Lab 9: Karaoke Circuits

Introduction

Ever wanted to grab hold of a microphone and belt out your favorite song? Singing in the shower is great, but with an amp (outside the shower) it can be exhilarating.

Fig. 1 Karaoke.vi Front Panel Displays Real-Time Signals and Frequency Levels

Purpose

This Lab uses myDAQ and components to build a karaoke circuit (Fig. 1). You can remove the vocals from your favorite iPod songs and sing along.

Equipment

- NI myDAQ
- 3.5 mm Sub-Miniature Stereo Cable (comes with NI myDAQ)
- iPod or Other Music Source
- Stereo Computer Speaker Set

Op Amp Circuits

- Three TL2071 Low Noise JFETs or 741 Operational Amplifiers
- Resistors: Six 10 kΩ, Two 100 kΩ, and One 1 kΩ
- Resistance Trim Pot 20 kΩ
- Capacitors: Three 10 μF (electrolytic)
- 3.5 mm Sub-Miniature Stereo Jack Cable

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- 3.5 mm Sub-Miniature Stereo Socket
- Breadboard

**Prerequisite Reference Materials**
Using the NI ELVISmx DMM:
[http://decibel.ni.com/content/docs/D0C-12877](http://decibel.ni.com/content/docs/D0C-12877)
Using the FGEN:
[http://decibel.ni.com/content/docs/D0C-12940](http://decibel.ni.com/content/docs/D0C-12940)
Using the Scope:
[http://decibel.ni.com/content/docs/D0C-12942](http://decibel.ni.com/content/docs/D0C-12942)
Simple Karaoke Circuit:

**Exercise 9-1: Getting Started—Building the Preamplifiers**

**Building the Right Channel Preamplifier**

Assemble the circuit components. Measure and record all the resistors using the DMM[\(\Omega\)]. Build the circuit in Fig. 2 for the right-channel preamplifier.

![Fig. 2 Right-Channel Preamplifier Circuit using an Op Amp Inverting Circuit](image)

The circuit gain is \(\frac{R_f}{R_1}\), where \(R_f\) is the feedback resistor (100 k\(\Omega\)), and \(R_1\) is the input resistor (10 k\(\Omega\)). The op amp requires a +15 V and –15 V power source. MyDAQ has both sources available on sockets (+15 V, –15 V, and AGND).

Connect the FGEN output AO 0 to the point R. Set the FGEN to a frequency of 1000 Hz and an amplitude of 0.5 \(V_{pp}\).
Use the Scope to verify the circuit operation:
Channel 0 Source AI 0, 100 mV/div connected to Op Amp input
Channel 1 Source AI 1, 1 V/div connected to Op Amp output
AI 0- and AI 1- connected to AGND
Timebase 1 ms
Triggering Edge Channel 0

[Run] continuously both the FGEN and Scope.

Use the vertical position dials to verify that the input and the output signals are out of phase (180 degrees) and the gain is close to the resistance ratio (10).

**Building the Left Channel Preamplifier**

Assemble the components and build the non-inverting Op Amp circuit shown in Fig. 3.

![Non-Inverting Circuit Diagram]

The circuit has a gain of \((1 + R_f/R_1)\). Here \(R_f\) equals 100 kΩ, and \(R_1\) is set near the center of the 20 kΩ pot, i.e. 10 kΩ. The nominal gain for this circuit is eleven.

Connect the FGEN output AO 0 to the point S. Connect the Scope sockets AI 0 and AI 1 to the circuit input and output points.

Use the FGEN and the Scope in the same manner as for the right-channel measurements to verify that the Op Amp output is in phase with the input signal and that the gain is approximately eleven.
Note: The gain is strongly affected by the pot resistance. Try it!

Matching the Input Preamplifiers

Karaoke circuits that remove the vocal component require the left and right signals be matched in amplitude. A simple method to check the signal levels is to connect the Scope input AI 0 to the output of the right-channel Op Amp (pin 6) and input AI 1 to the output of the left-channel Op Amp, (pin 6). Ensure the FGEN signal goes to both inputs.

[Run] the FGEN and Scope with the same settings. Use the vertical position dials to offset the two signals.

Now use a small screwdriver to adjust the amplitude of the left channel to match the amplitude of the right channel. You can read the amplitudes off the scope traces or just read the RMS or $V_{pp}$ indicators.

Note: Be sure to click on the [Display Measurement] boxes.

The left and right signals are now ready for voice removal.

How the Voice Removal Circuit Works

Most popular and rock music recordings use multiple microphones and mixers to generate the left and right signals. Listening in stereo gives a broad presence to the music. Adding these signals together affects the volume but not the musical content. On the other hand, subtracting the signals removes the vocals. The vocals are considered most important, and these are often recorded identically on both left and right channels. The background music due to the stereo mixing has no phase (time) relationship between the channels. If you subtract the channels (which can be accomplished by inverting one signal and then adding them together), the vocal signals are cancelled. This procedure often has the most profound effect on the lead singer and not the background vocals or instruments.

To add two analog signals, another Op Amp circuit called an adder (Fig. 4) is useful.
Kirchoff’s second law states that all currents at a nodal point add up to zero. The left and right signals are applied to the two input resistors $R_1$ and $R_2$. These are tied together along with the Op Amp input (pin3) at nodal point $Z$. Solving the circuit equations yields

$$V_{out} = -(R_f/R_1)(V_{left} + V_{right}).$$

If one of these circuits is out of phase with the other, then the adder circuit becomes a subtraction circuit—just what we need to complete our Karaoke circuit.

**Build the Op Amp adder using three 10 kΩ resistors and another TL021IC.**

To check out its operation, wire up the left and right Op Amp signals to the two adder inputs. Use the Scope to monitor the input signal (AO 0) on channel 0 and the adder output on Channel 1.

When the two input signals are balanced, you should see no AC signal (Fig. 5). Adjust the gain on the left channel to see an unbalanced signal.
Great! Now balance the signal. We are almost ready for the iPod.

**Completing the Karaoke Circuit**

Although our test signals have been AC, they have been directly coupled to our circuit, as shown in Fig. 6.

![Karaoke Circuit Before Addition of Decoupling Capacitors](image)

Fig. 6 Karaoke Circuit Before Addition of Decoupling Capacitors

Now we will remove any DC signals from the input signal sources by adding a 10 μF capacitor and a 10 kΩ resistor to each channel (Fig. 7). A similar circuit is added to the adder output.

![Decoupling Circuit Additions for Left(V_l) and Right(V_r) Inputs (V_{in}) and Output (V_{out})](image)

Fig. 7 Decoupling Circuit Additions for Left(V_l) and Right(V_r) Inputs (V_{in}) and Output (V_{out})
Now with the stereo plug and sockets, we are ready to fly.

Connect up the iPod music source and speakers. The music source (Mic input) is connected through the stereo cable to the stereo socket, which is then divided into left and right wires. Power up your circuit. Amazing!

*Note: How well the karaoke circuit works depends in large part on the recording method in the production of the CD tracks. Some songs will work better than others.*

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**Exercise 9-2: Software Karaoke Circuit**

We have seen in Lab 8 how the myDAQ can digitize an input signal, apply some processing, and then stream the data back out to the speakers in real time.

Can it also removal vocals? Yes!

Take a look at the LabVIEW program Karaoke.vi (Fig. 1). On the front panel, there has been added a master volume control and a switch that allows the song to be played normally or with the vocals removed.

Connect your iPod to the myDAQ input [AUDIO IN] and speakers to [AUDIO OUT]. Turn on the iPod music, [Run] the program, and be amazed yet again.

Stop the program and look at the block diagram in Fig. 8. It is similar to Spectrum.vi except for some additional processing of the input signals. What is new?

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**Fig. 8 Karaoke.vi Block Diagram**

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In the karaoke processing block, the left and right signals are subtracted (– sign is equivalent to out-of-phase by 180 degrees). A data selector controlled by the [Voice?] switch allows either the original signal or the voice-removed signal to pass to the merge function, which places the same signal on both the left and right channels. A master volume control component (multiply by a constant) allows the signal on the frequency graph to be enhanced.

Recall that removing the vocals required that the left and right channels be balanced. Return to the front panel and observe that the channel balance can be controlled by changing the left or right signal levels. It does not matter what the signal level is, as long as it is in balance.

Examples:
- Set the input levels to identical values between 0.2 and 1 (no vocals)
- Set left channel to 0.5 and right channel to any value except 0.5 (vocals)

**Summary**

The hardware solution requires three chips, numerous components, two power supplies, lots of wires, and considerable time to build, test, and debug. The software solution requires a simple virtual circuit built within a LabVIEW program. You might say this is a great example of the power of the microprocessor, until you recall that a microprocessor is just another digital IC: a universal gate with a great ability to program or morph itself into any function.

**myDAQ Challenge:** Add a microphone and modify your circuit hardware or software solution so you can mix your voice with your music.