17.368 Data Conversion and Lab
Lab 6
Fall 2013

Voltage to Frequency Converter and Frequency to Voltage Converter

Objective

1. To construct and test a Single Supply Voltage to Frequency Converter
2. To construct and test a Frequency to Voltage Converter
3. To apply a signal to a Voltage to Frequency Converter and take output and apply to a Frequency to Voltage Converter and compare the output with the original signal

Materials

- □ 1 Breadboard
- □ 2 XR-4151 (EXAR Voltage to Frequency Converter)
- □ 2 5.1 k-ohm Resistor
- □ 1 6.8 k-ohm Resistor
- □ 3 10 k-ohm Resistor
- □ 1 15 k-ohm Resistor
- □ 2 100 k-ohm Resistor
- □ 2 10 k-ohm Potentiometer
- □ 1 0.1 μF Capacitor
- □ 1 0.22 μF Capacitor
- □ 1 0.01 μF Capacitor
- □ 1 1.0 μF Capacitor
- □ 1 Dual Trace Oscilloscope
- □ 1 +5 Volt DC Power Supply
- □ 1 Signal Generator (Sine Wave)
- □ 1 Frequency Counter

Background Information

The XR-4151 is a device designed to provide a simple, low-cost method for converting a DC voltage into a proportional pulse repetition frequency. It is also capable of converting an input frequency into a proportional output voltage. The XR-4151 is useful in a wide range of applications including A/D and D/A conversion and data transmission. Block diagram is shown in Figure 1.

Single Supply Voltage-to-Frequency Converter (VFC) as shown in Figure 2 is the simplest type of VFC that can be made with the XR-4151. The input voltage range is from 0 to +10V, and the output frequency is from 0 to 10 kHz. The full scale frequency can be tuned by adjusting RS, the output current set resistor. Response time for this circuit is limited by the passive integration network $R_B C_B$. For the component values shown in Figure 1, response time for a step change input from 0 to +10V will be 135 msec.

The XR-4151 datasheet (downloaded during the Pre-Lab Preparation) contains detailed information and will be used throughout the lab.

The XR-4151 can be used as a frequency-to-voltage converter (FVC). Figure 3 shows the single-supply FVC configuration. With no signal applied, the resistor bias networks tied to pins 6 and 7 hold the input comparator in the off state. A negative going pulse applied to pin 6 (or positive pulse to pin 7) will cause the comparator to fire the one-shot. **For proper operation, the pulse width must be less than the period of the one-shot, T = 1.1 R_0C_0. Make sure duty cycle is great enough, if less than 20%, you will be unable to obtain full frequency.** For a 5Vpp square-wave input the differentiator network formed by the input coupling capacitor and the resistor bias network will provide pulses which correctly trigger the one-shot. An external voltage comparator can be used to "square-up" sinusoidal input signals before they are applied to the XR-4151. Also, the component values for the input signal differentiator and bias network can be altered to accommodate square waves with different amplitudes and frequencies. The passive integrator network R_BC_B filters the current pulses from the pin 1 output. For less output ripple, increase the value of C_B.

Pre-Lab Preparation

1. Download datasheet for the XR-4151 (EXAR Voltage to Frequency Converter). Link to the datasheet can be found on the Class Web site.

2. **** NOTE **** Construct two separate circuits, the first will be the Voltage to Frequency converter. The second is the Frequency to Voltage converter. The third portion of the lab will be to connect the Voltage to Frequency converter to the Frequency to Voltage converter.

Procedure

Experiment 1. VOLTAGE TO FREQUENCY CONVERTER

a. Construct a Voltage to Frequency Converter as shown in Figure 2. A few modifications to the circuit will be required to accommodate parts that are available in the lab. The changes are as follows:

R_S = 5.1K in series with a 10K Pot vice the 12K in series with the 5K Pot.

V_I = construct a voltage divider network from a +15V supply through a 5.1K and a 10K Pot to ground. The tap of the 10K Pot goes to V_I. (V_I will = 0 to 10 Volts).

V_L = 5 Volts (the frequency output terminal is an open collector logic output. A pull-up resistor is usually connected to a 5V logic supply to create standard logic level pulses. It can, however, be connected to any power supply up to V_{CC}.

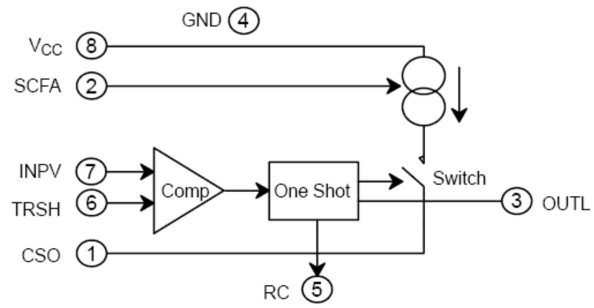

Figure 1. Block Diagram

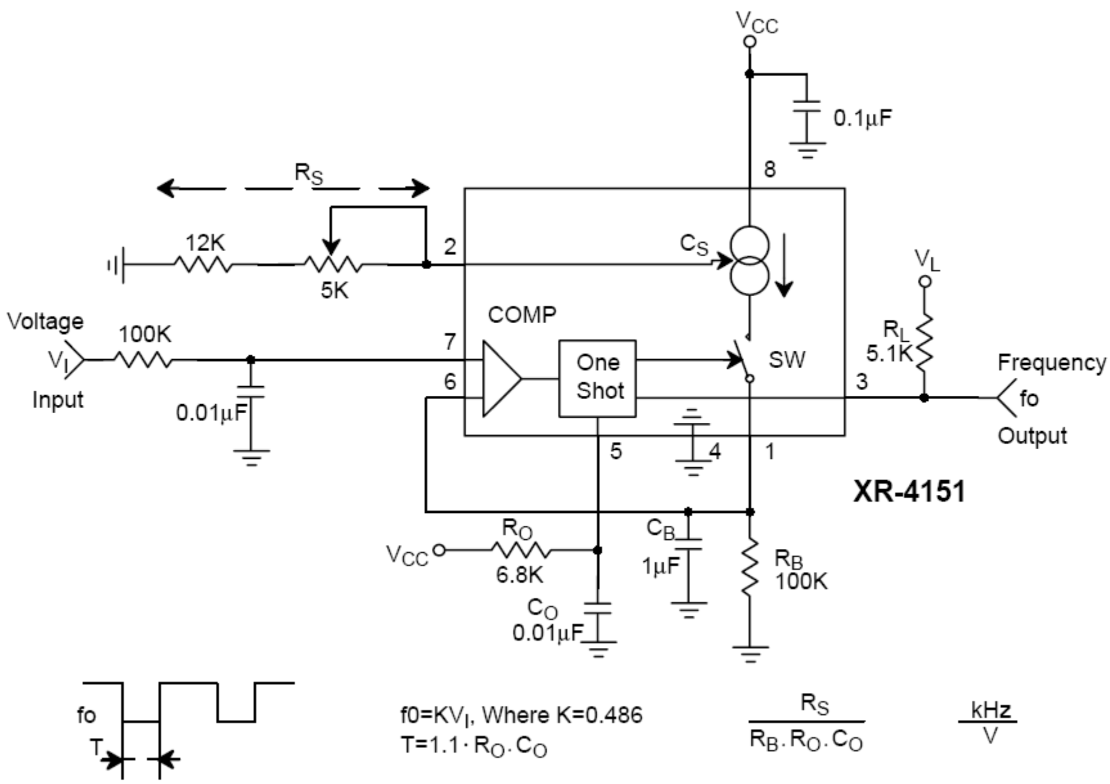

Figure 2. Voltage-to-Frequency Converter

b. The input voltage range is from 0 to +10V, and the output frequency is from 0 to 10 kHz. Tune the full scale frequency by adjusting R_S, the output current set resistor, by applying 10 volts to the input and adjusting R_S so that the output frequency is 10 kHz. Value of R_S will be approximately 14 k ohms.

Record the actual value of R_S ________________.

c. Calculate Output Frequencies for the input voltages listed in TABLE 1 using the following equation (also found on the datasheets and Figure 2 of this lab)

$f_o = kV_1$ where $k = 0.486 * \left(\frac{R_S}{R_B R_O C_O} \right)$ in kHz per Volts

d. Apply a DC input voltage of 0 volts and record the frequency with either an oscilloscope or frequency counter in Table 1.

e. Increment the input voltage by 2 volts and again record the in Table 1.

f. Repeat Step e until 10 volts is applied.

TABLE 1		
	Output Frequencies	
Input Voltage	Calculated	Measured
0		
2		
4		
6		
8		
10		

Experiment 2. FREQUENCY TO VOLTAGE CONVERTER

a. Construct a Frequency to Voltage Converter as shown in Figure 3. A few modifications to the circuit will be required to accommodate parts that are available in the lab. The changes are as follows:

R_S = 15K vice 14K.

V_L = 5 Volts (the frequency output terminal is an open collector logic output. A pull-up resistor is usually connected to a 5V logic supply to create standard logic level pulses. It can, however, be connected to any power supply up to V_{CC}.

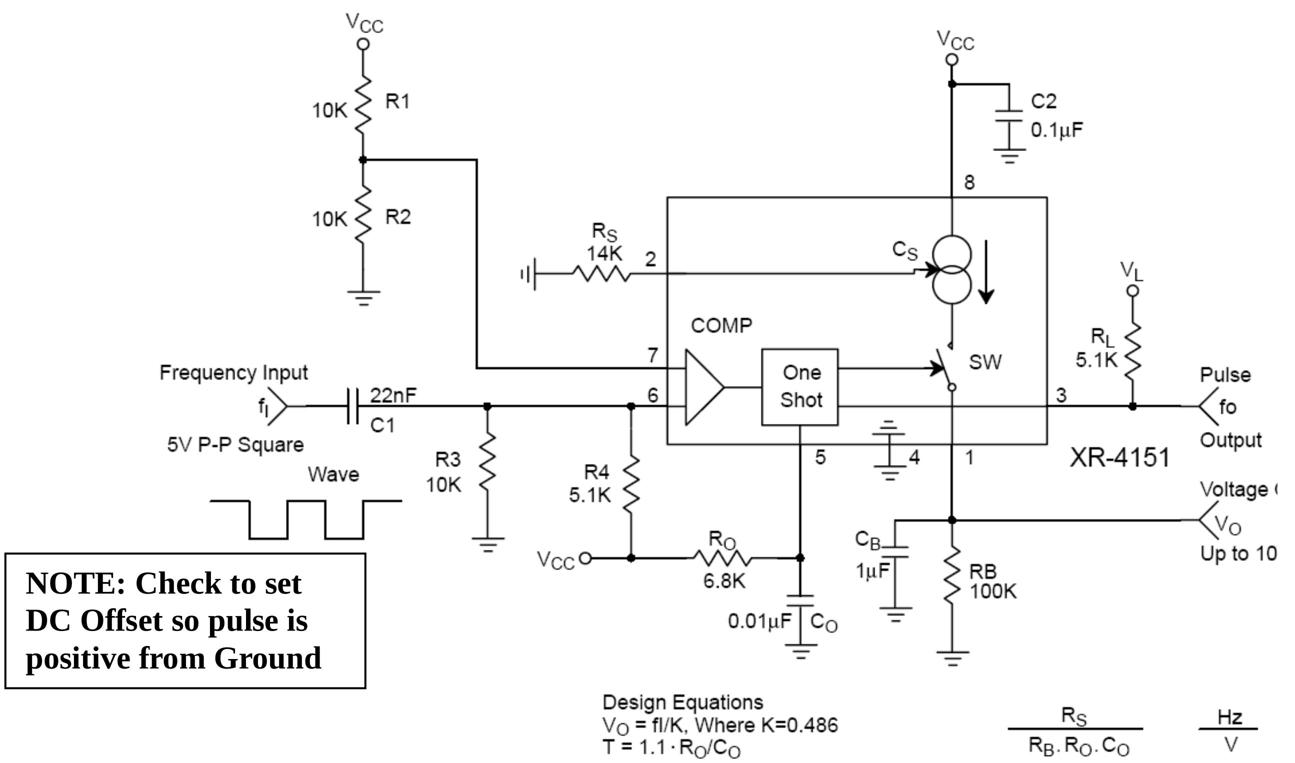

Figure 3 **Frequency to Voltage Converter**

b. Calculate the Output Voltages for the input Frequencies listed in TABLE 2 using the following equation (also found on the datasheets and Figure 3 of this lab)

$V_o = \frac{f_1}{k}$ where $k = 0.486 * \left(\frac{R_S}{R_B R_O C_O} \right)$ in Hz per Volts

c. Using a pulse generator, we will input a frequency as indicated in Step b and will note the output voltage measured on the oscilloscope or DC voltmeter.

d. Take data from 5 points and place in Table 2. The frequency input should be a pulse between 0 and 5 volts pp. Offset is not required because of the 0.22 μF capacitor.

TABLE 2		
	Output Voltages	
Input Frequency	**Calculated**	**Measured**
0		
2 kHz		
4 kHz		
6 kHz		
8 kHz		
10 kHz		

Experiment 3. VOLTAGE TO FREQUENCY & BACK TO VOLTAGE CONVERSIONS

a. Connect Frequency output of circuit shown in figure 1 (experiment #1) to the Frequency input of the circuit shown in figure 2 (experiment #2).

b. Apply DC voltages as indicated in Table 3 and record results for each voltage applied.

c. How well do they compare?

TABLE 3	
Input Voltage (volts)	**Output Voltage (volts)**
0	
2	
4	
6	
8	
10	