Gautebøye, rev1, Instrument response

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1 Hydrophone decoupling

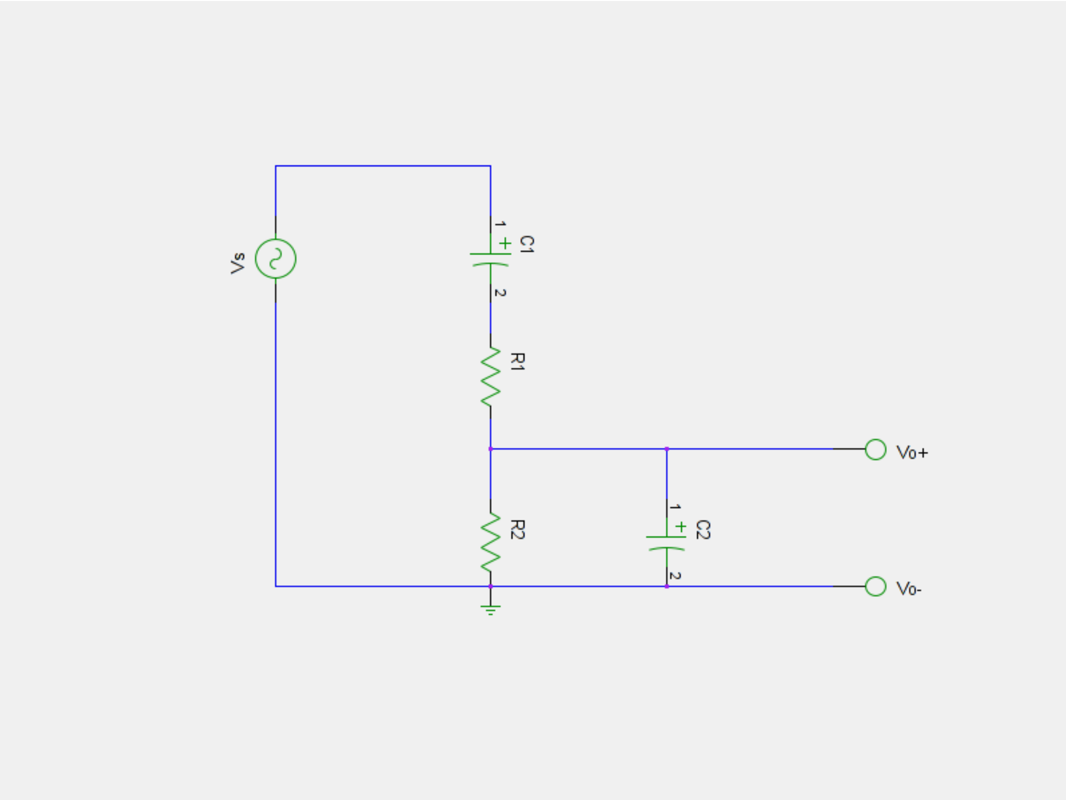

Figure 1: Hydrophone decoupling circuit

The figure above (1) shows an equivalent circuit of the deployed input decoupling to the hydrophone.

The circuit was based on the suggested decoupling in figure 2 seen below, it was designed to have the same properties, but also low-pass the signal at cutoff frequency f_{LP}. The original design already decouples, and high-passes, the signal at frequency f_{HP}.

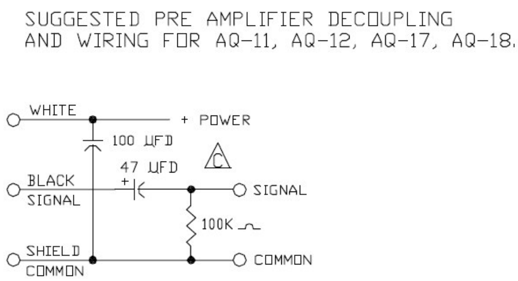

Figure 2: AQ-18 suggested decoupling and wiring [1].

2 Derivation of transfer function

i_1 and i_2 signify the current loops passing through respectively left and right loop. Using Kirchoff's equation:

$$V_s = i_1(Z_{C_1} + Z_{R_1}) + (i_1 - i_2) \cdot Z_{R_2} \tag{1}$$
$$0 = (i_2 - i_1) \cdot Z_{R_2} + i_2 \cdot Z_{C_2} \tag{2}$$

V_s is the signal source, the hydrophone. See separate data sheet for hydrophone frequency response. V_o, output, is measured at the terminals T_+ and T_-.

$$V_o = i_2 \cdot Z_{C_2} \tag{3}$$

$$H(s) = \frac{V_o}{V_s}, s = i\omega \tag{4}$$

Solving for $H(s)$ gives:

$$H(s) = \frac{8.218 \cdot 10^{60} \times s^2}{1.822 \cdot 10^{56} \times s^3 + 1.972 \cdot 10^{61} \times s^2 + 4.196 \cdot 10^{60} \times s} \tag{5}$$

A bode plot of the transfer function (instrument response) is shown in figure 3 below.

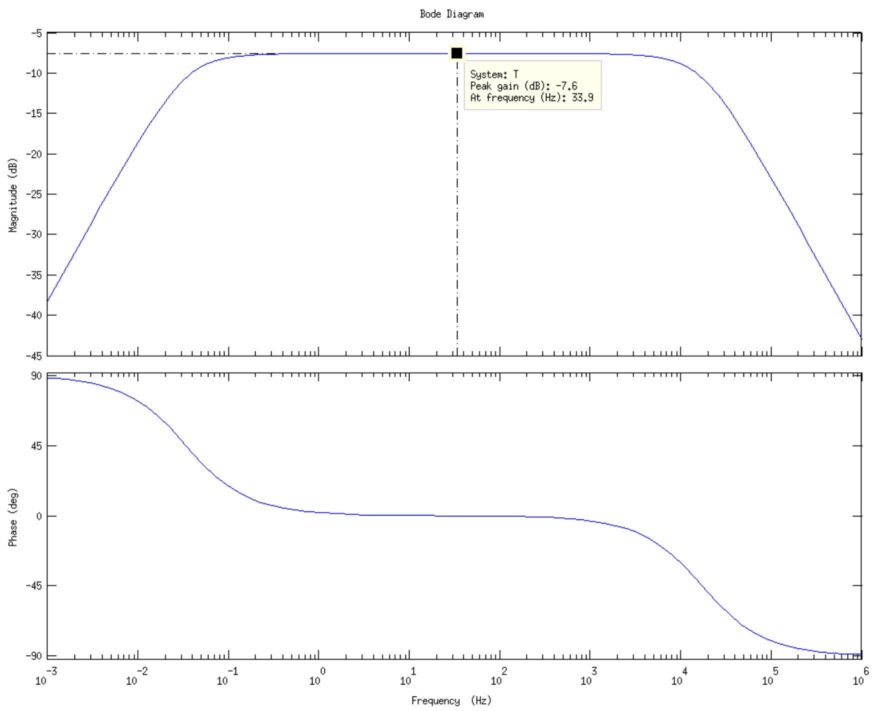

Figure 3: Bode plot of transfer function, showing peak response at 33.9 Hz.

Equation 5 can be solved by using the MATLAB script response.m (listing 1), the Bode plot in figure 3 was created with the same script.

2.1 Analysis

The transfer function is a bandpass filter with the suggested decoupling creating a high-pass filter with corner frequency at $f_{LP} = 0.0339$ Hz or a period of 29.4985 s. The upper corner frequency is at $f_{HP} = 17.189$ kHz. f_{HP} was chosen arbitrary to be well above the band of interest (< 1 kHz), but to provide sufficient damping at the Nyquist frequency of the AD converter which has a modulator speed of $f_{clk}/4 = 4$ MHz$/4 = 1$ Mhz [2] and a Nyquist presumabley... at $f_{Nyquist} = 1 \cdot 10^6/2 = 500$ kHz.

2.1.1 Stability

System stability was ensured using the Routh-Hurwitz method, MATLAB code is included in listing

2.1.2 Output

The output is scaled by -7.6 dB $= 0.4169\frac{V}{V}$ which is to scale the input from $\pm 6V$ to $\pm 2.5V$, $0.4169 \approx 5/12 = 0.4167$, which is the input range of the ADS1282EVM ([3] and [2]) in bipolar mode. The slightly inaccurate scaling is due to available resistor values.

References

[1] Benthos. *AQ-18 suggested decoupling*.

[2] Texas Instrument. *ADS1282 (Datasheet)*. rev b. Texas Instruments.

[3] Texas Instrument. *ADS1282EVM (datasheet)*. Texas Instruments.

3 Attachments

3.1 response.m

Listing 1: response.m, MATLAB code for calculating instrument response

```
% Calculates instrument response
r1 = 58.33e3;
r2 = 41.67e3;

c1 = 47e-6;
c2 = 380e-12;

syms s i1 i2 vs;
zc1 = 1/(s*c1);
zr1 = r1;
zc2 = 1/(s*c2);
zr2 = r2;

[i1, i2] = solve ('vs = i1*(zc1 + zr1) + (i1 - i2)*zr2', ...
           '0  = (i2 - i1)*zr2 + i2*zc2', 'i1', 'i2');

vo = i2*sym('zc2');
H  = vo/vs;
pretty (simplify(H))
H  = subs (H);

pretty(H);

[n, d] = numden (H);

Tn = sym2poly(n);
Td = sym2poly(d);
T = tf(Tn, Td)


P = bodeoptions;
P.FreqUnits = 'Hz';

bodeplot (T, P);
```

3.2 routhtable.m