Hochschule Ulm

University of
Applied Sciences

Diagnostic Ultrasound

(Physics and Electronics)

Technik
Informatik & Medien
Hochschule Ulm
University of
Applied Scienc

TAE, August 2008

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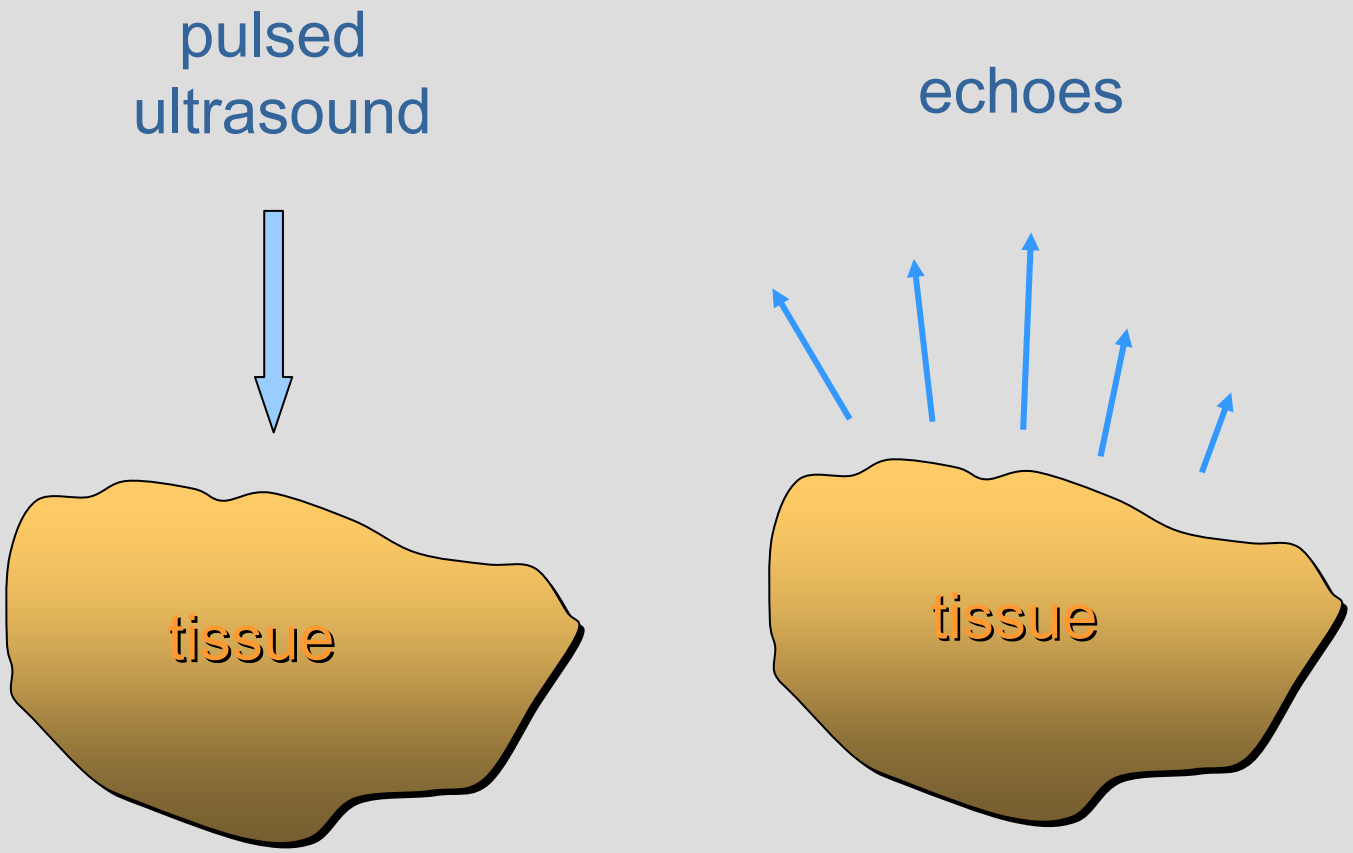
Physics: Application of ultrasound

Content:

- Ultrasound
- Transducer
- Doppler
- Emboli
- Doppler processing
- Electronics
- Nyquist Plot
- Bode Diagram
- PSpiece demo
- Laboratory



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Physics: Pulsed ultrasound waves

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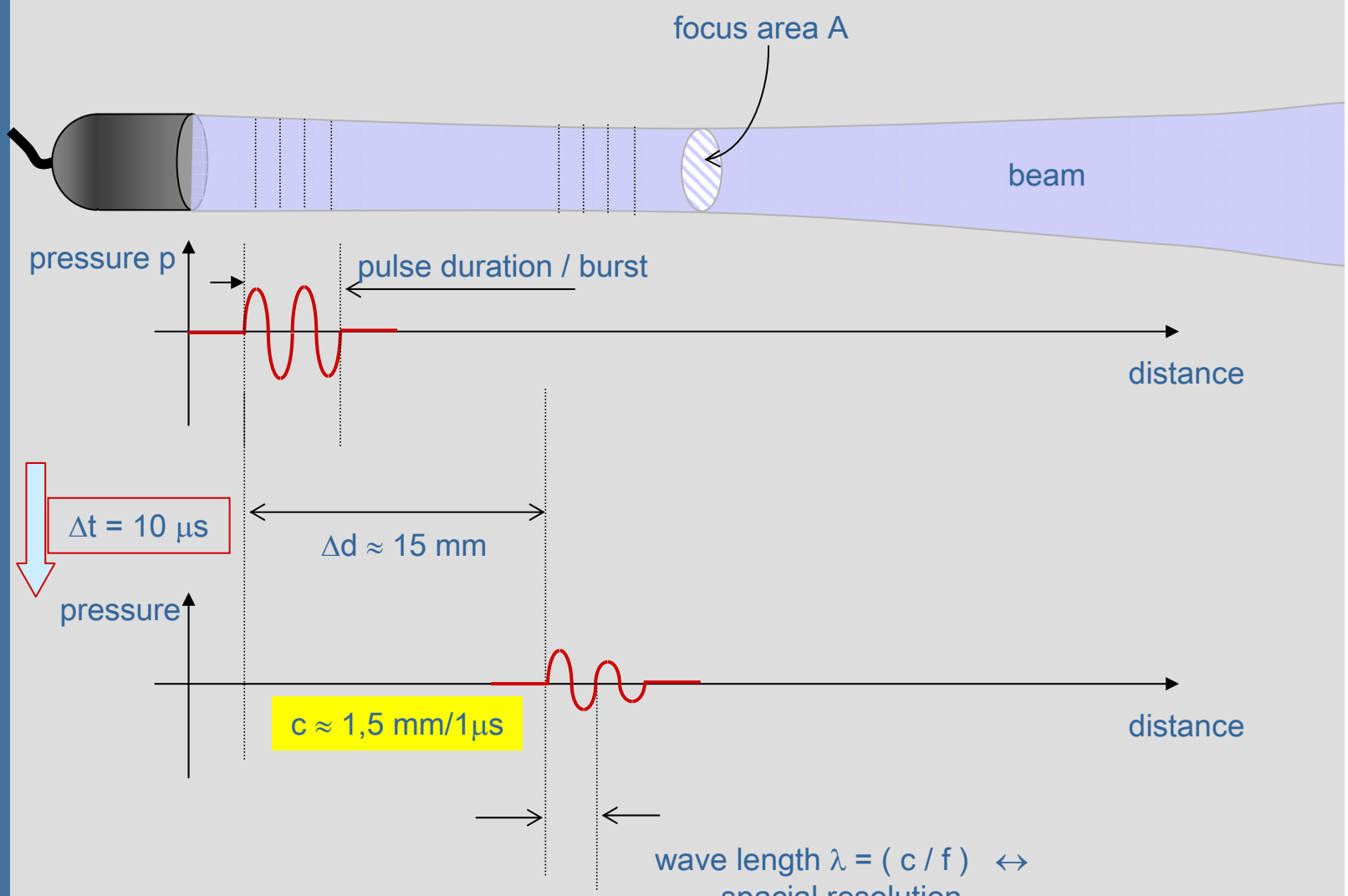

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Physics: Pulsed insonation ↔ depth limit

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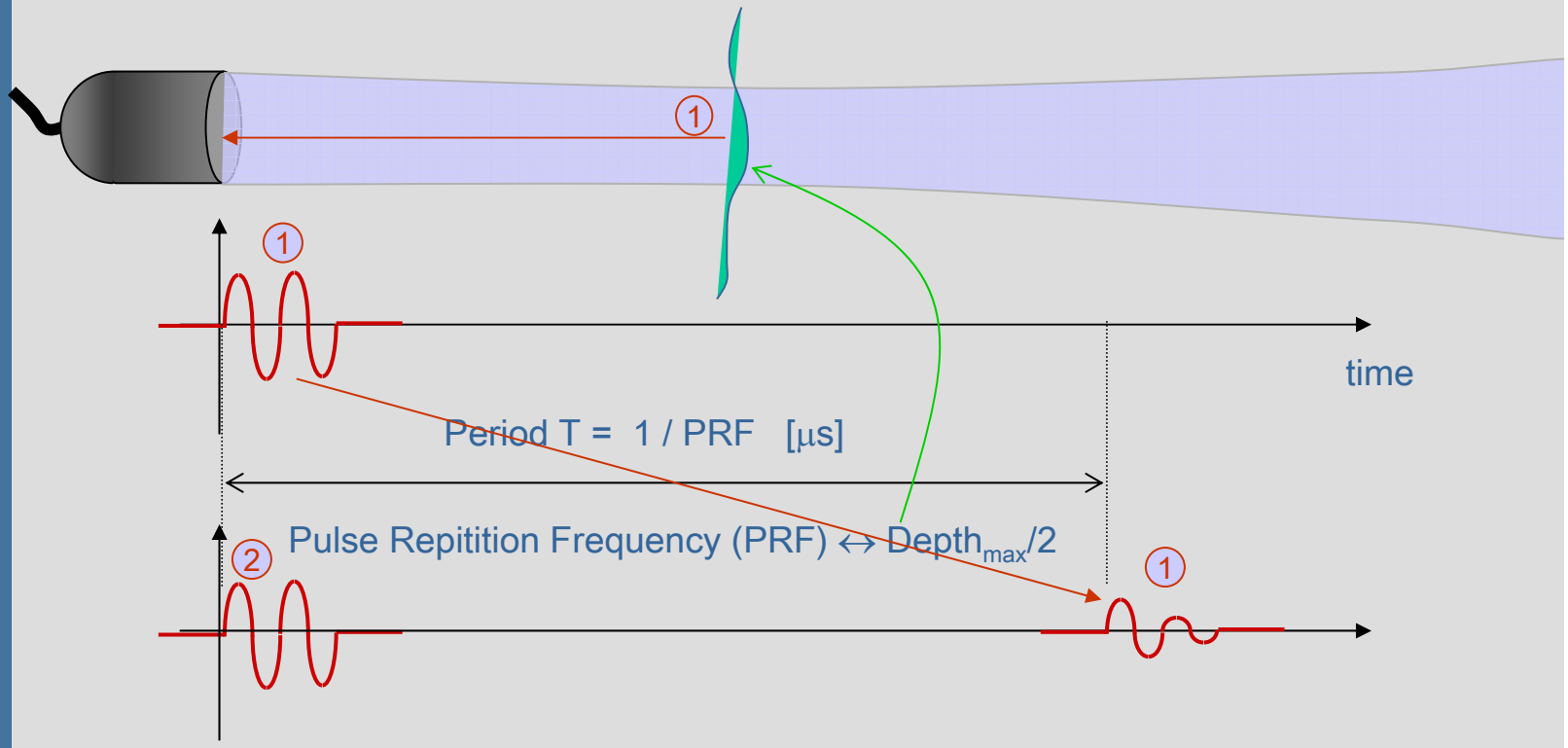

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Physics: Echoes (static ↔ dynamic)

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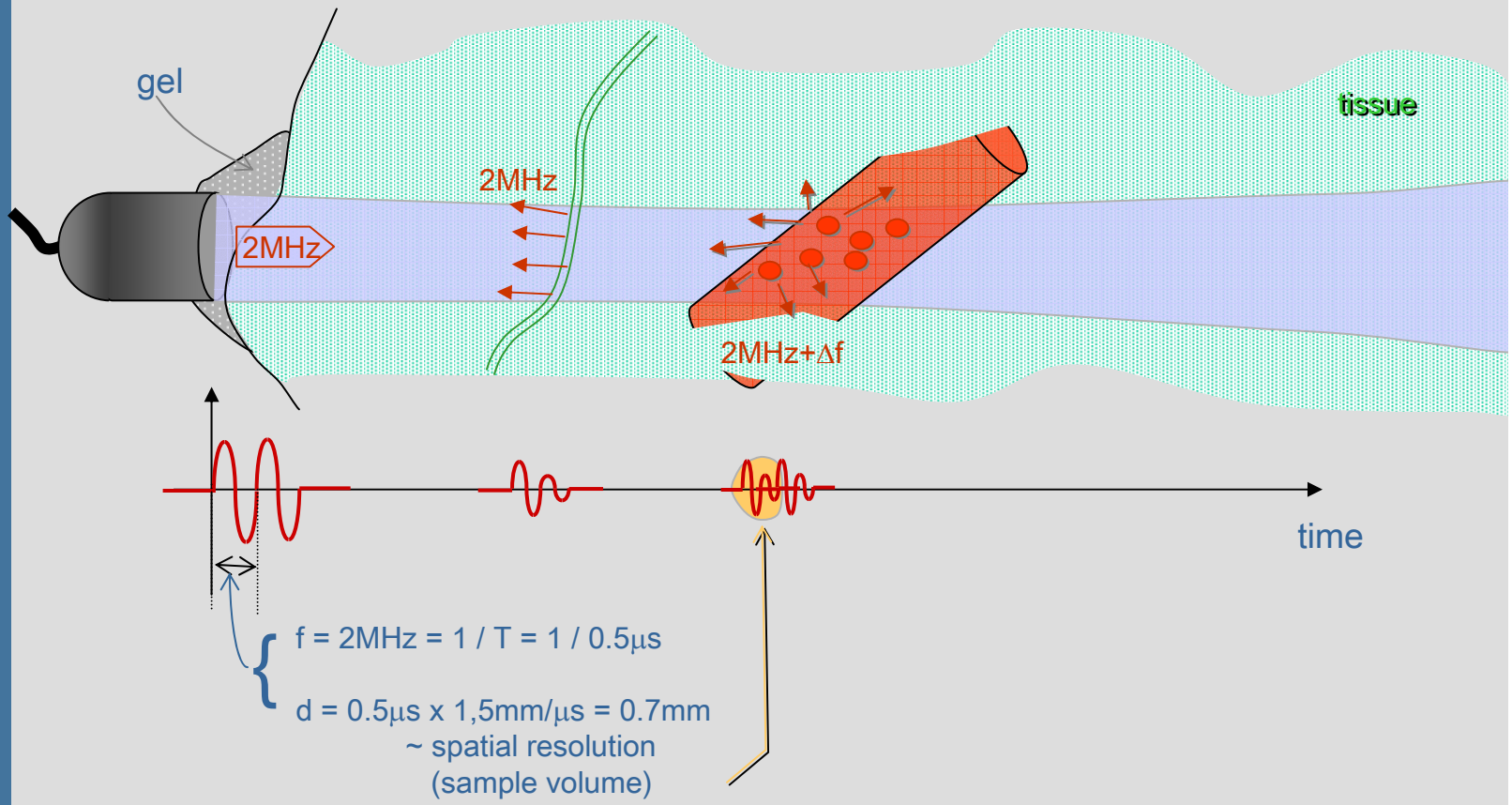

Dynamic echoes at 2MHz: → Doppler shift frequencies Δf :

blood flow velocity v ≈ 40 cm/s ↔ Δf ≈ 1kHz

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Diagnostics: Vessel insonation

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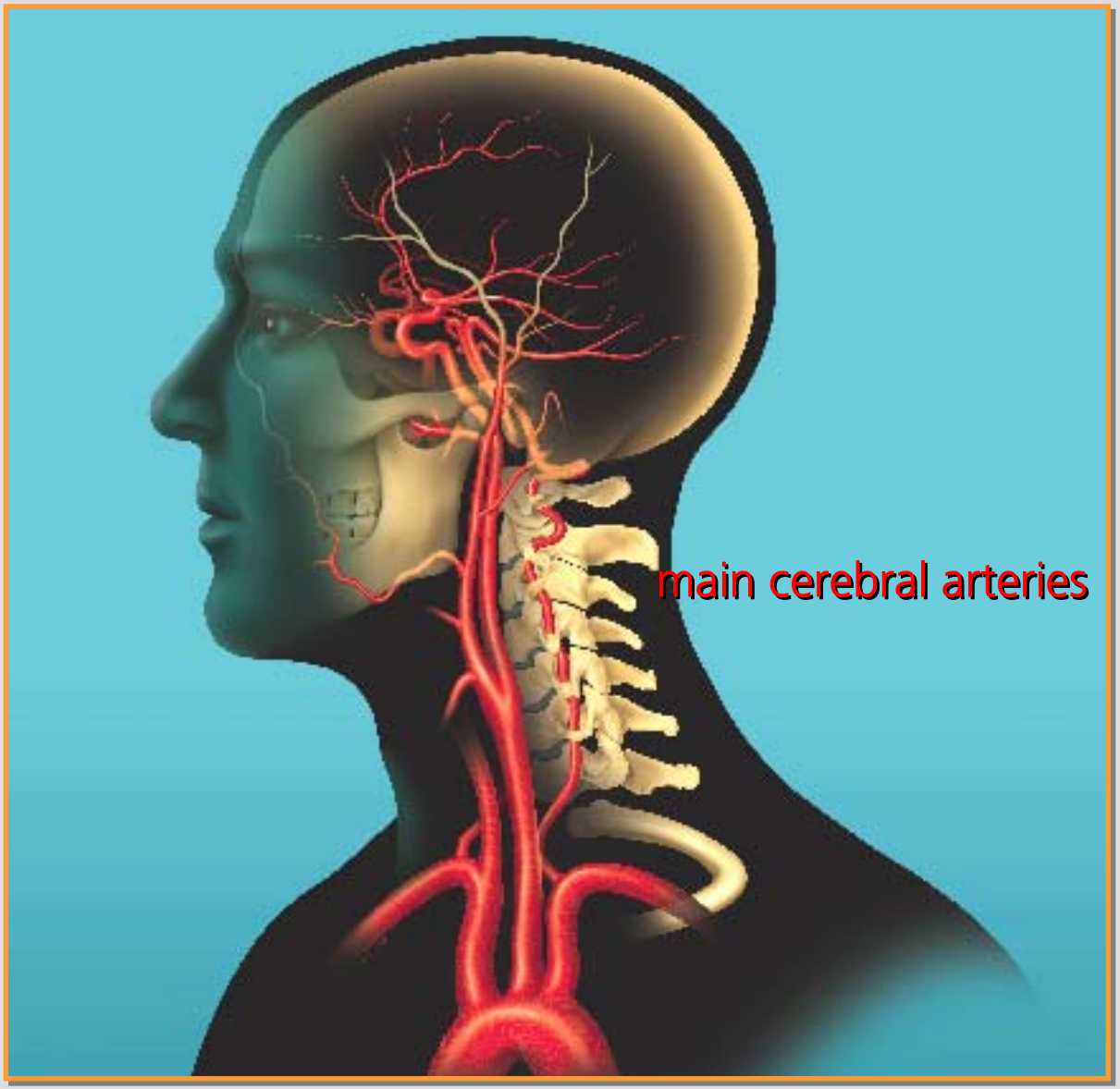

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Diagnostics: TCD (transcranial Doppler)

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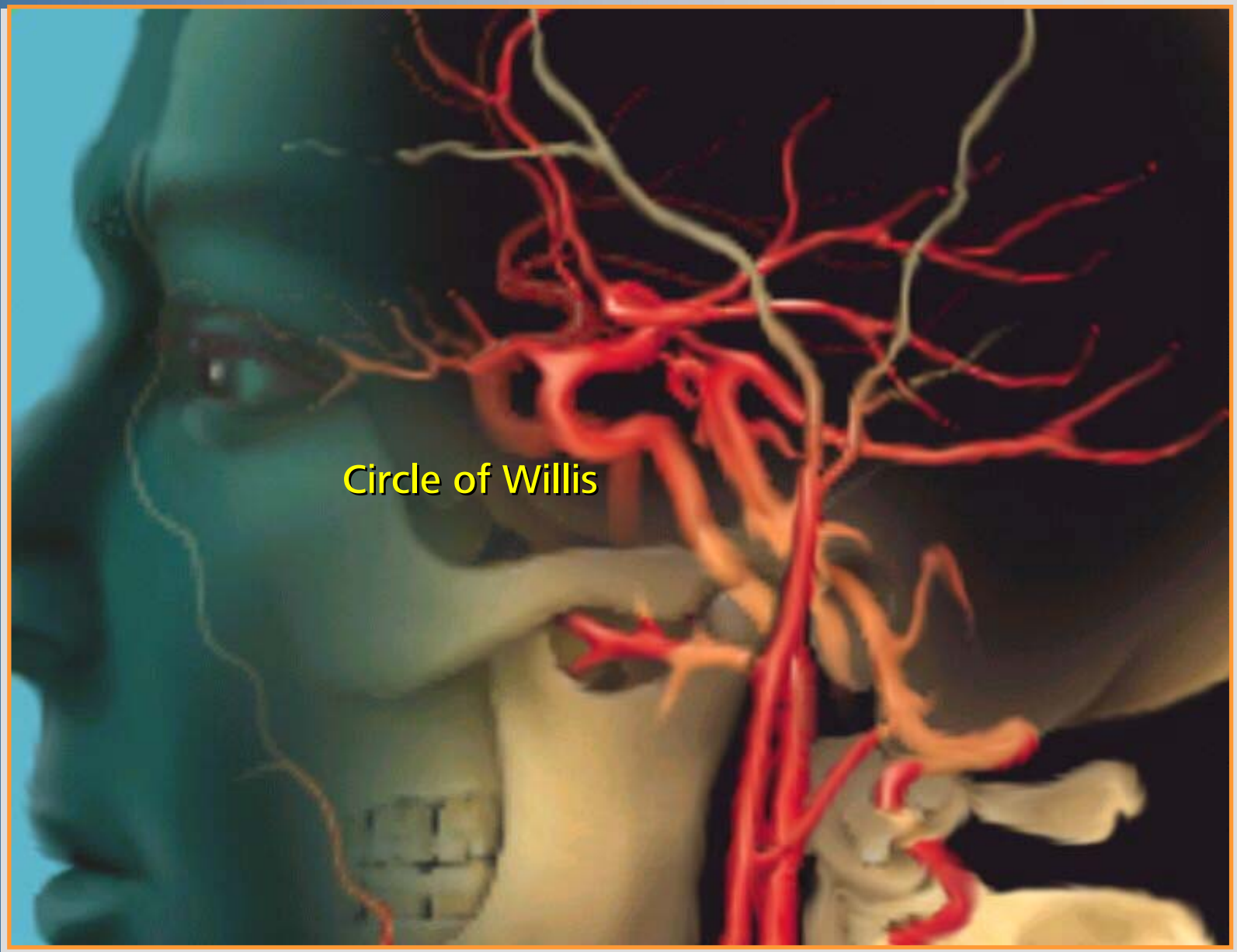

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Transducer: Single elements

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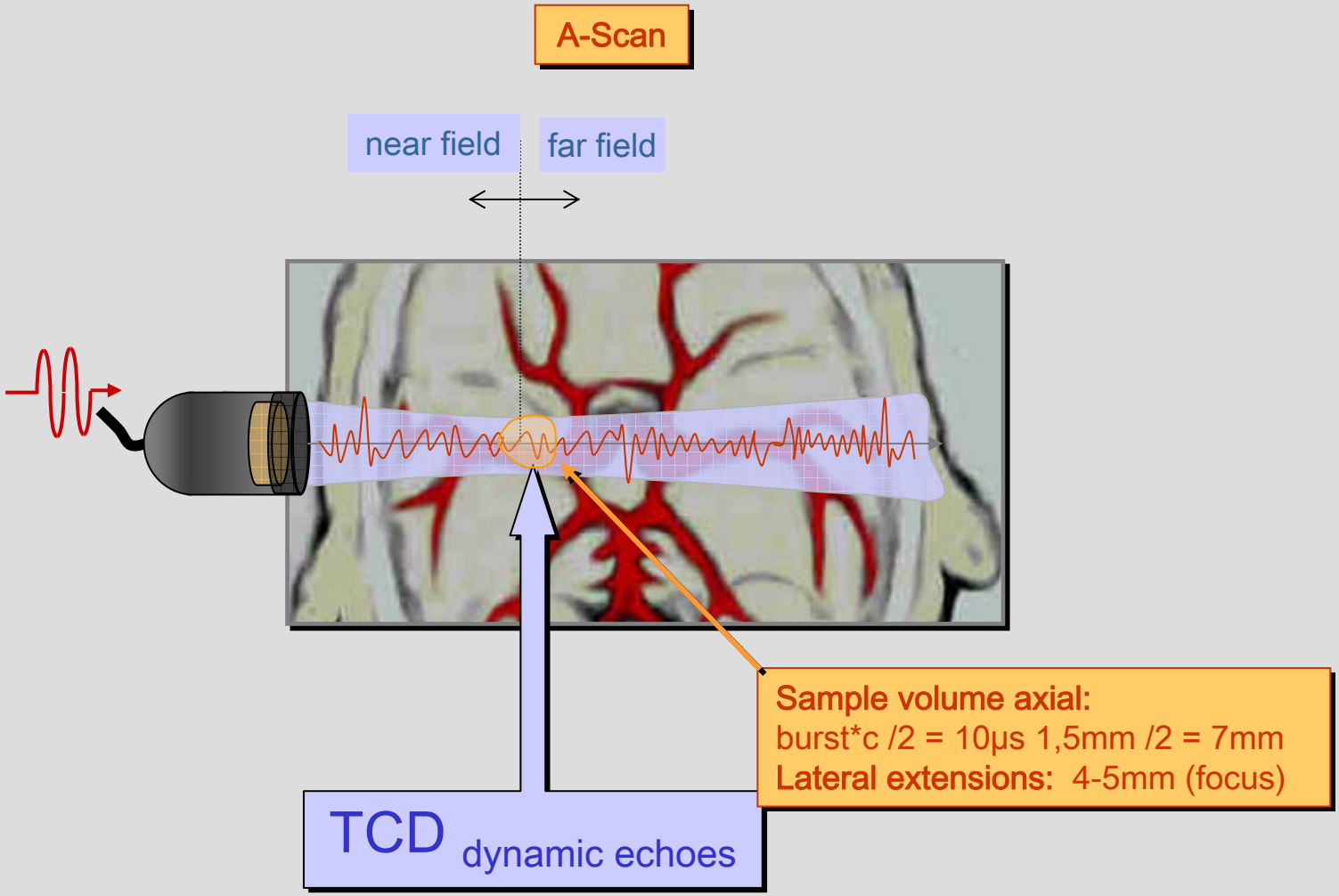

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Instrumentations: Single element TCD-Doppler

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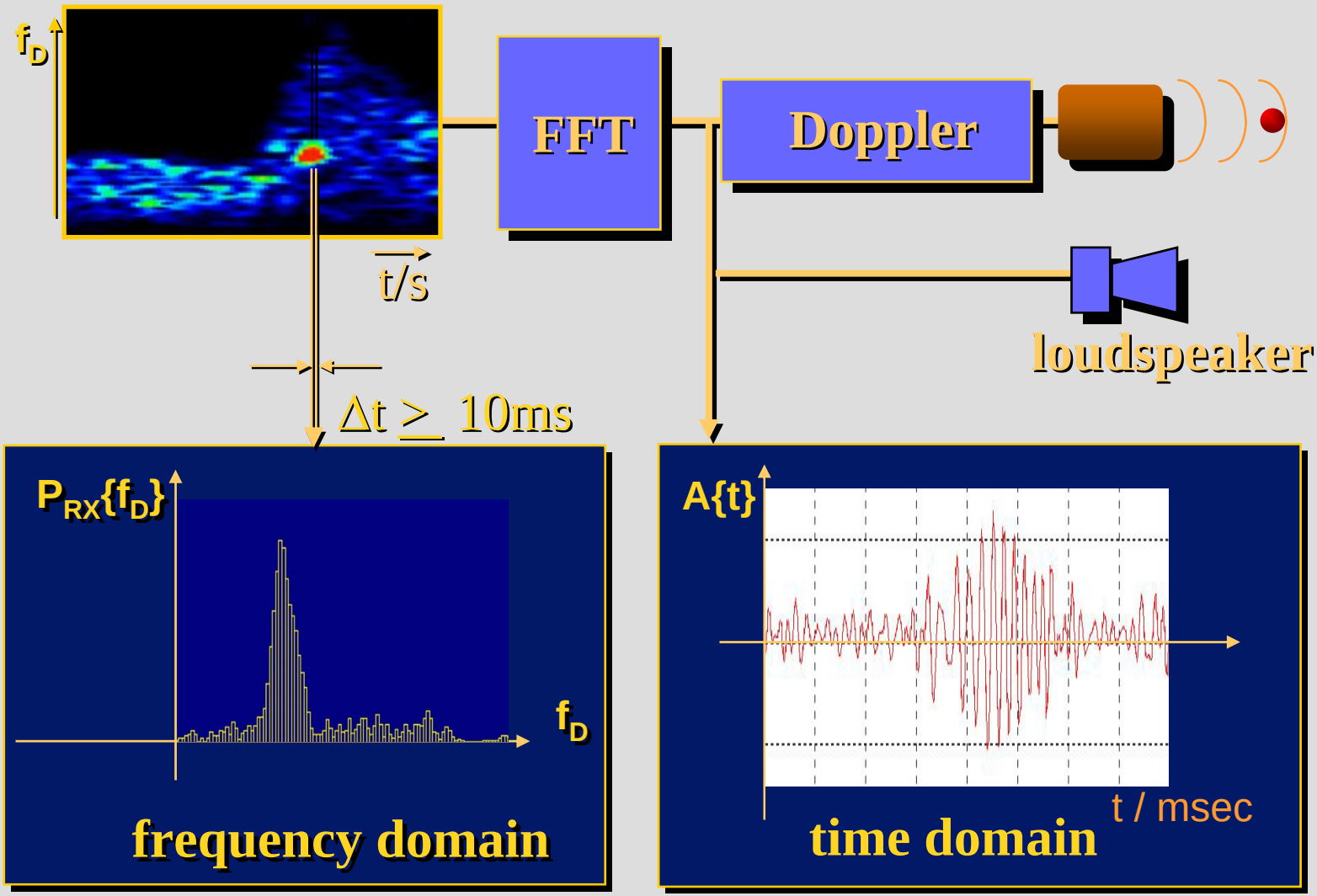

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Stroke monitoring by Emboli detection

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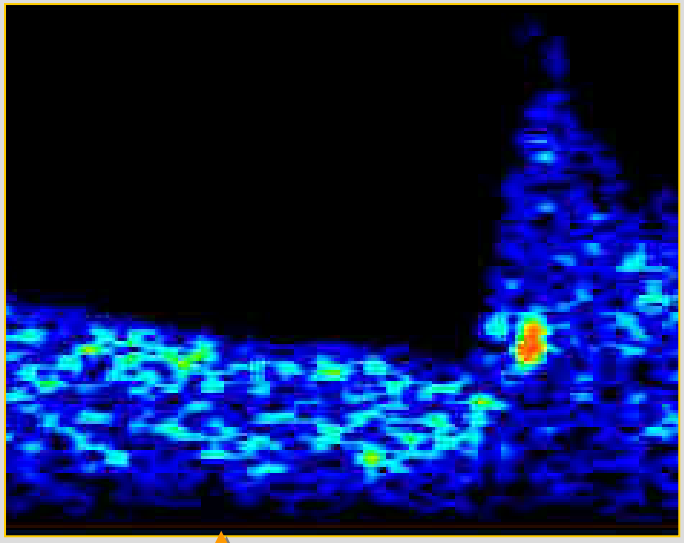

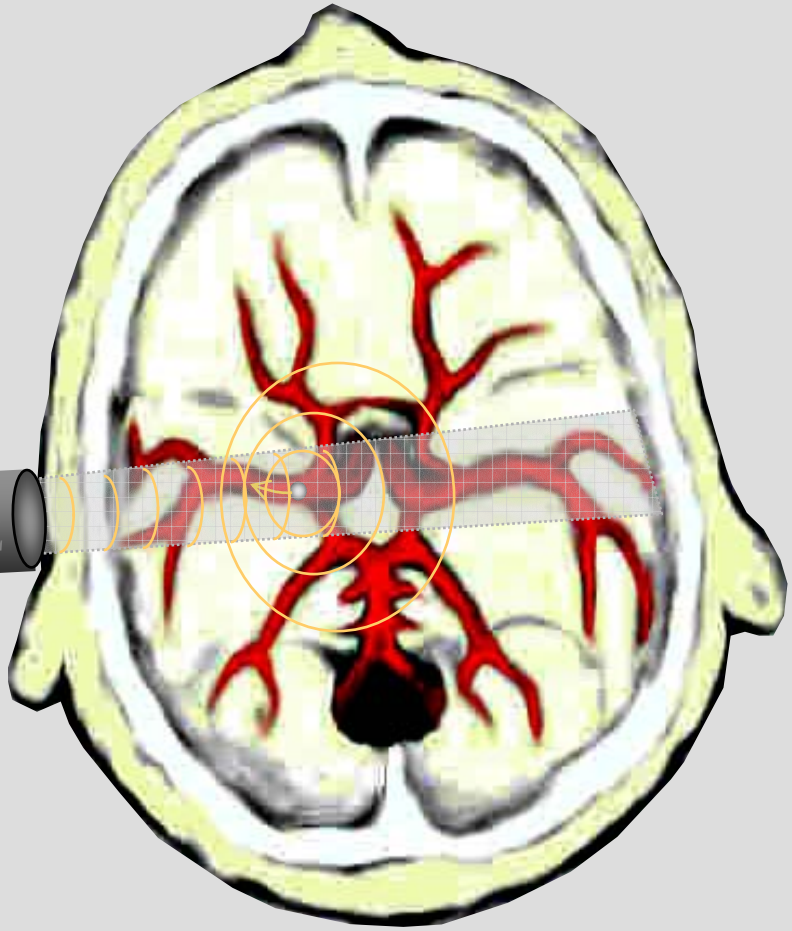

Realtime FFT
RF-demodulator

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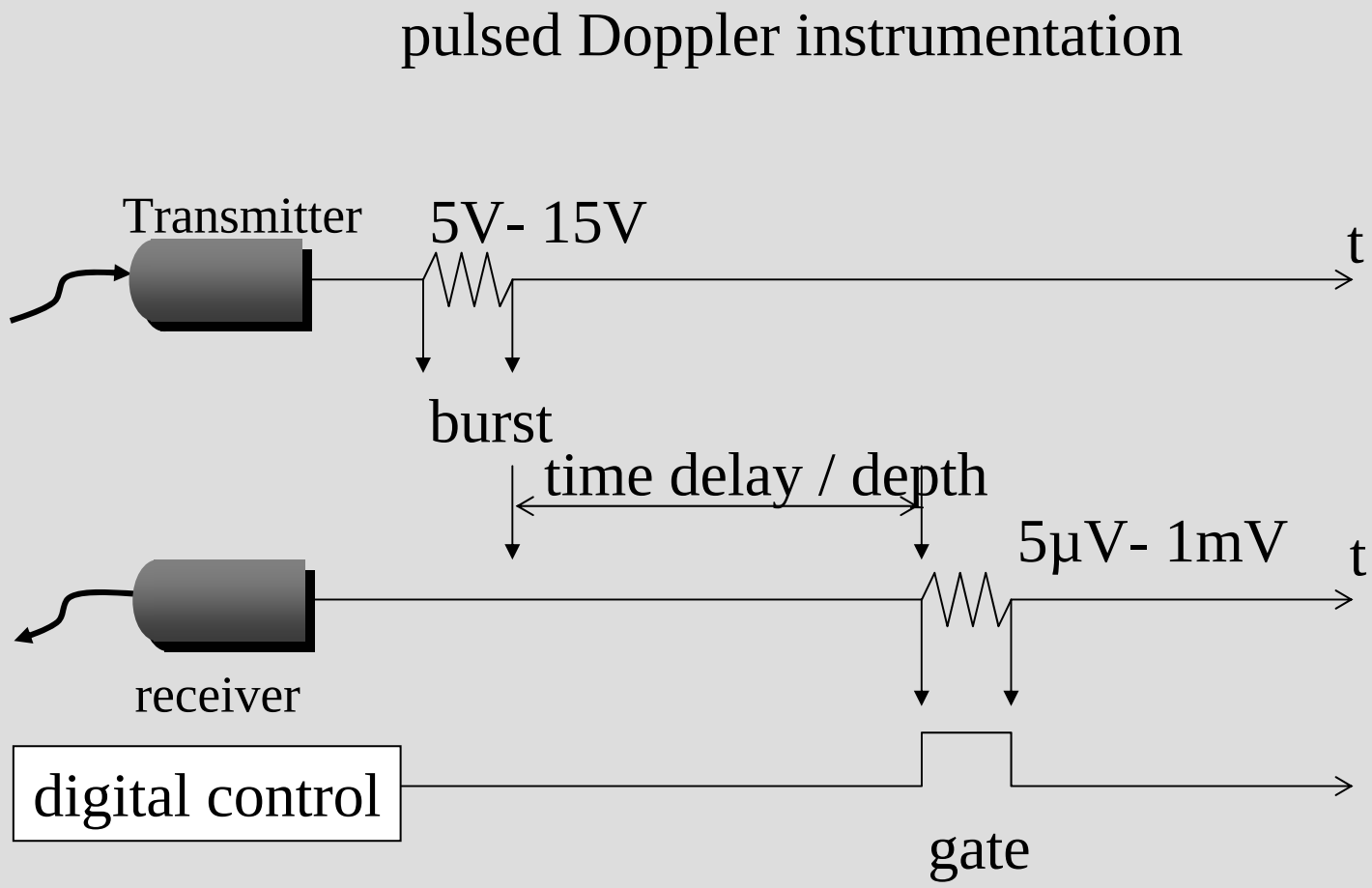
Ultrasound signal processing

Ultrasound transmitter/receiver



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Ultrasound signal processing

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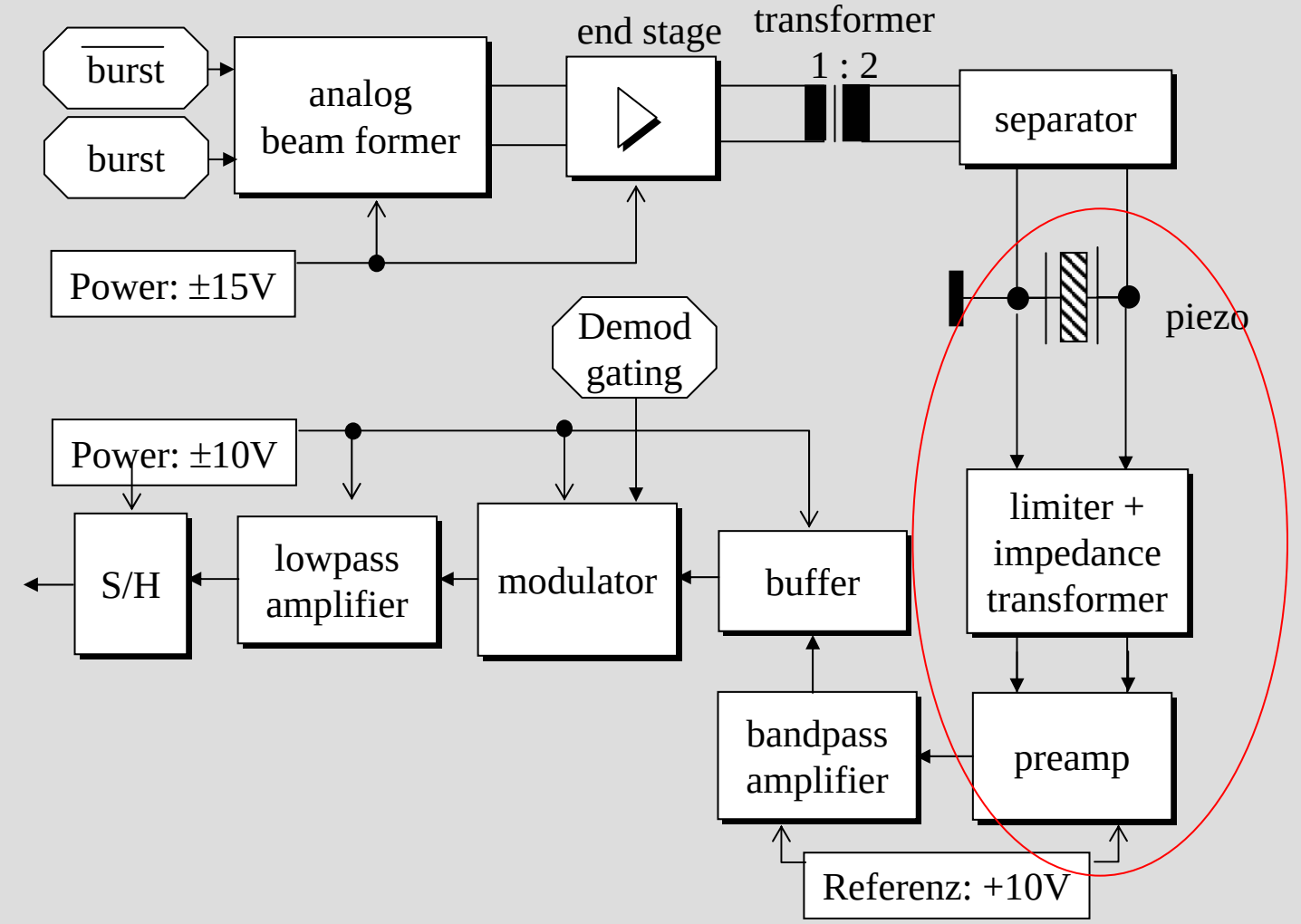
Ultrasound Doppler frontend



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Ultrasound signal processing

Electronic circuit: Piezo-preamplifier matching

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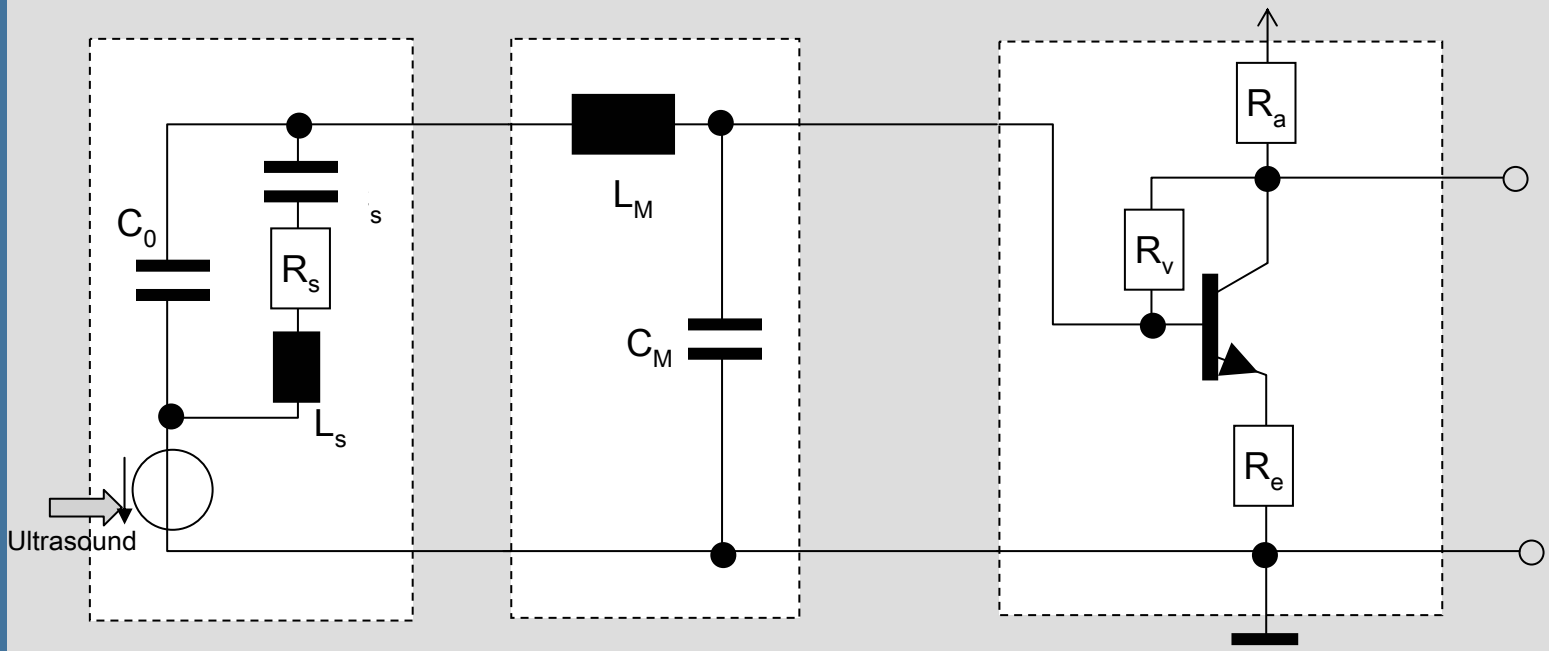

source „piezo“

matching circuit

preamplifier

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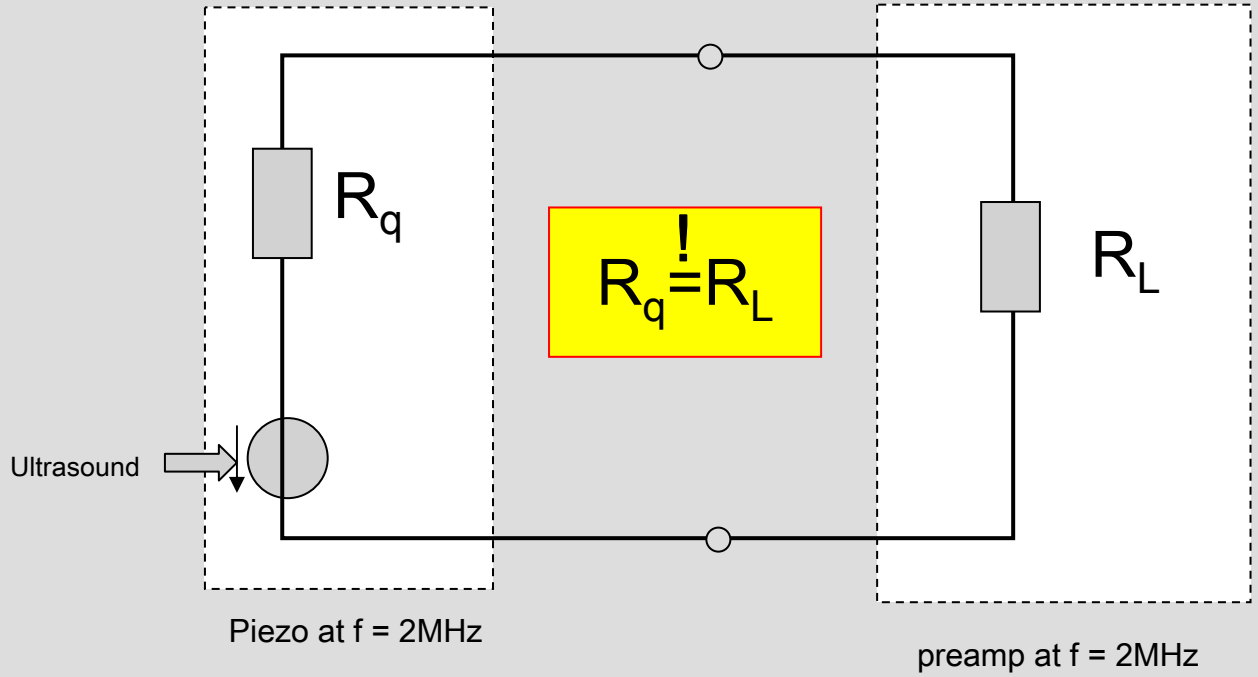
Electronic circuit design in frequency:

Problem „matching“



Electronic design tools

Content:

- Ultrasound
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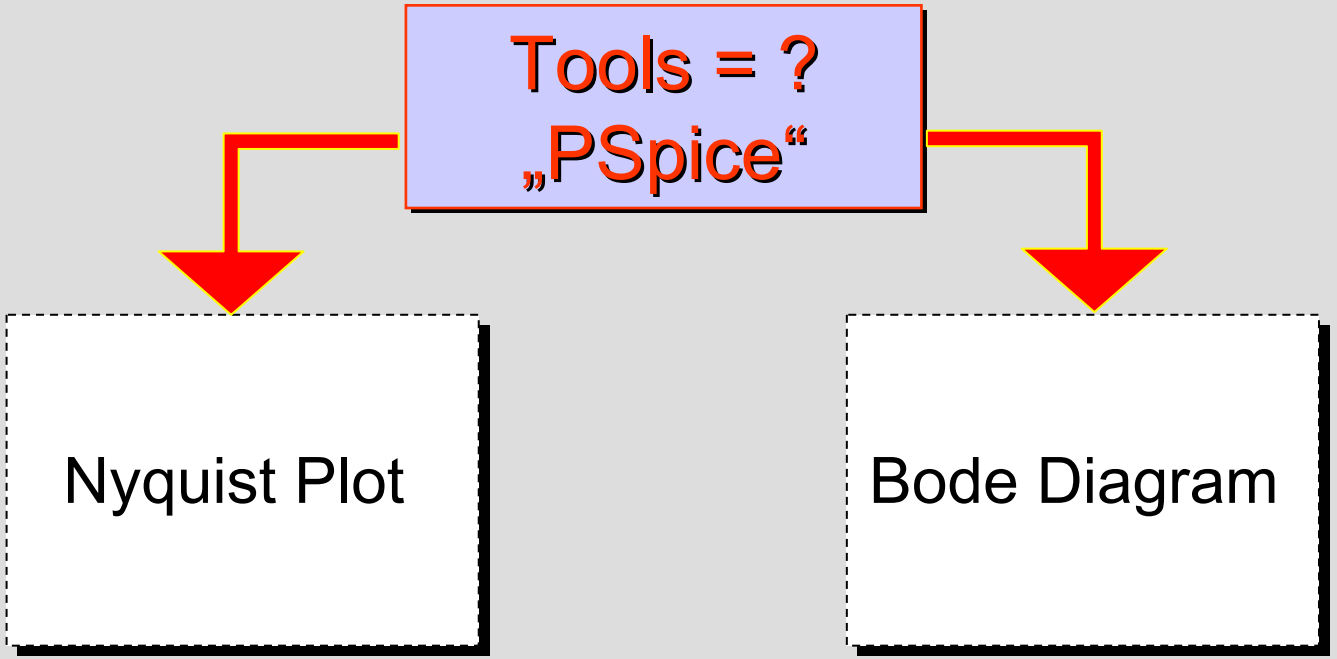
Electronic circuit design in frequency:

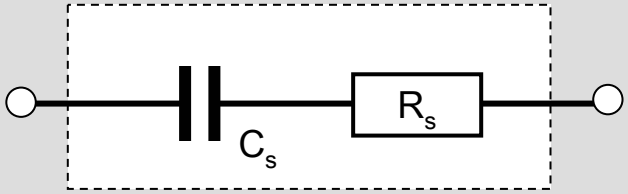
Modelling and frequency dependancy

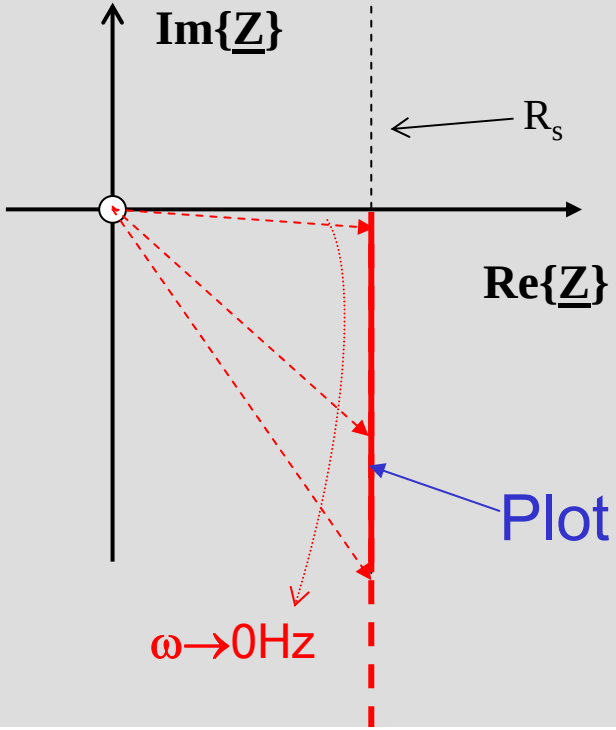


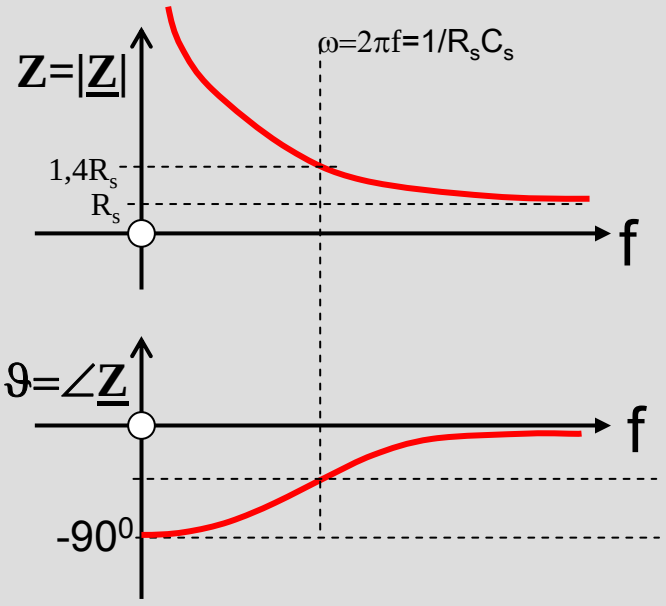
Nyquist Plot (Input impedance LP 1st order)

$$\underline{Z}\{j\omega\}\Big|_{\omega=2\pi f} = \mathrm{Re}\{\underline{Z}\} + j\,\mathrm{Im}\{\underline{Z}\} = Z\{j\omega\}\cdot e^{j\omega t+\varphi}$$

$$\underline{Z} = R_S + \frac{1}{j\omega C_s} = R_S - j\frac{1}{\omega C_s}$$







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Bode Diagram (Low pass filter 1st order)

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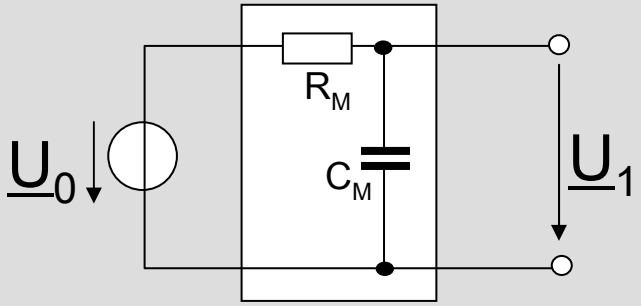
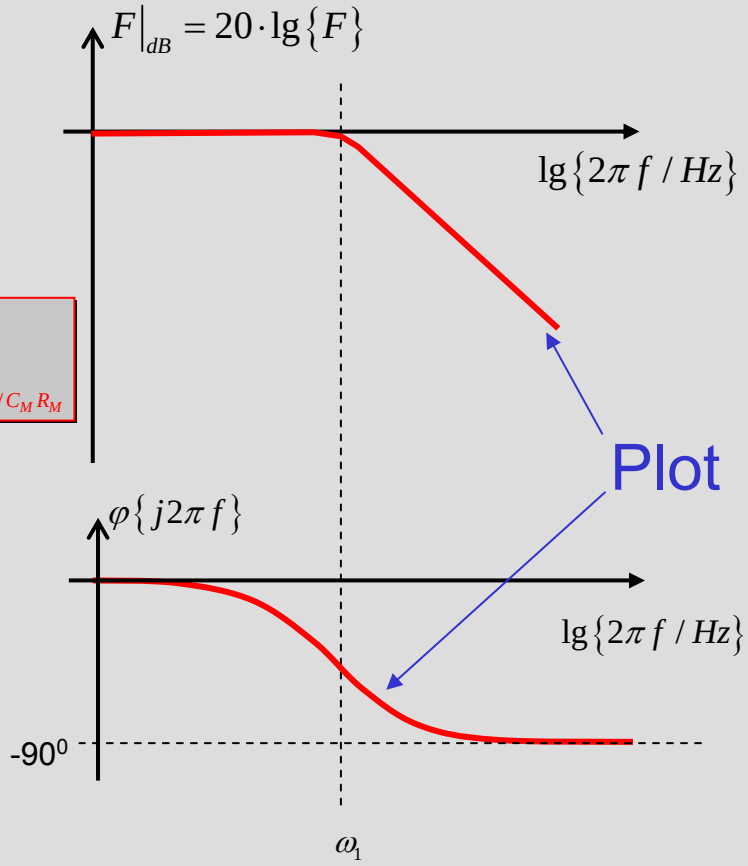
$$\underline{F}\{j\omega\}\big|_{\omega=2\pi f} = F\{j\omega\}\cdot e^{\varphi}e^{j\omega t} = \frac{\underline{U}_1}{\underline{U}_0} = \frac{1/j\omega C_M}{R_M + 1/j\omega C_M} = \frac{1}{j\omega C_M R_M + 1}$$



$$\underline{F}\{j\omega\}\big|_{dB} = \left|\frac{1}{j\omega C_M R_M + 1}\right|_{dB} = 0dB - 20\cdot\lg\left|1 + j\frac{\omega}{\omega_1}\right|_{\omega_1 = 1/C_M R_M}$$

$$\varphi = \angle\{1\} - \angle\{j\omega C_M R_M + 1\}$$
$$= 0^0 - \arctan\left\{\frac{\omega C_M R_M}{1}\right\} = -\arctan\left\{\frac{\omega}{\omega_1}\right\}$$



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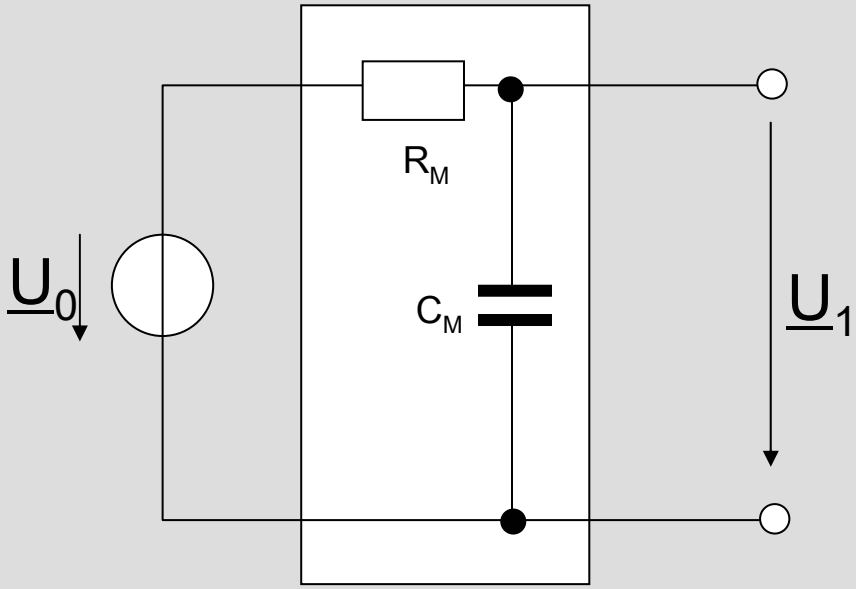
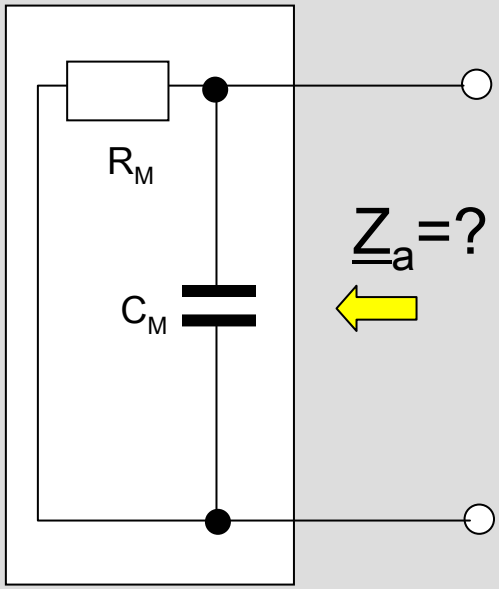
PSpice: Low-pass filter 1st order

I

$\underline{F} = \underline{U}_1 / \underline{U}_0 = ? = $ Bode Diagram

$\underline{Z}_a = ? = $ Nyquist Plot





$$\underline{F}\{j\omega\}\big|_{\omega=2\pi f} = \frac{1}{j\omega C_M R_M + 1}$$

$$\underline{Z}_a = \frac{1}{\frac{1}{R_M} + j\omega C_M} = \frac{R_M}{1 + j\omega C_M R_M}$$

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Continuation in Laboratory

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Diagnostic Ultrasound
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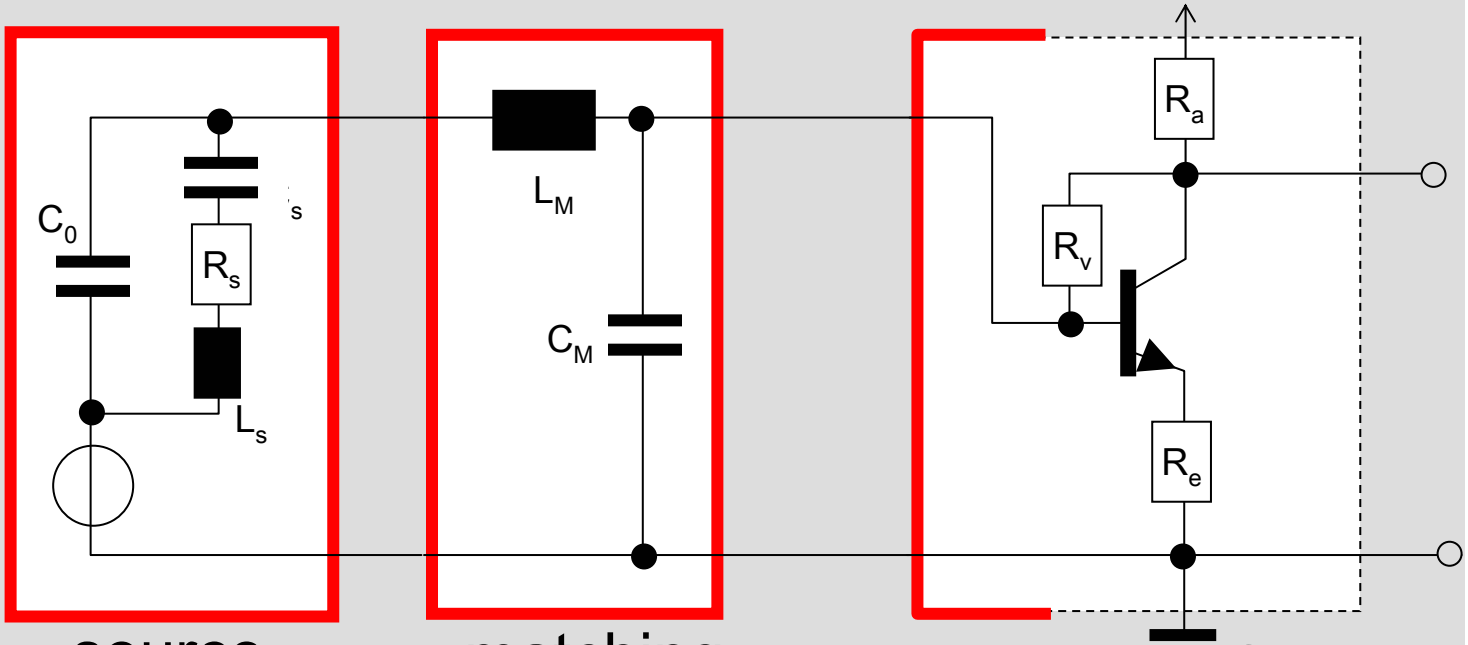
Matching between Ultrasound sensor and preamp



source „Piezo“ — II

matching circuit — III

preamplifier — IV

(Source Impedance at f = 2 MHz)

(Impedance transformation: LP-filter 2nd order)

(Input Impedance As load)

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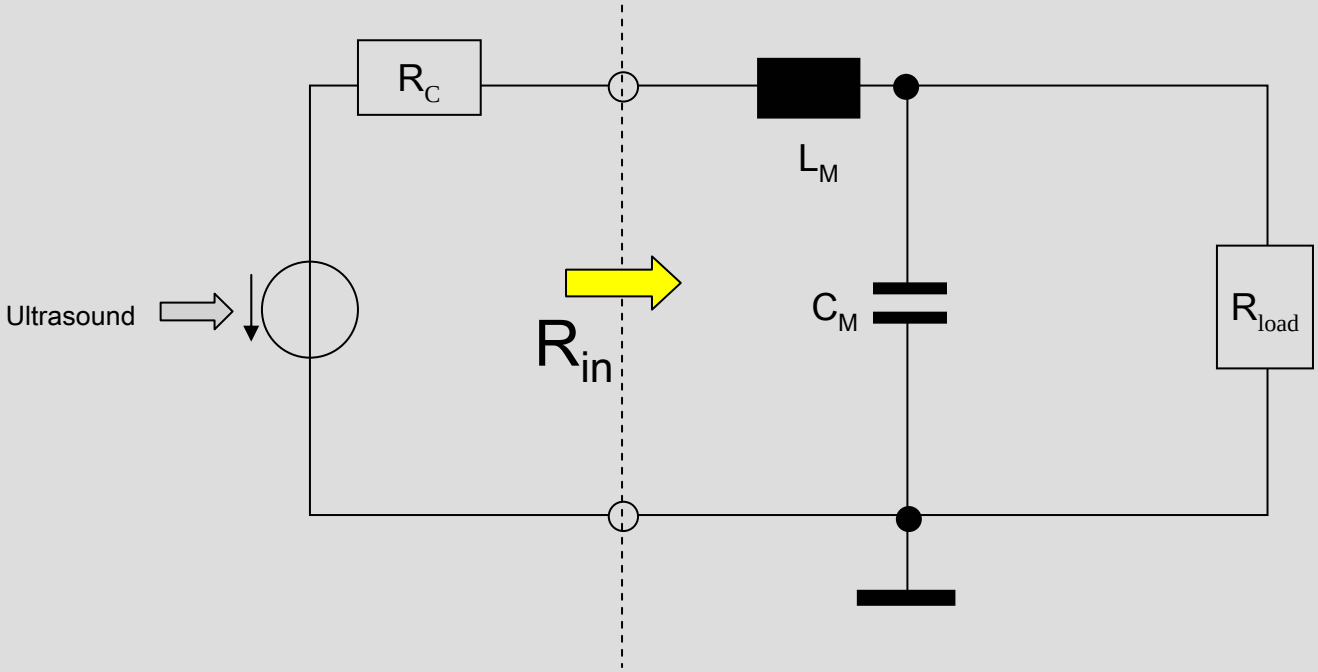

matching conditions {f=2MHz}: $R_C \overset{!}{=} R_{in}$

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any questions ?

discussion ?

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