

Two undergraduate students working on very different projects share one oscilloscope. Michaela works on high-frequency circuits, which are designed to drive  $50\ \Omega$  loads via  $50\ \Omega$  co-ax cables. Audie works on audio amplifiers optimized to drive  $8\ \Omega$  speakers, and needs to see the amplifiers' output voltage waveforms with the speakers connected. For each of the oscilloscope's input channels, there is a selector switch that allows the user to select between  $50\ \Omega$  and  $1\ \text{M}\Omega$  input impedances. Here, the input impedance refers to the equivalent impedance looking into the input channel. To make the best use of the oscilloscope, which impedance should Michaela choose? Which should Audie choose? Explain the rationale for both choices.

**Answer:**

Michaela should choose the  $50\ \Omega$  input impedance. The oscilloscope channel input impedance is the load in her case. The  $50\ \Omega$  load matches the  $50\ \Omega$  co-ax cable, therefore no reflection. For circuits working in the microwave spectral regime, this must be considered.

Audi should choose the  $1\ \text{M}\Omega$  input impedance. Audio frequencies are usually  $< 20\ \text{kHz}$ , and the corresponding wavelength is orders magnitude larger than any dimension relevant to the circuits, wires, cables. Wave phenomena do not need to be considered. The channel input impedance  $1\ \text{M}\Omega \gg 8\ \Omega$ , the load the audio amplifier is driving, therefore it can be neglected when in parallel with the  $8\ \Omega$  load and be considered open circuit. In contrast,  $50\ \Omega$  is not that much larger than  $8\ \Omega$ .

**Grading guidelines:**

Wrong choices for both Michaela and Audie: 60 (credit for effort)

One correct choice and one wrong choice: 70 + points for explanations

Two correct choices: 80 + points for explanations

Correct explanations each earn 10 points

For the explanation for Michaela's choice to be correct, the student must state impedance match. Explanations such as high frequencies require low impedance do not earn points.

For the explanation for Audie's choice to be correct, the student must state that  $1\ \text{M}\Omega$  is essentially open circuit with regard to  $8\ \Omega$  therefore the oscilloscope is measuring the voltage waveform of the speaker load. Explanations such as low frequencies require high impedance do not earn points.