Objective

- Learn to operate function generators (**Wavetek FG3B, BK Precision 4011A, Instek AFG-2112**).
- Understand digital storage oscilloscope (**Tektronix TDS 2012B**) functionality.
- Analyze and compare signal waveform characteristics.
- Measure frequency response and create **Bode plots**.
- Explore **AC vs. DC coupling** effects in oscilloscope measurements.

Exploration

Setting Up the Function Generator

1. **Select waveform type** (sine, square, or triangle) using the front panel buttons.
2. **Adjust frequency**
3. **Adjust amplitude**
4. **Set DC offset**: Not needed, default setting.

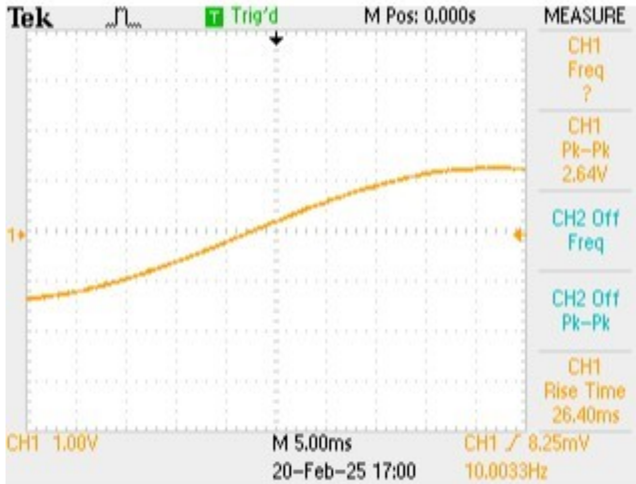
Connecting the Function Generator to the Oscilloscope

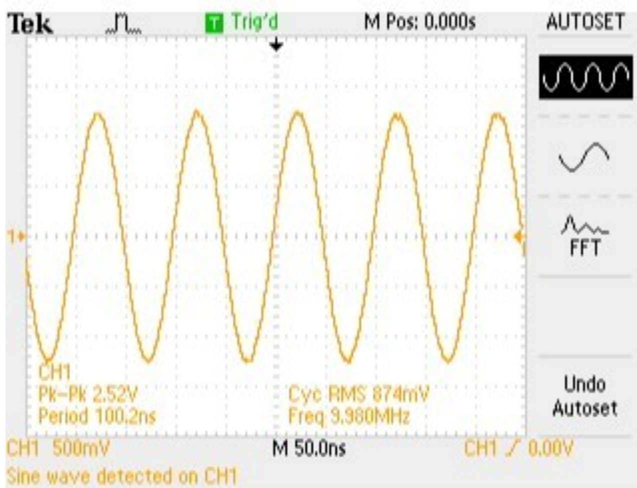
1. **Connect a cable** from the **function generator output** to **channel 1 of the oscilloscope**.
2. **Turn on the oscilloscope** and verify input settings:
   - **Channel 1 selected**
   - **Vertical scale (VOLTS/DIV) adjusted to display the waveform properly.**
   - **Horizontal scale (TIME/DIV) adjusted to show 1–2 full waveform cycles.**
3. **Verify waveform on the oscilloscope**:
   - **Adjust time/div and volts/div for better visibility.**
   - **Use the trigger menu to stabilize the waveform:**
     - **Set source to channel 1**
     - **Adjust trigger level to align with the waveform.**
4. **Try different waveforms** (sine, square, and triangle) and observe changes in shape.
5. **Change amplitude and frequency** on the function generator and observe the effects.

Procedure

A: Measuring Signal Characteristics

1. **Use oscilloscope measurement functions**:
   - **Press the MEASURE button and select:**
     - **Peak-to-peak voltage (Vpp)**
     - **RMS voltage (Vrms)**
     - **Frequency**
2. **Compare different measurement methods**:
   - **Use the cursor function to measure peak-to-peak voltage manually.**
   - **Compare manual cursor measurements with the automated MEASURE function.**
3. **Capture sine waves at two different frequencies**:
   - **10 Hz**
   - **10 MHz**
   - **Save screenshots for analysis.**

<table>
<tr>
<td>10 Hz sine wave</td>
<td>


TDS 2012B - 3:17:45 PM 2/20/2025
</td>
<td>Vpp hand measurement = 2.8V
$V_{RMS} = \frac{2.8}{\sqrt{2}}$</td>
</tr>
<tr>
<td>10 MHz sine wave</td>
<td>


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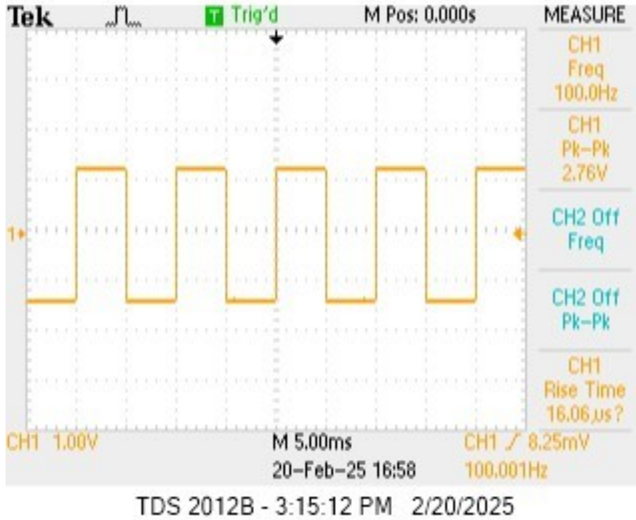
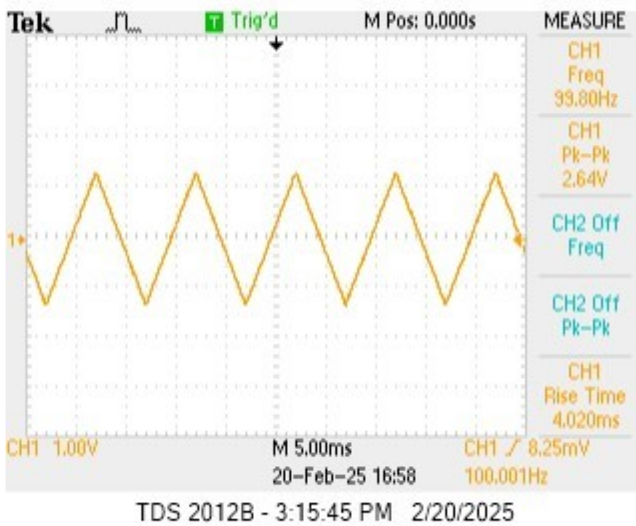
</td>
<td></td>
</tr>
</table>

Square		$V_{RMS} = 2.8\ V$
Sawtooth/triangle		$V_{RMS} = \frac{2.7}{\sqrt{3}}$

B: Frequency Response of a Voltage Divider

1. **Build a voltage divider circuit** using:
   - **R1 = 100kΩ**
   - **R2 = 2.2kΩ**
2. **Measure actual resistor values** with a multimeter before assembling the circuit.
3. **Set the function generator** to output a (**0.75V peak-to-peak) sine wave** at **100 kHz – 1000 kHz**.
4. **Connect function generator output** to:
   - **Top of the voltage divider (across R1 + R2).**
   - **Channel 1 of oscilloscope (same node as generator output).**
5. **Record voltage readings**
   - **Measure both RMS and peak-to-peak voltage using the MEASURE function.**
     - [**RMS Values**]

- **Verify using cursor measurements.**
- **Compare MEASURE vs "by hand" measurements**
  - ____
- **Adjust scope to 0.1 V/division and repeat 5.**

6. **Connect oscilloscope channel 2 across R2** (output voltage of divider).
   - Predict outcome first.
   - Measure as in 5.
   - Compare measurements to predictions.

C: Creating a Bode Plot

1. **Set function generator output** to **10V peak-to-peak sine wave** with **zero DC offset**.
2. **Measure voltage across R2 as frequency changes** from **1 Hz to 2 MHz**:
   - **Record Vout at logarithmically spaced frequencies (e.g., 1, 2, 3, 5, 10, 20, 30, 50, 100 Hz, etc.).**
   - **Use both scope channels, using DC coupling of the input signal**
3. **Create a Bode plot**:
   - **Vertical axis: (dB scale)**
     - $\mathbf{20\log_{10}}\left(\frac{V(f)}{V(\mathbf{1000}\ \text{Hz})}\right)$
   - **Horizontal axis:**
     - $\mathbf{\log_{10}}(f)$
   - *"...The numerical value of the amplification in decibels is ten times more than it is in bels, so* $A_{\text{decibel}} = A_{\text{dB}} = \mathbf{20\log_{10}}\left(\frac{V_{\text{out}}}{V_{\text{in}}}\right)$
4. **Identify the -3 dB point** (where amplitude drops to 70.7% of reference value).
5. **Determine roll-off rate** (decibels per decade).
6. Answer questions at end of section
   - If the response falls at a rate of a dB/decade, what does this imply about the functional form of (f)?

ii. Is the high frequency behavior what you expect for a device made entirely of resistors?
iii. Can you explain what might be happening?

D: AC vs. DC Coupling in the Oscilloscope

1. **Feed the same signal to both oscilloscope channels**:
   - **Channel 1: DC coupling**
   - **Channel 2: AC coupling**
2. **Measure frequency response of AC coupling**:
   - **Compare both channels at different frequencies, starting high.**
   - **Find -3 dB point where AC coupling starts attenuating low frequencies.**
3. **Plot AC vs. DC coupling response**:
   - **Use a Bode plot format (similar to previous step).**
   - **Identify frequency where AC coupling reduces signal significantly.**

     50kHz

Key Takeaways

- Oscilloscope trigger settings determine waveform stability.
- Voltage divider response depends on frequency, affecting amplitude.

- Bode plots reveal frequency-dependent gain variations.
- AC coupling removes DC bias but affects low-frequency signals.