

## Analog Lab Report Example

December 31, 2023      Professor Mike Jacob

**A. Design:** See Figure 1 below.

Calculate the component values necessary to implement a low pass, first order filter with:

Include your calculations unless otherwise instructed in the lab procedures. A neat, handwritten version may be acceptable. Ask your lab instructor. The point is to make your choices obvious.

1. Input impedance  $\geq 1 \text{ k}\Omega$ :

Pick  $100\text{k }\Omega \gg R_1 > 1 \text{ k}\Omega$

$R_1 = 10 \text{ k}\Omega$  because of availability

2. Critical frequency,  $f_o = 1.5 \text{ kHz} (\pm 5\%)$

Since  $R_1 \ll 100 \text{ k}\Omega$  ( $R_2$ ),  $R_2$  does not affect the filter's critical frequency.

$$f_o = \frac{1}{2\pi \times R_1 \times C_1}$$

$$C_1 = \frac{1}{2\pi \times R_1 \times f_o} = \frac{1}{2\pi \times 10 \text{ k}\Omega \times 1.5 \text{ kHz}} = 10.6 \text{ nF}$$

This can be produced with a 10 nF capacitor in parallel with a 560 pF capacitor, if necessary.

3. Pass band gain,  $A_o = 5 = \left(1 + \frac{R_f}{R_i}\right)$

Pick  $R_i = 10 \text{ k}\Omega$  to prevent op amp loading and because of availability

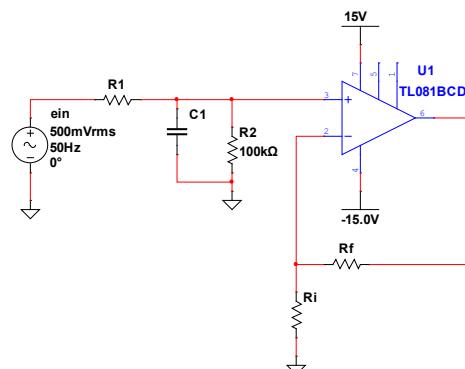
$$R_f = 4 \times R_i = 40 \text{ k}\Omega$$

$R_f = 39 \text{ k}\Omega$  in series with  $1\text{k}\Omega$ .

Put a table of component values right beside the schematic. Be sure to handle the units correctly and to align the decimals.

**Table 1** Component values

	nominal	measured
$R_1 (\text{k}\Omega)$	10	9.987
$R_2 (\text{k}\Omega)$	100	101
$R_i (\text{k}\Omega)$	10	10.13
$R_f (\text{k}\Omega)$	40	40.06
$C_1 (\text{nF})$	10.6	10.2



You may copy the given schematic. If you do, you must include a citation or the report receives a 0%.

**Figure 1** Low pass filter with gain  
(Courtesy of Purdue SoET, ECET)

Table captions go on the TDP and figure captions go below. Provide useful captions.

## B. Measurements

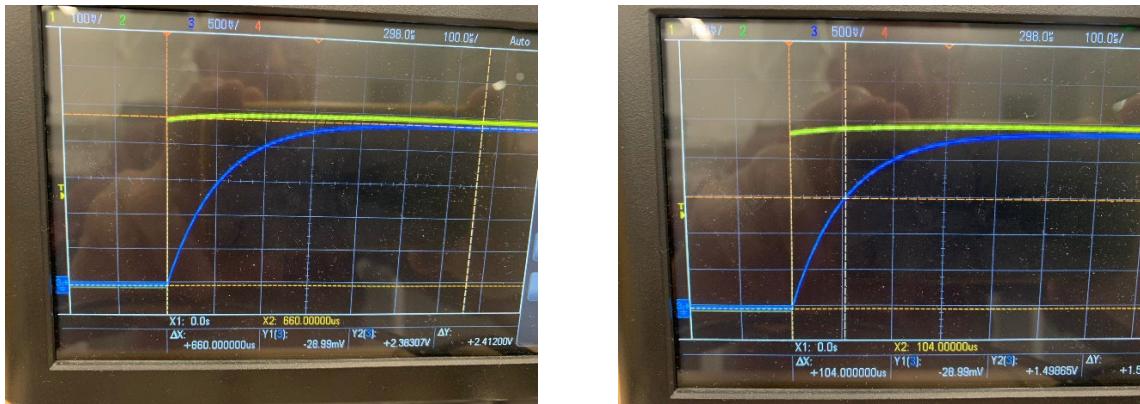
The gain was measured by applying a 500 mV, 50 Hz, 0 V<sub>DC</sub> sine wave and measuring the output. The results are shown in Table 2 below.

The phase shift of the output was measured as the frequency was increased until the output was lagging by -45°. The output phase fluctuated  $\pm 2^\circ$ . The results are shown in Table 2.

The time constant was measured by changing the input to a 500 Hz, square wave, 0V to 0.5V. Both the input and output are displayed in Figure 2 below, and the results tabulated in Table 2.

**Table 2** Circuit design parameters verification

	specification	measurement	error (%)
$A_o$	5	4.995	0.1
$f_o$ (kHz)	1.5	1.5	0
$\tau$ ( $\mu$ sec)	105	104	1



**Figure 2** Time constant measurement

This section may be much longer. But you do *NOT* have to repeat the Lab Procedure verbatim. Include enough information that a skilled engineer can follow what you did.

The results of each procedure must be easily seen from those procedures. In the example, the procedures were short enough to combine the results into a single table. But, often you may have several different procedures, even different circuits and different data. Keep all of the information for a single procedure together; the schematic, component values table, measurement description, and resulting data (with calculations). Then move on to the next section.

Do *NOT* write a long paragraph describing everything you did, then put in a bunch of schematics, then a wad of tables. Keep related information together.

*Answer any questions asked in the lab instructions.*

## Analysis and Conclusions

### Questions

To convert this circuit into a high pass filter, reverse the position of R1 and C1. Capacitor C1 is connected to the input and R1 is in parallel with R1.

$$f_o = \frac{1}{2\pi RC}$$

$$\tau = RC$$

$$f_o = \frac{1}{2\pi \times \tau} = \frac{0.159}{\tau}$$

### Summary

A low pass filter with a given critical frequency and gain was correctly designed and built using a series RC circuit into a noninverting amplifier. The configuration of the RC produced the low pass performance, the value of that RC set the critical frequency and the op amp's negative feedback voltage divider set the gain.

### Errors

There were no errors  $> 5\%$ , the design requirement. The fluctuation in the phase is within the  $\pm 3^\circ$  typical for this oscilloscope.

*Also provide two additional paragraphs, one that summarized the DETAILS of the facts demonstrated.*

*In the Errors paragraph, do NOT blame component value errors, because you measured the component values and should take these values into consideration, or replace the bad component.*