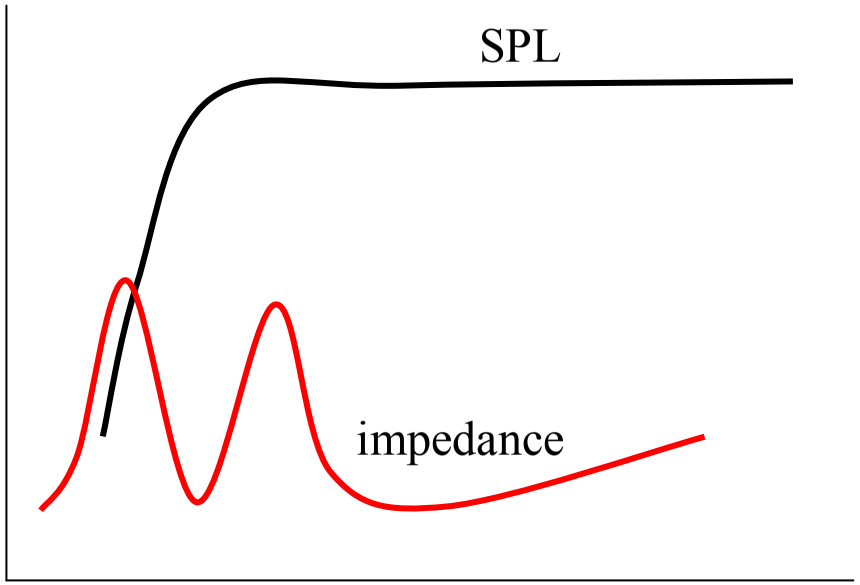
密閉型　Sealed box





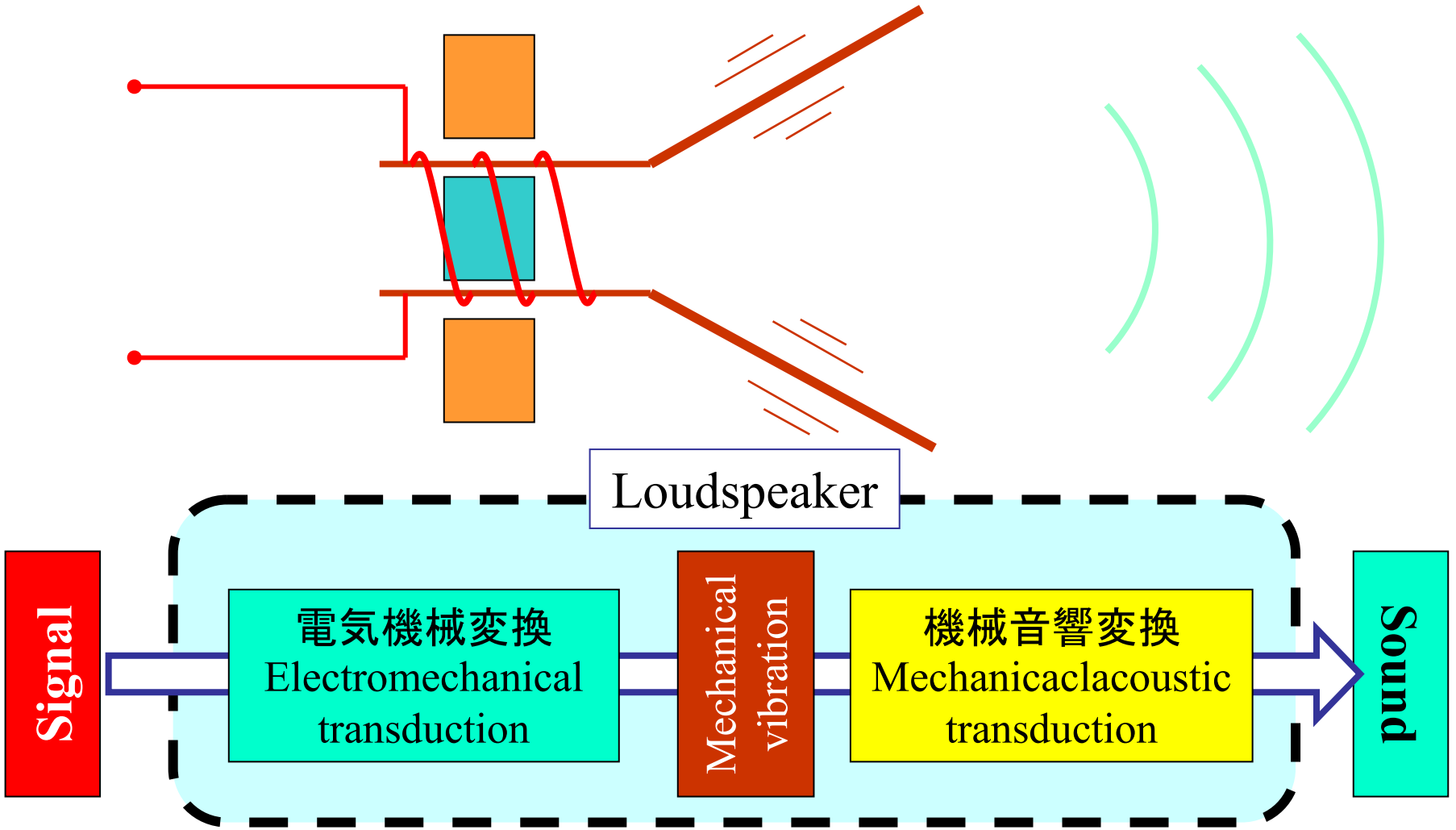
Vented box



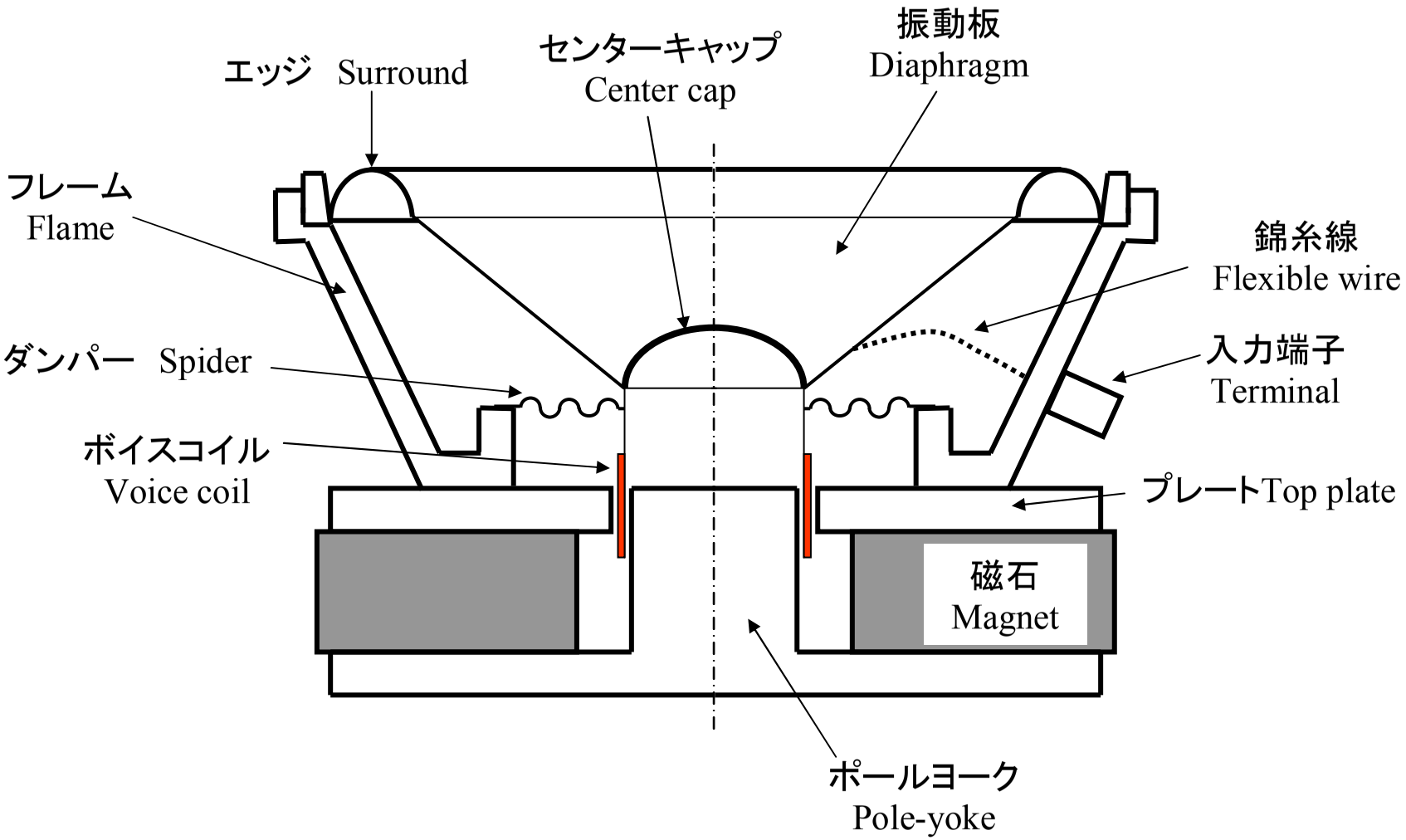


Detail of moving coil direct radiator

Principle



Structure



Parameters

Parameters

Re : ボイスコイル抵抗 Voice coil resistance
Le : ボイスコイルインダクタンス
Voice coil inductance
B : 磁束密度 Magnetic flux density
l : コイル長 Voice coil length
A : 力係数 Force factor (*Bl*)
Zm : 機械インピーダンス
Mechanical impedance
Cm : 機械コンプライアンス
Mechanical compliance
Lm : 振動質量 Mechanical mass
Rm : 機械抵抗 Mechanical resistance
Sd : 実効振動面積 Effective diaphragm area
Za : 音響インピーダンス Acoustic impedance
Vas : 等価空気体積 Equivalent air volume
F0 : 共振周波数 Resonance frequency

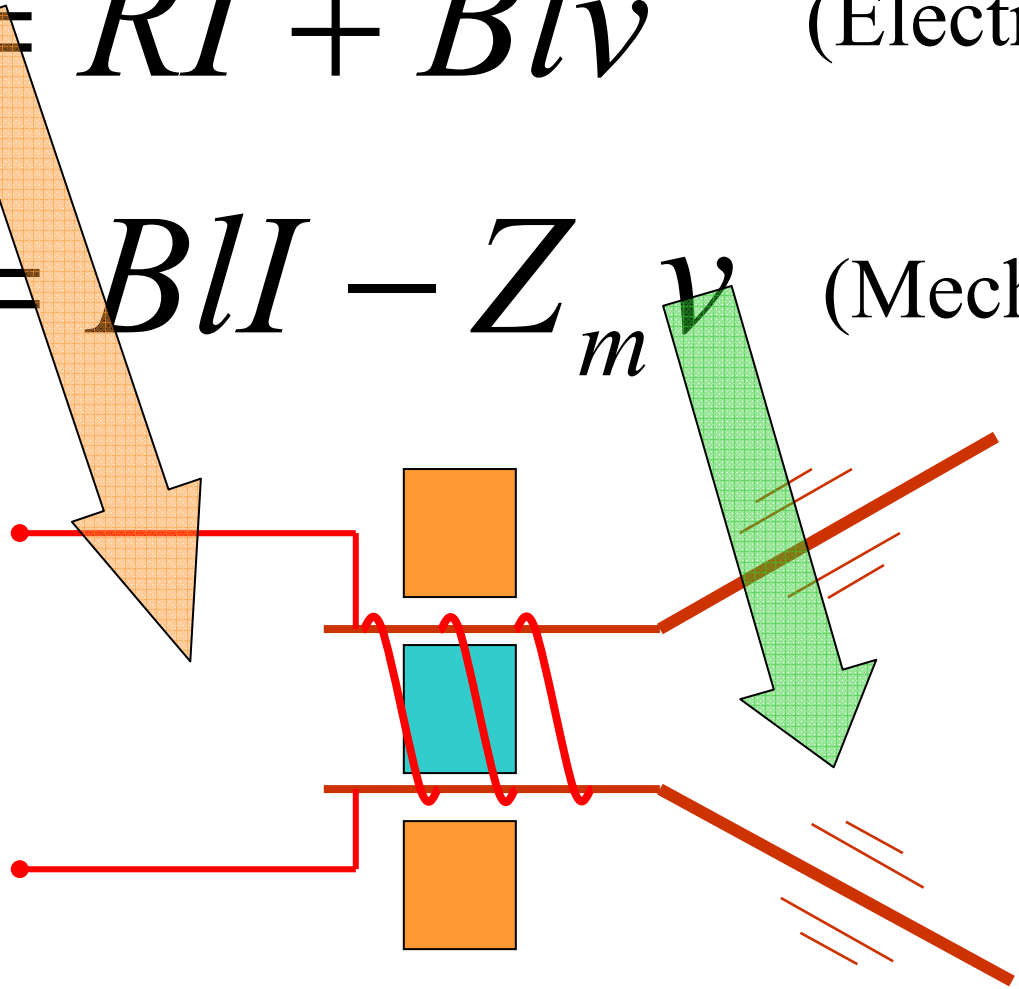
Constants

ρ : 空気密度 Air density ($1.2kg/m^3$)
c : 音速 Sound velocity (340m/sec)

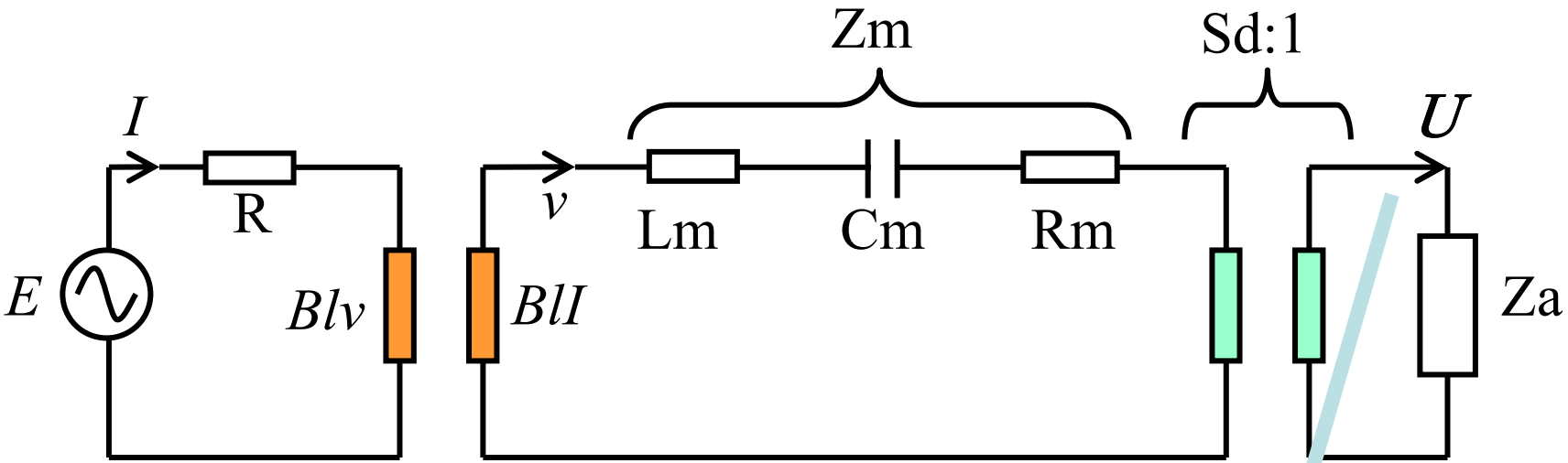
スピーカの動作 Motion equation

$$E = RI + Blv \quad \text{(Electric)}$$

$$F = BlI - Z_m v \quad \text{(Mechanical)}$$



等価回路 Equivalent circuit

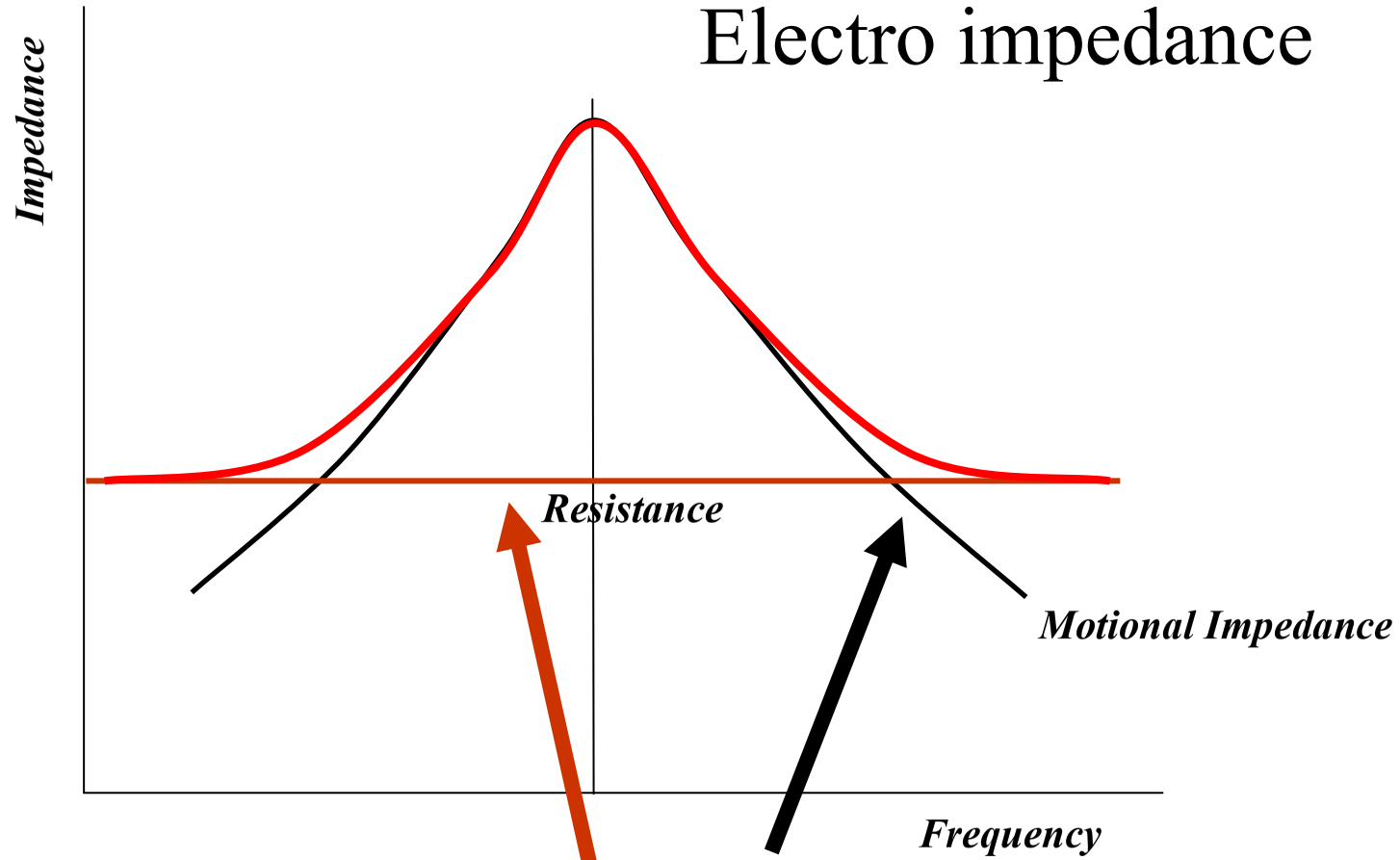


$$E = RI + \frac{Bl^2}{Zm} I = \left(R + \frac{Bl^2}{Zm} \right) I$$

$$P = j\omega\rho \frac{U}{2\pi r} e^{(-jkr)}$$

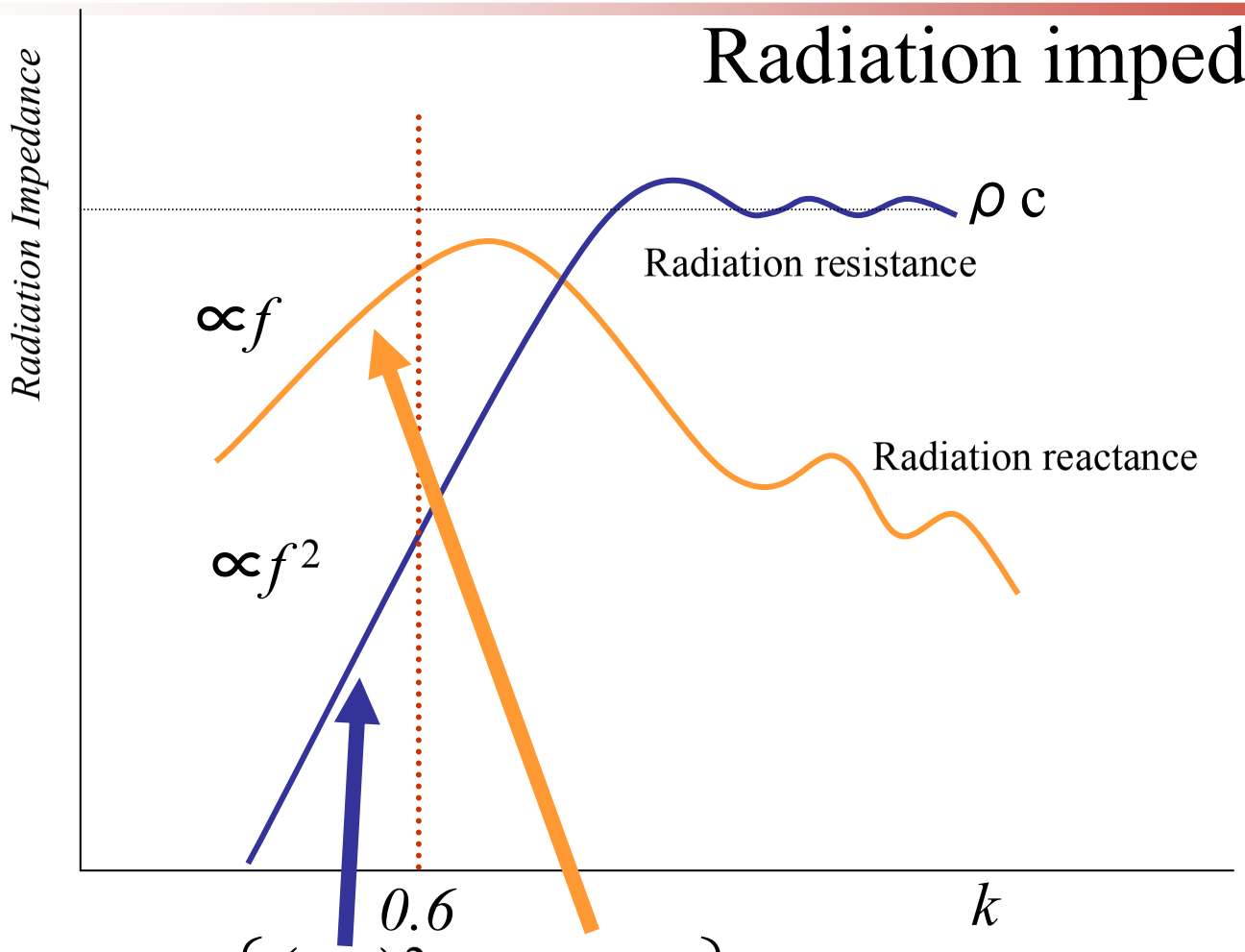
点音源からの音の放射
Point source radiation

電気インピーダンス



$$E = RI + \frac{Bl^2}{Zm} I = \left(R + \frac{Bl^2}{Zm} \right) I$$

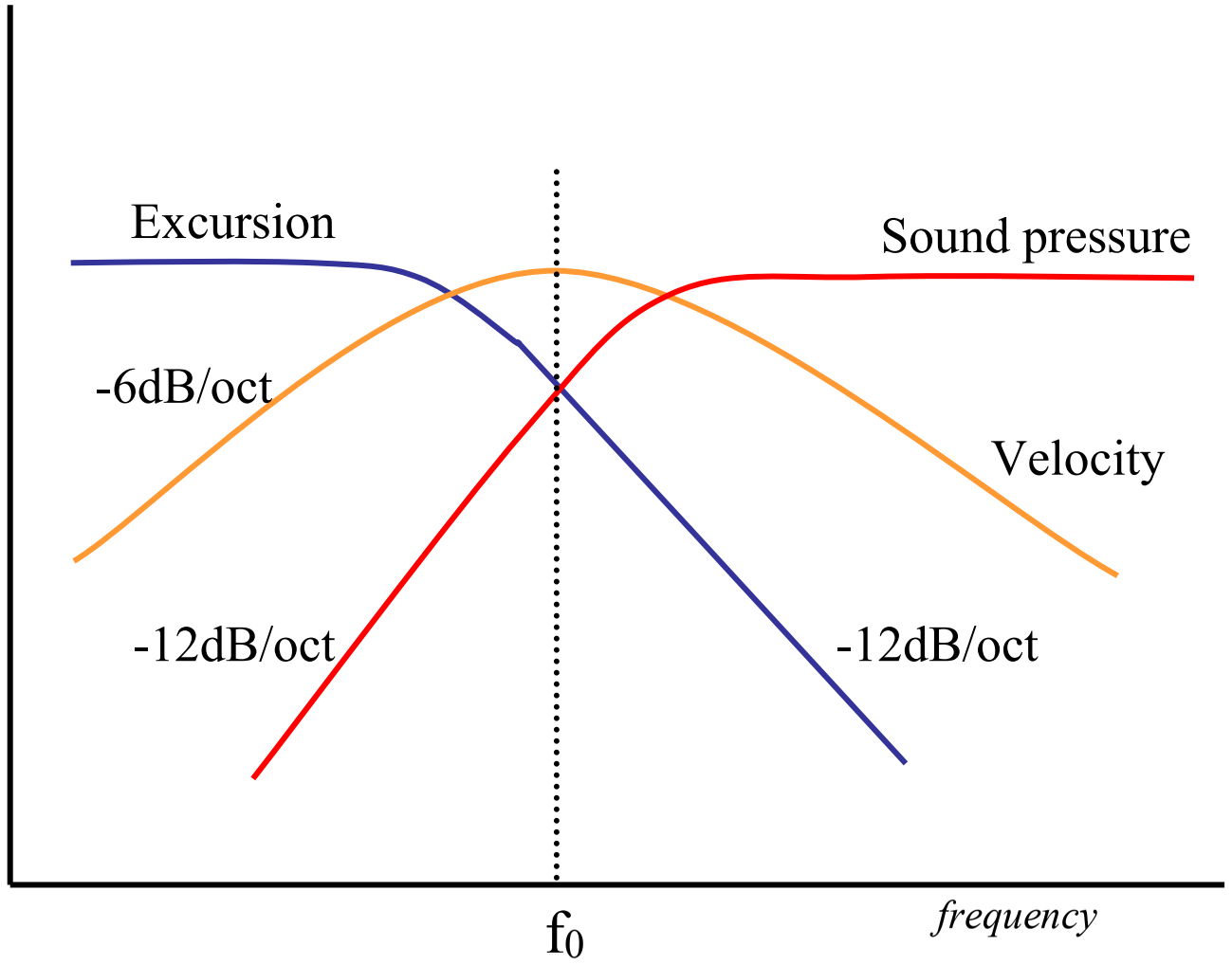
放射インピーダンス



$$Zs = \rho c\left\{\frac{(ka)^2}{2} + j\frac{8ka}{3\pi}\right\} \quad (k<0.6)$$

動電型スピーカの動作

Response of dynamic speaker



ホーンスピーカ

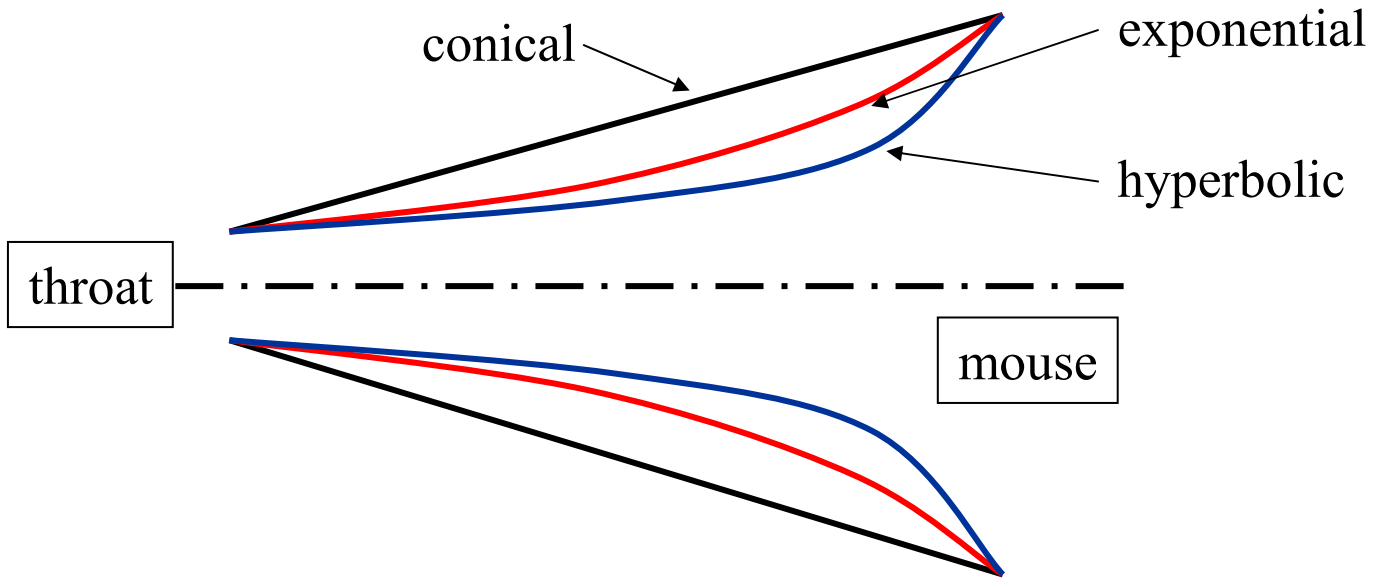
Detail of horn speaker

What is horn speaker?

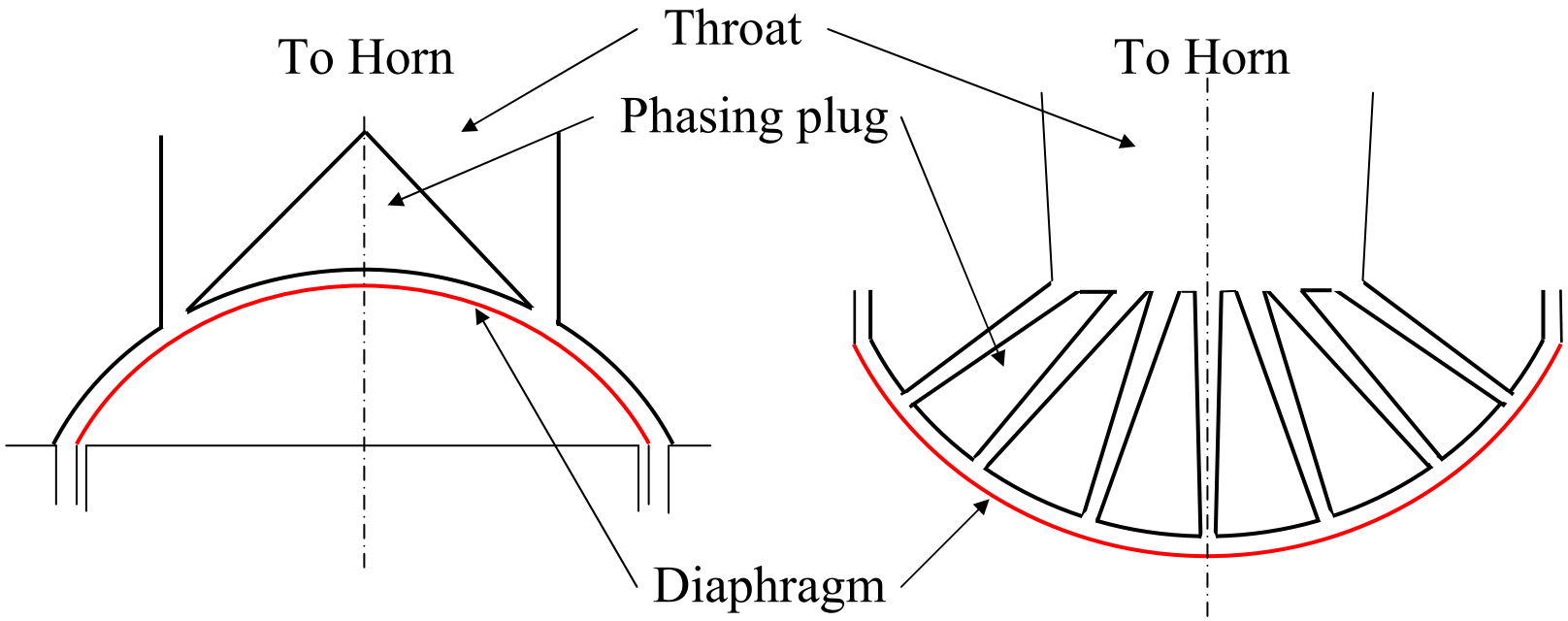
・ホーンはスピーカの周波数特性、指向性、効率を改善するための音響伝送系

Horn is a acoustic transmission line which improve frequency response, directivity and efficiency.

・基本形状 Basic shapes



ドライバーの構造 Driver Structures

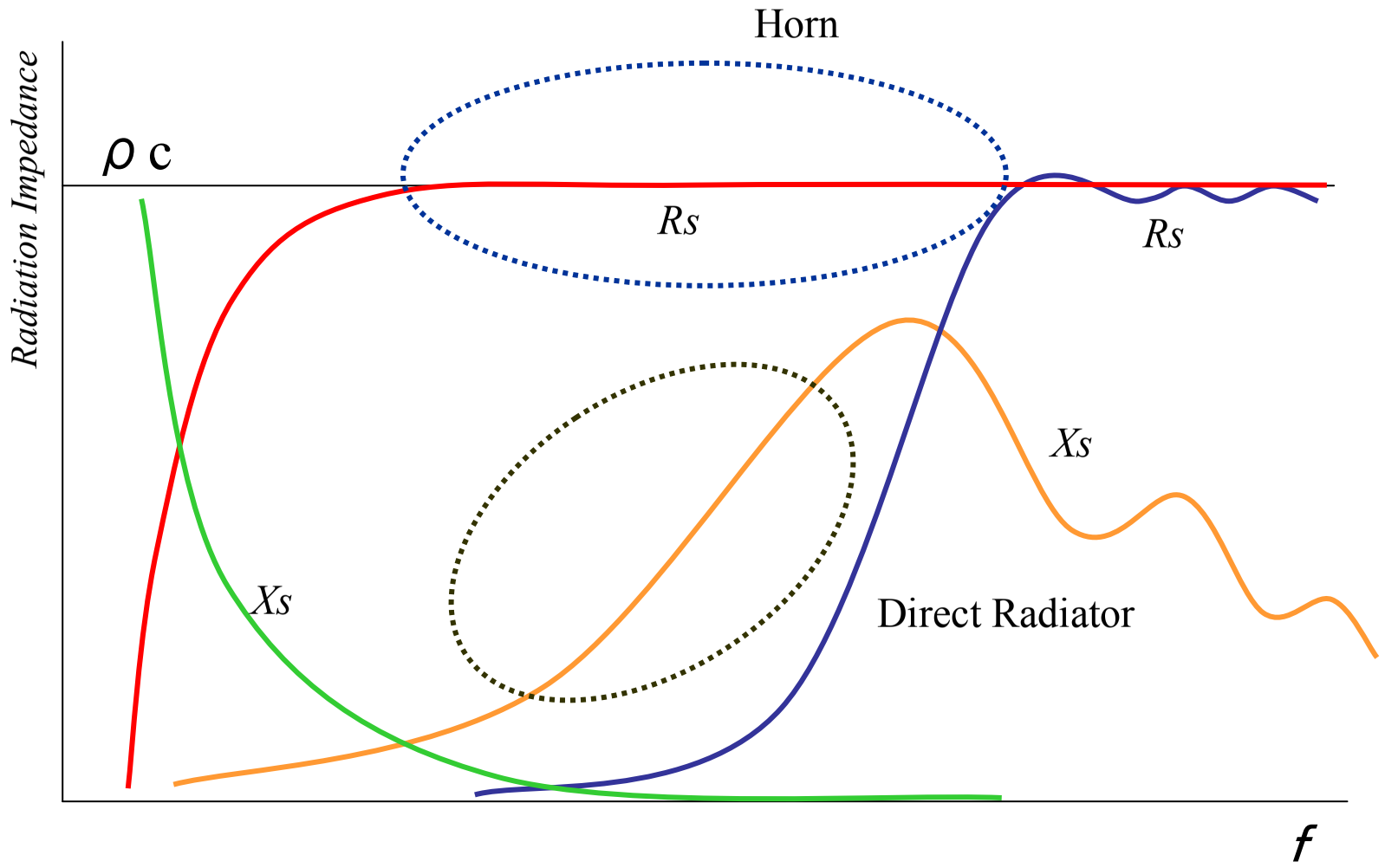


Front load type

Rear compression type

放射インピーダンス比較

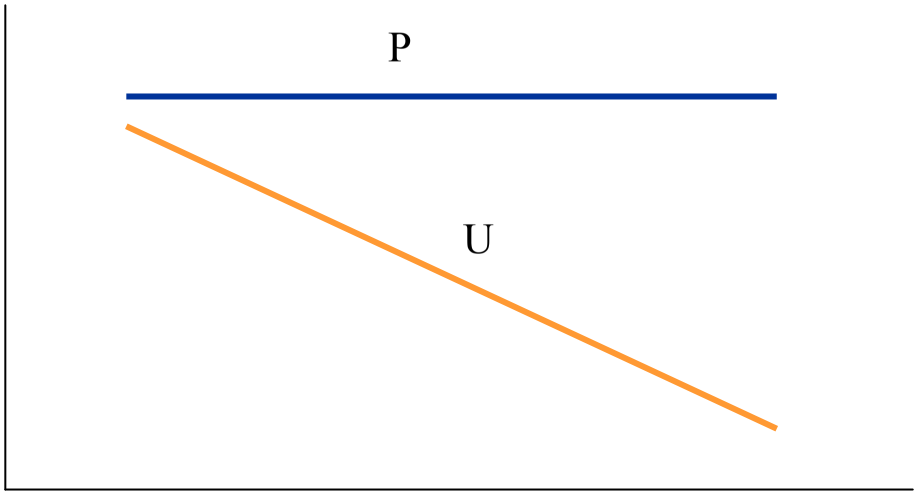
Comparison of radiation impedances



Response of Horn and Direct radiator

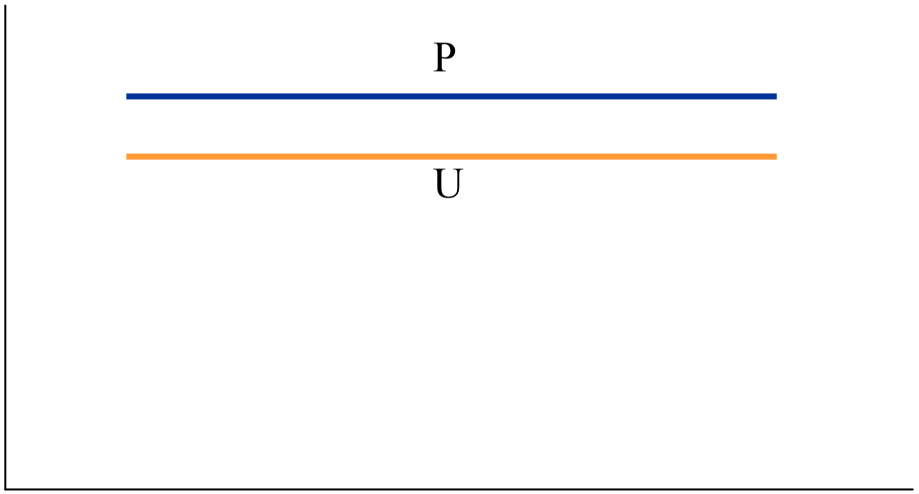
Direct Radiator

$$P = j\omega\rho \frac{U}{2\pi r} e^{(-jkr)}$$

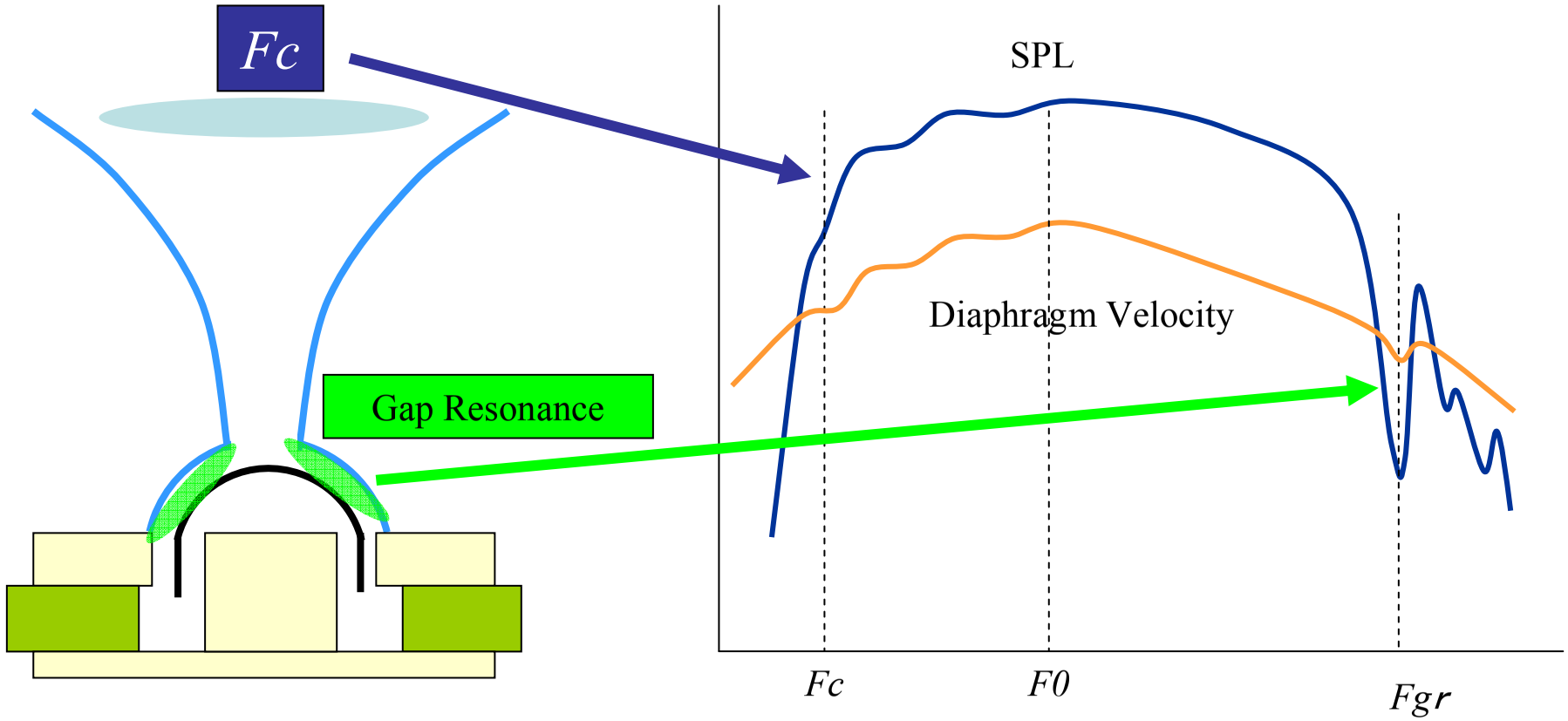


Horn

$$P = \rho c \frac{U'}{2\pi r} e^{(-jkr)}$$



Actual Horn Speaker response



Multi-way system

Cross-over network

クロスオーバーネットワークは

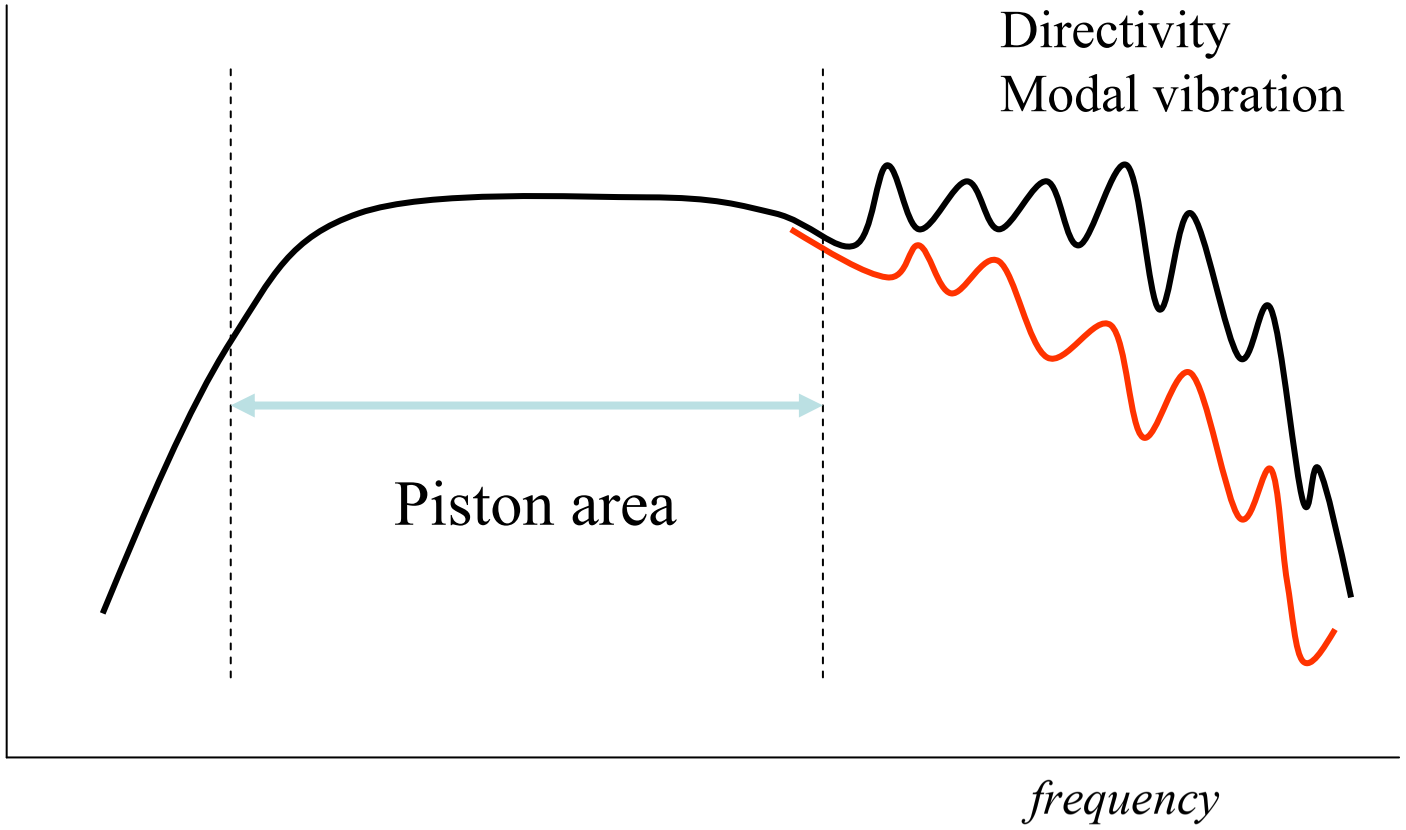
Cross- over network is used with multi-way speaker system in order to realize

- 最適な周波数特性
  optimum frequency response
- 低歪み
  low distortion
- 要求する音質
  required sound quality

の実現

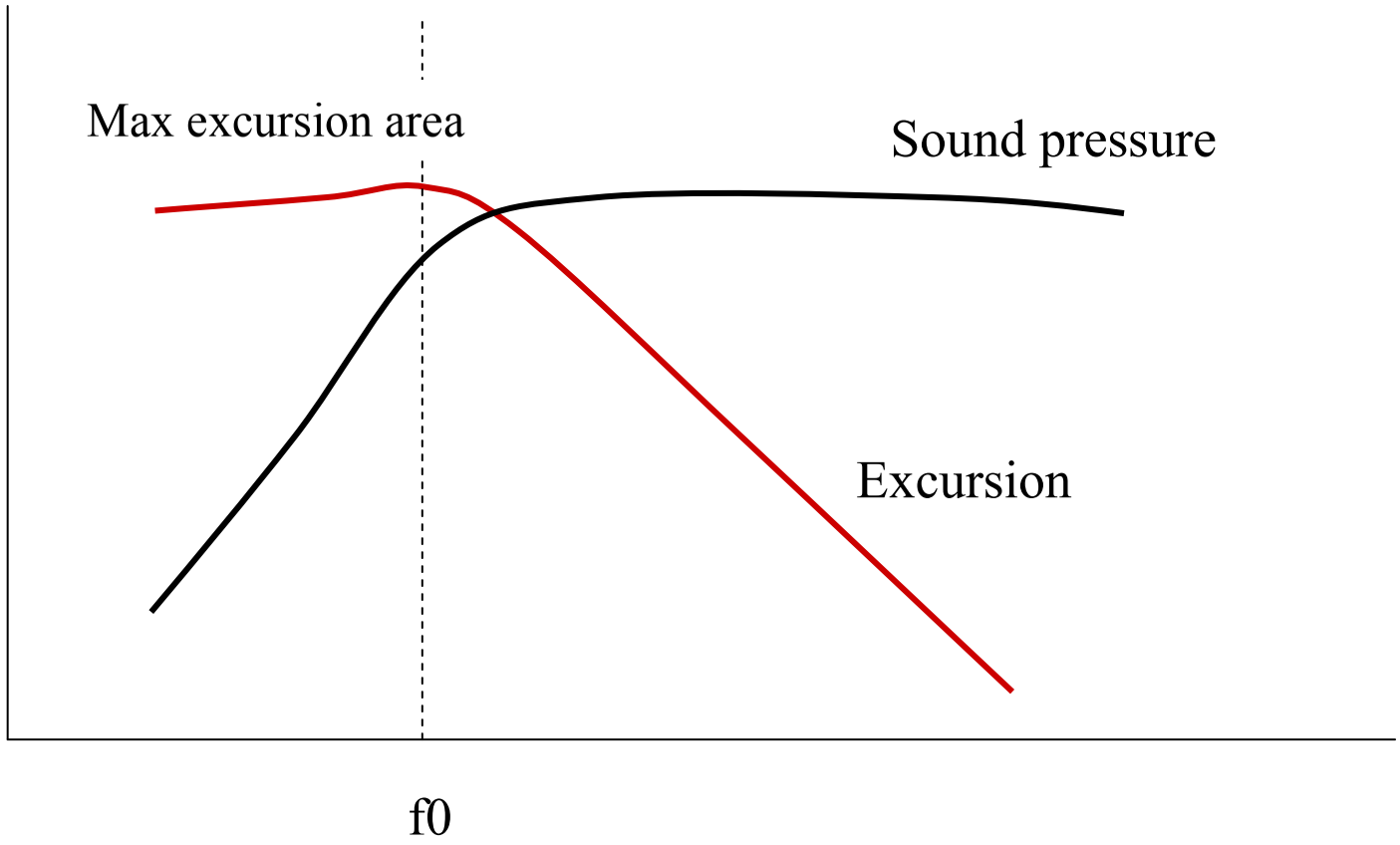
最適再生周波数帯域

Optimum reproduction frequency range



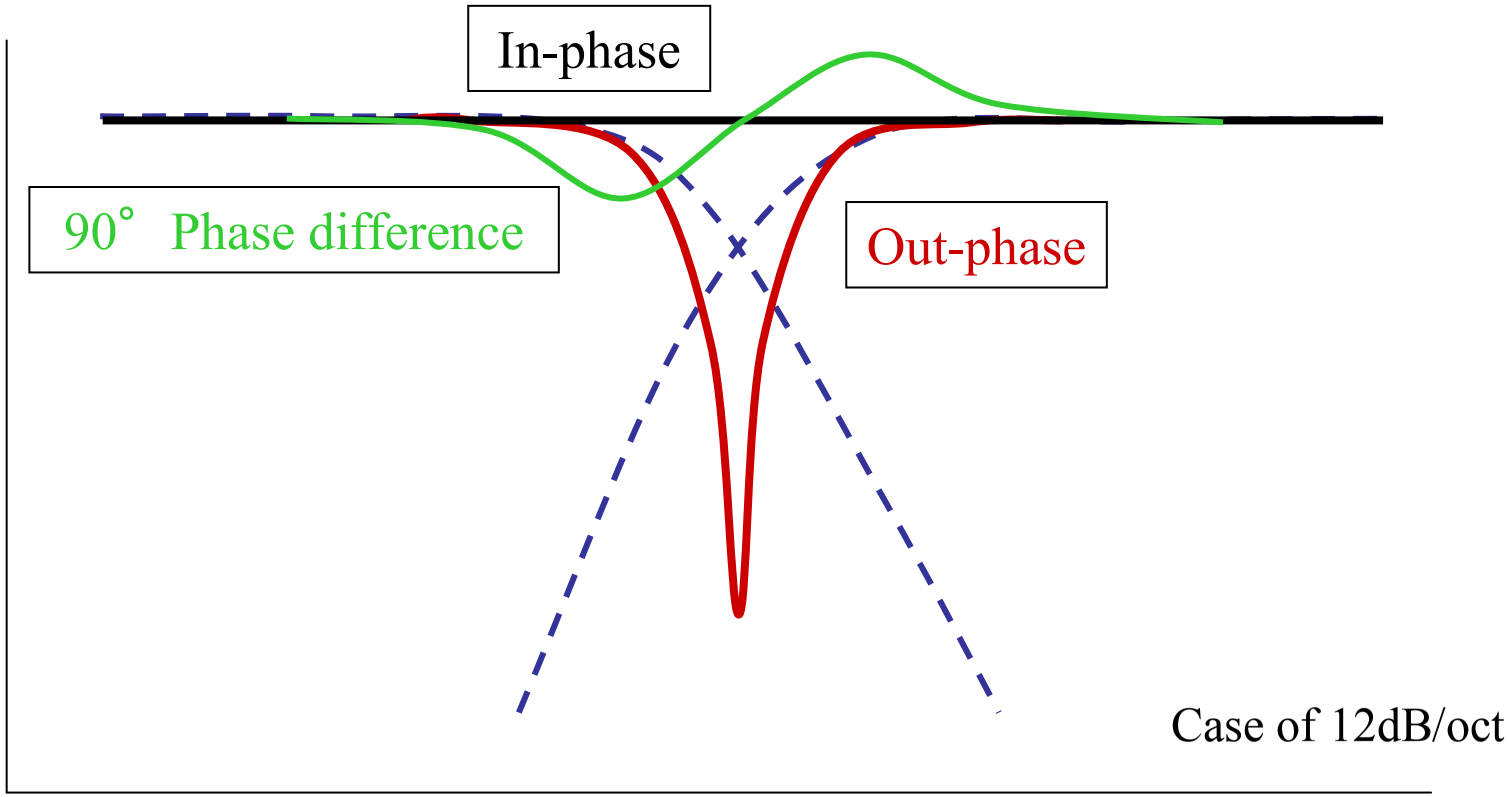
過大入力からの保護

Protect from over load

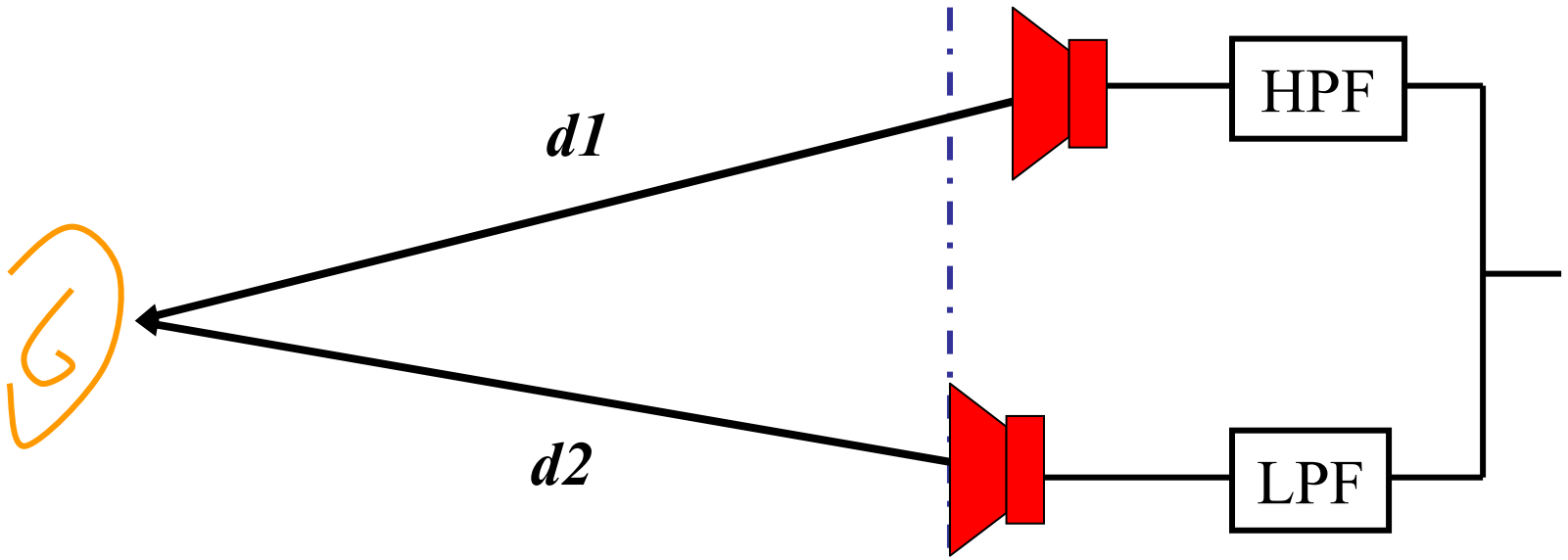


Response at crossover

Polarity

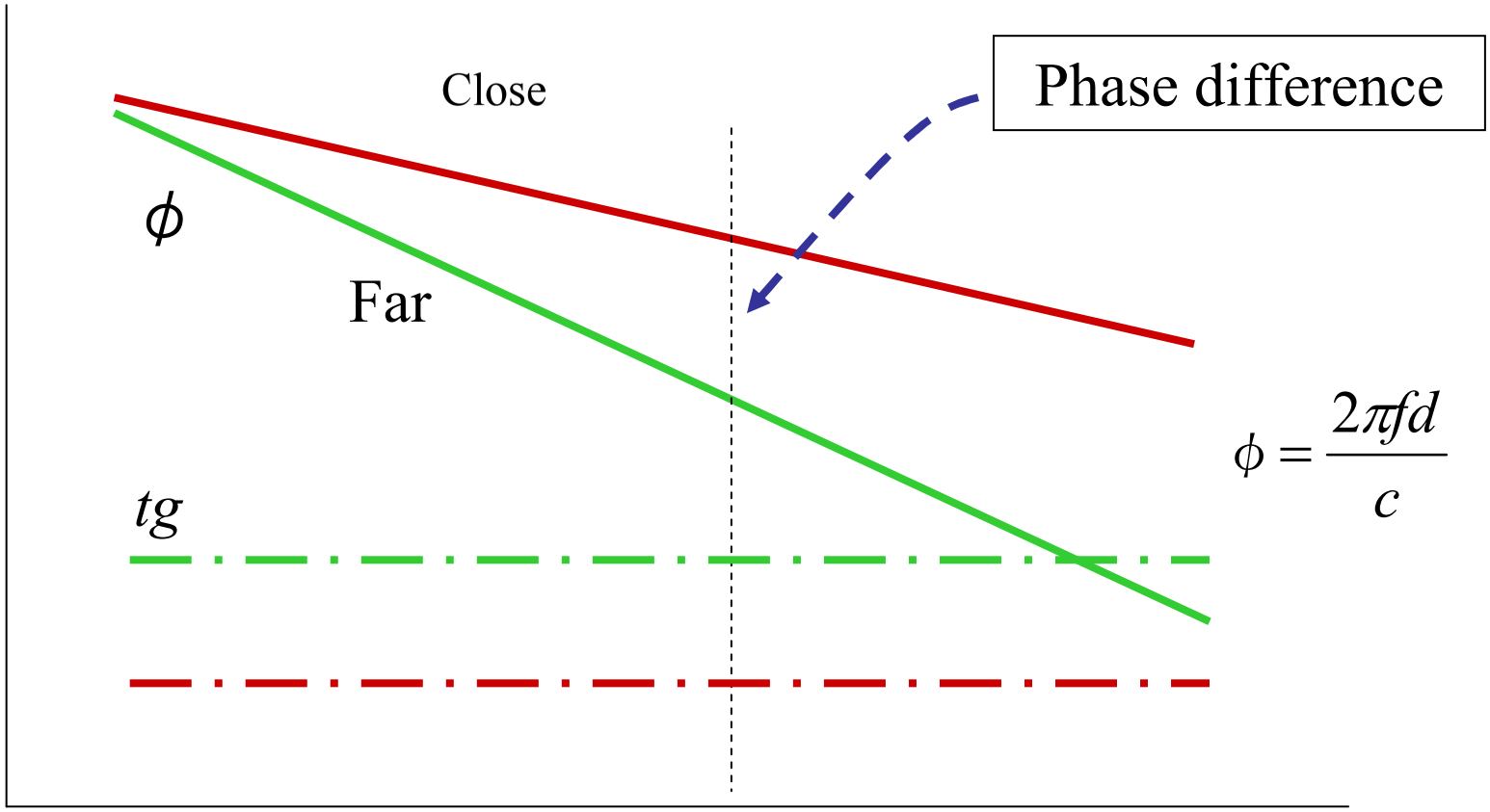


Phase response at listening point

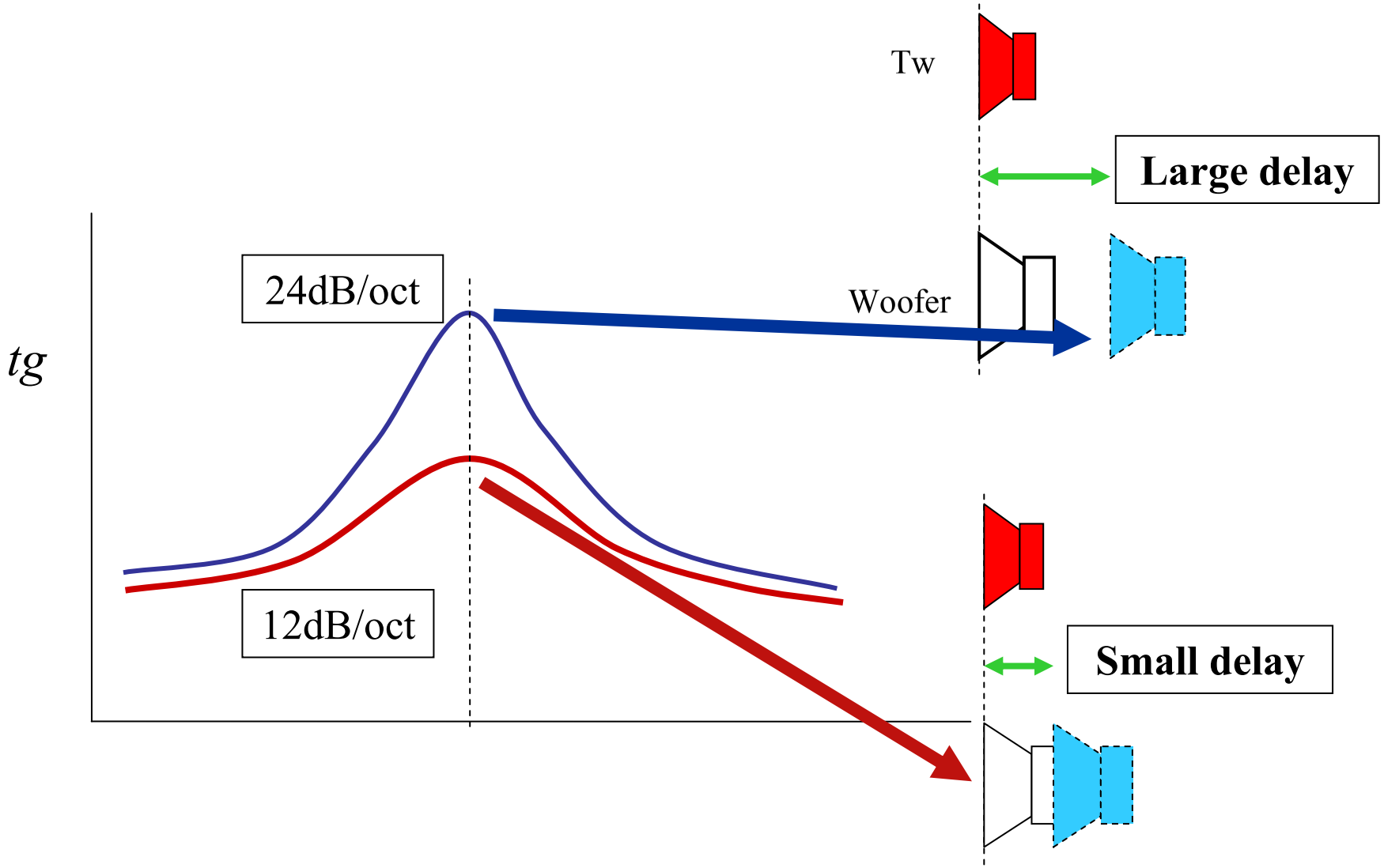


$$\phi = \frac{2\pi f (d_1 - d_2)}{c}$$

Influence of driver location

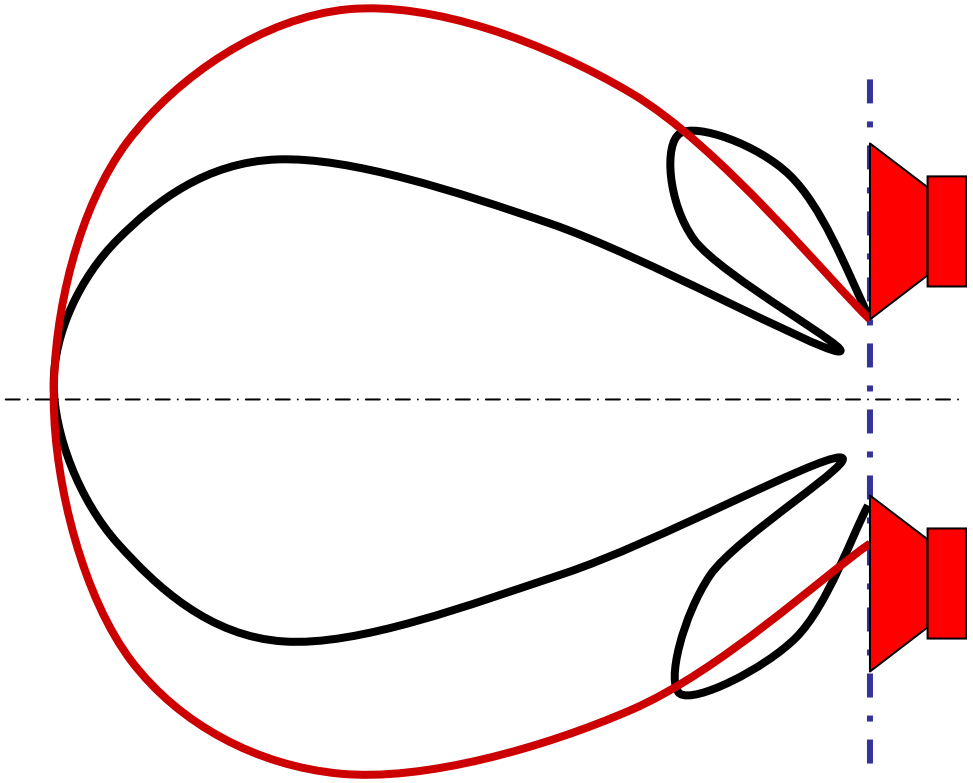


Influence of filter order



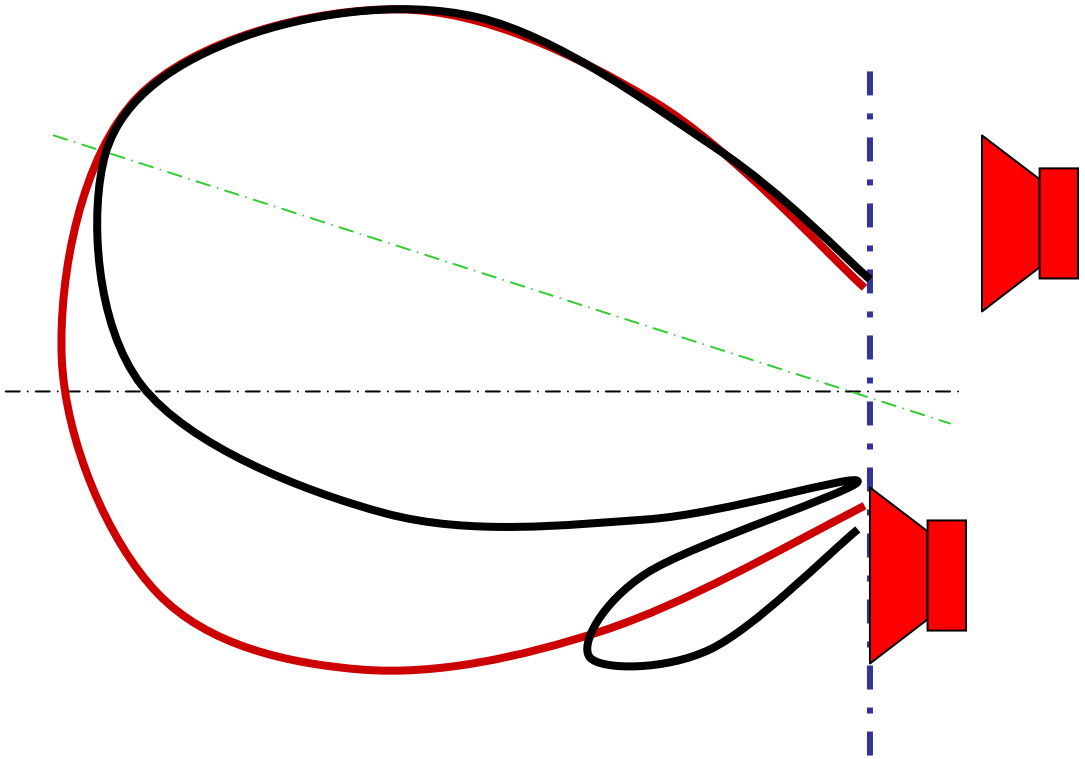
Response at crossover

Directivity on same plane



Response at crossover

Directivity on offset position



Design method for vented box

There are two method for designing of vented box.

・カットアンドトライによる方法　One is cut and try.

全てのスピーカパラメータが必要

Required all parameters for equivalent circuit

バスレフスピーカの動作を理解する必要がある

Understanding the detail behavior of vented box

・Another is analytical method.

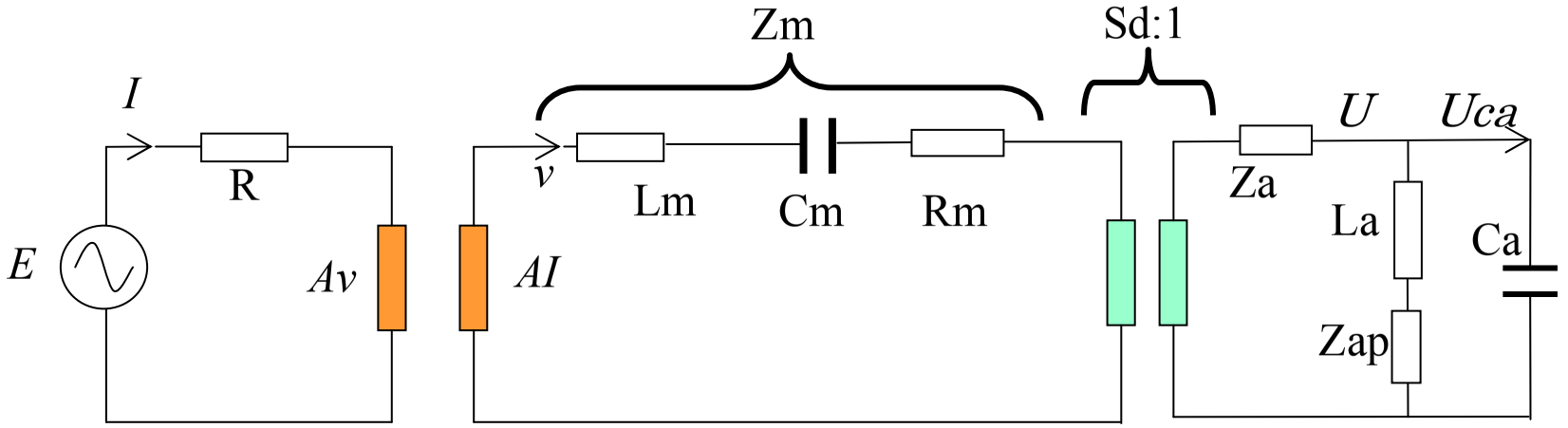
ティール・スモール法

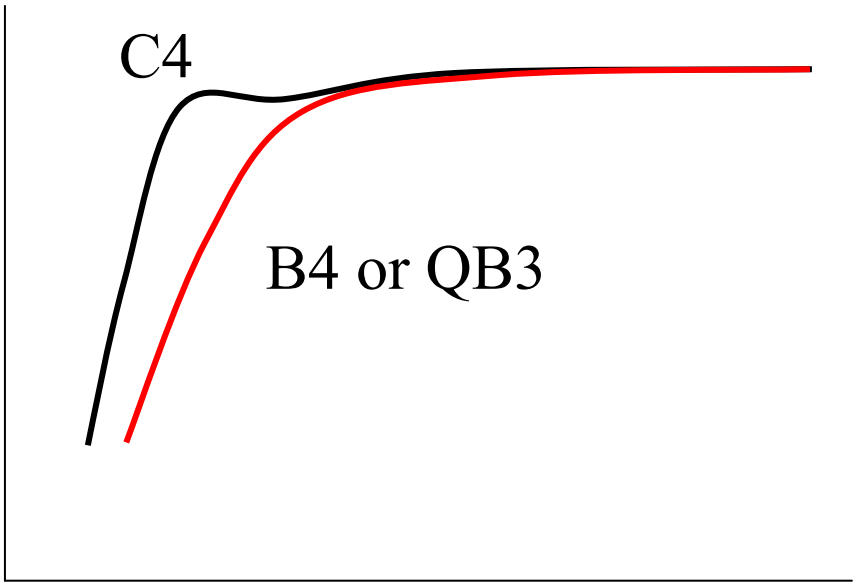
TS method is one of the famous method

解析的に設計できる

Benefit for sealed or vented box design

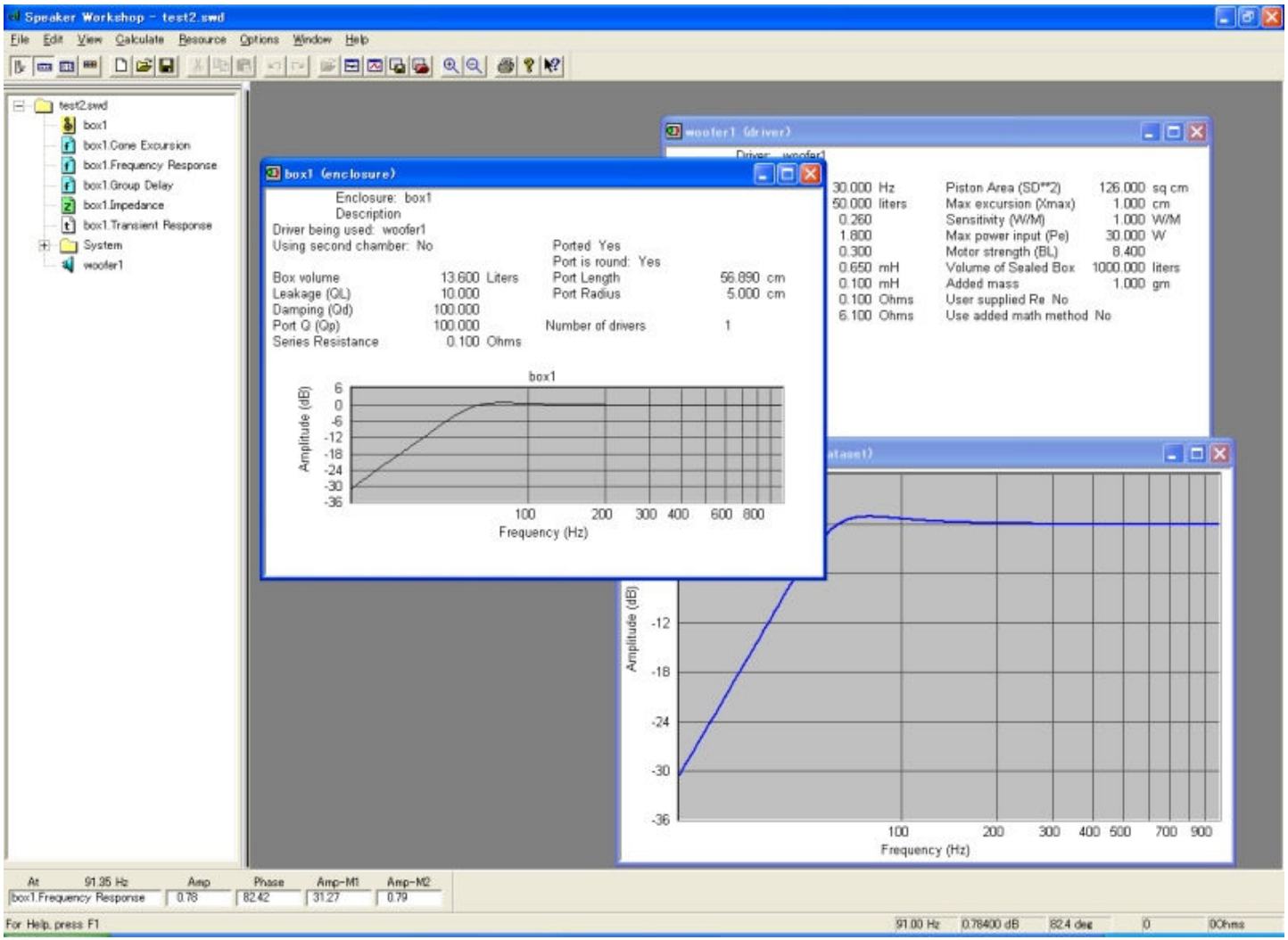
Equivalent circuit of vented box





Calculate Example

There are many tools such as LEAP, SpeakerWorkshop etc.



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