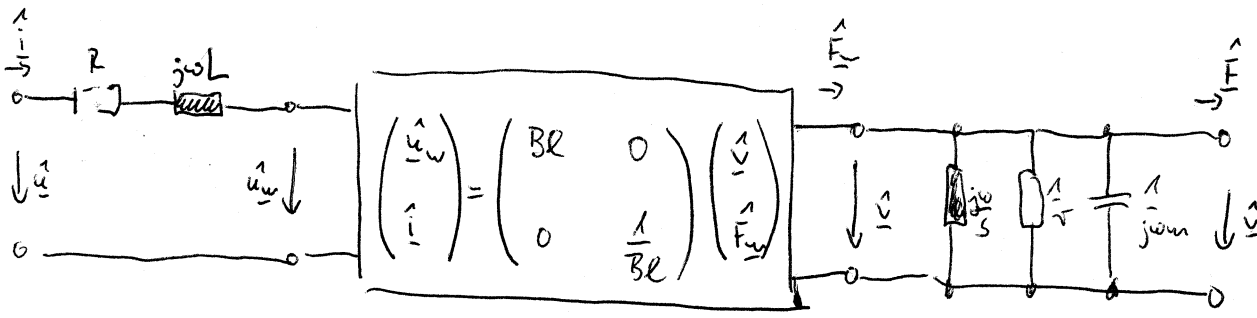
Aufgabe 1: Elektrodynamischer Wandler

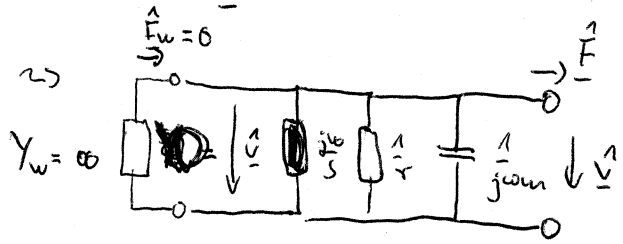
Ein elektrodynamischer Wandler (z.B. das Antriebssystem eines Lautsprechers) hat die folgenden Kenngrößen:

- Flußdichte im Luftspalt: $B = 1.2$ Vs/m^2
- Schwingspulendurchmesser: $d = 2$ cm, $N = 100$ Windungen
- bewegte Masse $m = 8$ g
- mechanische Resonanzfrequenz $f_0 = 50$ Hz, Güte $Q = 2$ (beides für elektrischen Leerlauf)
- im mechanisch festgebremsten Zustand ist der Betrag der elektrischen Impedanz $Z_{el} = 4\,\Omega$ und die Phasenverschiebung $\varphi_{el} = 45°$.

Erstellen Sie das Ersatzschaltbild des Wandlers und berechnen Sie die Schaltelemente!



- $B = 1.2 \frac{Vs}{m^2}$, $l = \pi \cdot d \cdot N = 6.28$ m $\rightarrow$ $Bl = 7.54 \frac{Vs}{m}$
- $m = 8$ g
- $f_0 = 50$ Hz bei $\hat{i} = 0 \rightarrow \hat{F}_w = 0$, $Q = 2$



$\rightsquigarrow \omega_0 = \sqrt{\frac{s}{m}}$ $\quad s = \omega_0^2 m = 4\pi^2 \cdot 2500 \cdot s^{-2} \cdot 0.008$

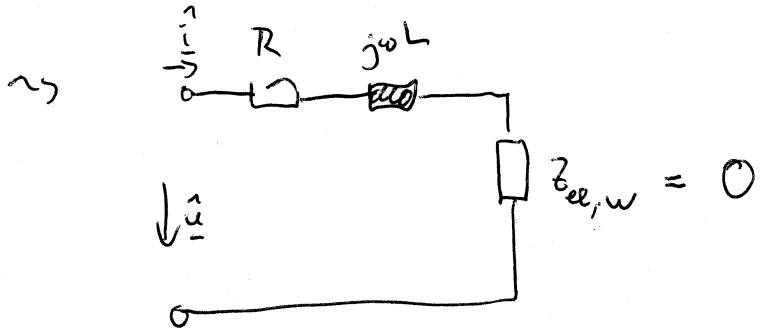
$s = 790 \frac{N}{m}$

$1 \frac{s}{kg} = 1 \frac{s \cdot m}{N s^2} = \frac{1\ m/s}{N}$

$\rightsquigarrow \frac{s}{r} = \omega_0 Q$ $\quad \frac{1}{r} = \frac{\omega_0 Q}{s} = \frac{\omega_0 Q}{\omega_0^2 m} = \frac{Q}{\omega_0 m}$

$r = 0.127$ kg

- mechanisch festgebremst: $\underline{\hat{v}} = 0 \rightsquigarrow \underline{\hat{u}}_w = 0$



$\rightsquigarrow \underline{z}_{el} = R + j\omega L$

$|\underline{z}_{el}| = \sqrt{R^2 + \omega^2 L^2} = 4\Omega \quad \varphi\{\underline{z}_{el}\} = 45° \rightsquigarrow R = \omega L$

$\downarrow$

$R^2 = 8\,\frac{V^2}{A^2} \rightarrow R = 2.83\,\Omega$

$\omega^2 L^2 = 8\,\frac{V^2}{A^2} \qquad \omega L = 2.83\,\frac{V}{A} \rightarrow L = \frac{2.83}{2\pi \cdot 100}\,\frac{Vs}{A}$

$L = 4.5\,\text{mH}$

```
% script file eldynwandler.m
%
% Copyright (C) 2006-2012 by Matthias Blau
% Author :  Matthias Blau <matthias.blau AT jade-hs.de>
% Date   :  08 Dec 2006
% Updated:  10 Oct 2012
%
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%
%
%
%    i               i                                  F_W             F=0
%   -->  ___        -->  _____________________________  -->             -->
%    o--|___|--uuuu--o--|                             |--o--*---*---*---o
%                       |  /u_W\   / Bl   0  \   / v \ |     |   |   |
%    |                  |  |   | = |         | * |   | |     3   | |   |   |
%  u |           u_W |  |  \ i /   \ 0   1/Bl/   \F_W/ |     3   | | ===  | v
%    V               V  |                             |     |   |   |   V
%    o---------------o--|_____________________________|--o--*---*---*---o
%
%  / u \        / v \           / v \                        v       1
%  |   | = Ages |   | = A1*A2*A3 |   |   u = Ages(1,1)*v     - = ---------
%  \ i /        \F=0/           \F=0/                        u   Ages(1,1)
%
%      / 1  R+jwL \         / Bl   0  \         /    1         0 \
%  A1= |          |    A2 = |         |    A3 = |               |
%      \ 0    1   /         \ 0   1/Bl/         \ jwm+r+s/jw   1 /
%
%


%---------------------------- Parameter -------------------------------------
B = 1.2;
m = 0.008;
N = 100; d = 0.02;
f0 = 50; Qmech = 4;
Zel_1200Hz = 4*exp(sqrt(-1)*pi/4); % Zel_1200Hz refers to v=0, i.e. u_W=0
                                   % thus, Zel_1200Hz = R+j*2pi*1200Hz*L

%--------------------------------------------------------------------------
l = pi*d*N; Bl = B*l;
s = (f0*2*pi)^2*m;
r = s/(f0*2*pi)/Qmech;
R = abs(Zel_1200Hz)/sqrt(2); L = R/(2*pi*1200);


%---------------------------- Modell ----------------------------------------
f = 1:2000; w = f*2*pi;
A1 = [1 0; 0 1]; A2 = [Bl 0; 0 1/Bl]; A3 = [1 0; 0 1];

a11 = zeros(1,length(f));
for q = 1:length(f)
  A1(1,2) = R+1j*w(q)*L;
  A3(2,1) = r+1j*w(q)*m+s/(1j*w(q));
```

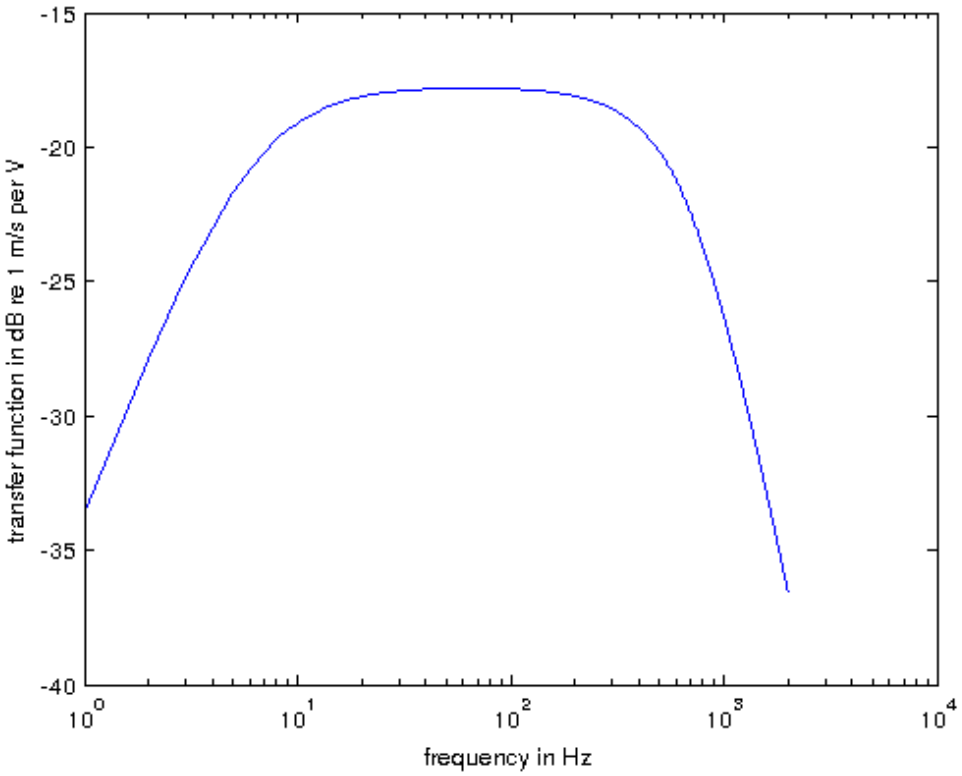
```
  Ages = A1*A2*A3;
  a11(q) = Ages(1,1);
end

v_re_u = (1)./a11;

%---------------------------- Grafik ----------------------------------------
figure();
semilogx(f,log10(abs(v_re_u))*20);
xlabel('frequency in Hz');
ylabel('transfer function in dB re 1 m/s per V');


%##########################################################################
% noch ein paar Spielereien

%------------------ elektrische Eingangsimpedanz -------------------------
a21 = zeros(1,length(f));
for q = 1:length(f)
  A1(1,2) = R+1j*w(q)*L;
  A3(2,1) = r+1j*w(q)*m+s/(1j*w(q));
  Ages = A1*A2*A3;
  a21(q) = Ages(2,1);
end
Zin_el = a11./a21;
```



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