Difference Amplifier

Materials:

- 2 Series Mixed Series Oscilloscope (MSO)
- Arbitrary/Function Generator (AFG): AFG1000 and internal AFG on 2 Series
- Digital Multimeter (DMM): DMM6500
- Direct current (DC) power supply: 2230 High Power Programmable Power Supply
- Resistors (4)
- Operational Amplifier (Op amp) (1)
- Breadboard
- Jumper wires

Procedure:

R = 1 kΩ Op Amp PN: UA741

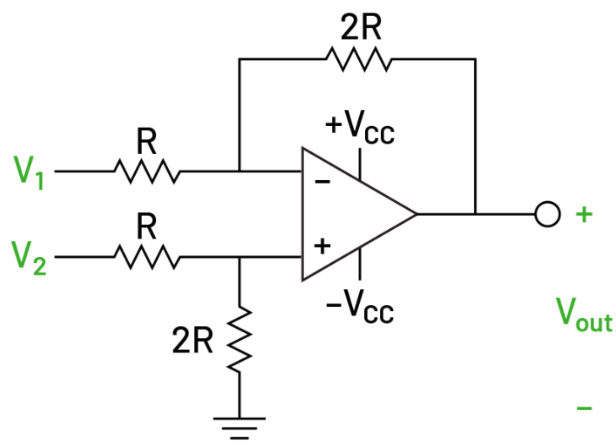

Figure 1. Difference amplifier circuit diagram.

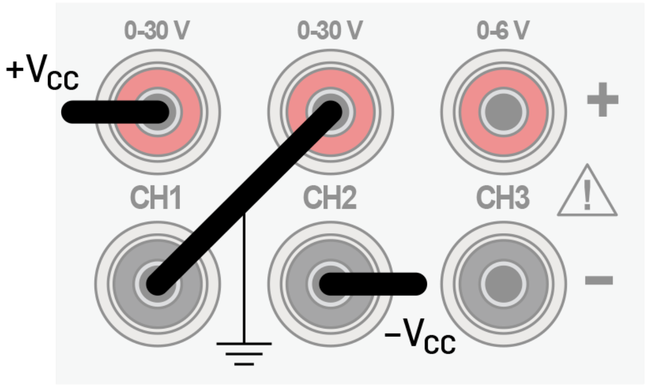

Figure 2. Wire diagram of 2230 power supply for powering op amp.

1. Build the difference amplifier circuit in Figure 1. making sure to connect the correct resistors to the inverting and non-inverting inputs. To power the op amp, use the DC power supply with the configuration in Figure 2. By connecting the negative output from channel 1 and the positive output from channel 2, the new reference ground allows the power supply to output positive and negative voltages. Connect the channel 1 probe to V_1, channel 2 probe to V_2, and channel 3 probe to V_{out} on the oscilloscope.

2. The difference amplifier takes the difference of the two input voltages and multiplies it by the gain. The gain of this amplifier is 2 because the feedback resistor is double the inverting input resistor and the voltage divider on the noninverting input is the same. The expected output of this amplifier can be solved using the following formula:

$$V_{out} = 2(V_2 - V_1)$$

   Input 1 kHz sine waves into V_1 and V_2 with inputs varying from 0 to 1 V. Add amplitude measurements using the "Measure" feature for all three channels for analysis. Fill out Table 1. and compare the measured output values to the expected calculated values. Are these values expected? What happens when $V_2 = V_1$? Are the input and output values in phase with each other?

V_2	V_1	Measured V_{out}	Calculated V_{out}

Table 1. Measured and calculated output voltages with varied inputs.

3. Instead of hand calculating expected output voltages, the 2 Series MSO features a Math tool to perform mathematic operations on waveforms. Set V_2 to a 1 kHZ sine wave with an Amplitude of 1 V and V_1 to an amplitude of 500 mV. Use the vertical scale knob to set all three channels to be 200 mV/div. To use the scaling knob, press the corresponding, colored channel buttons to the right of the knob. The scales for each channel are listed on the left corner of the scope's screen. To add a Math channel, click the Math button. Configure the channel to the settings in Figure 3. The vertical scale is set to 100 mV/div to account for the 2 V gain of the output.

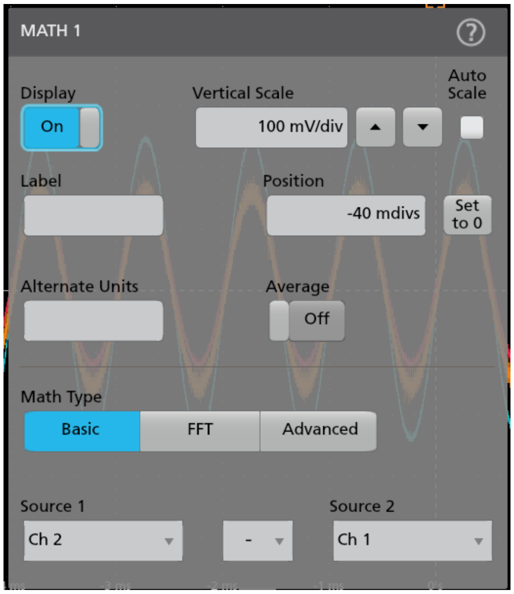

Figure 3. Math channel configuration. Vertical scale: 100 mV/div, Source 1: Ch 2, Operation: "-", Source 2: Ch 1

Compare the Math channel to the output channel on channel 3. What is the amplitude of the Math channel? Does the Math channel follow the output waveform?

Instructors Notes:

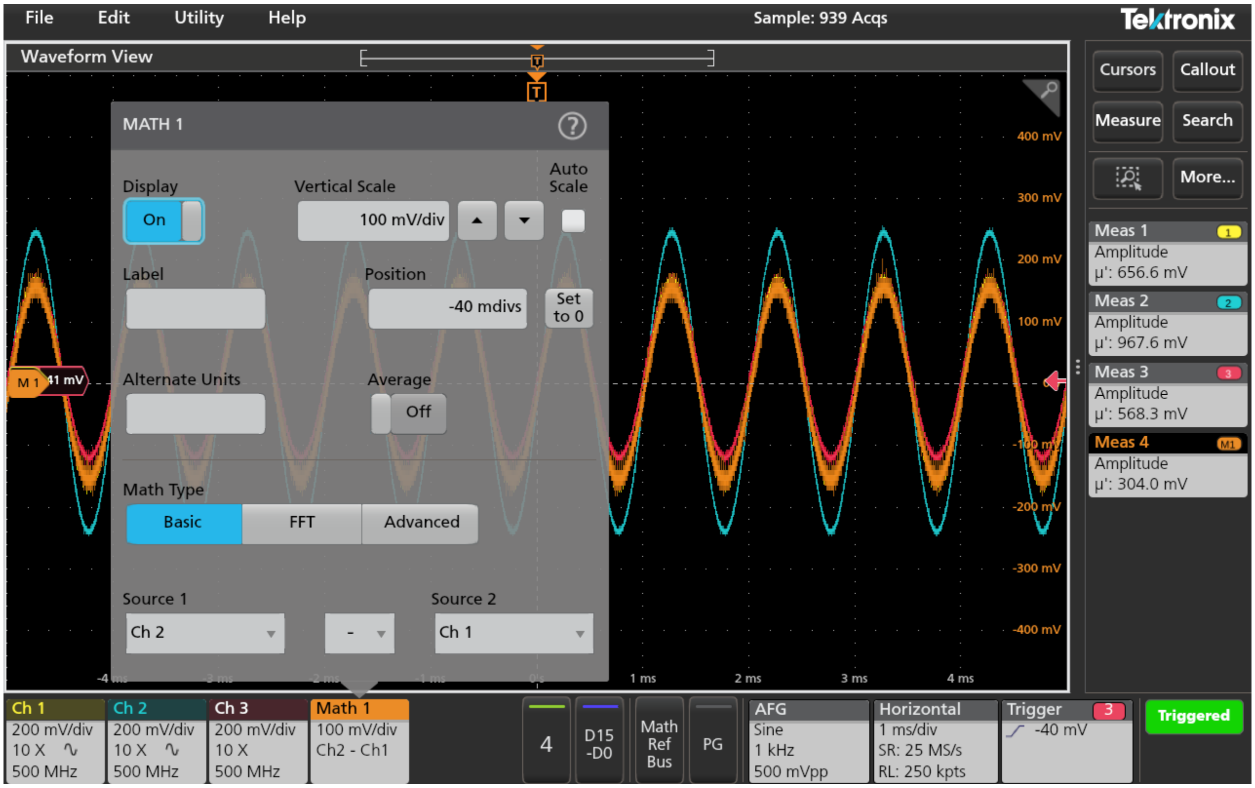

Figure 3. Input waveforms, output waveform and Math waveform.

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