Speed of Light

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Why: The speed of light plays a fundamental role in physics and this lab will show how such a very high speed can be determined (inside a cable).

What: An electromagnetic wave will be generated, split in two parts that travel different measured distances, and the measured time delay between them used to calculate their speed.

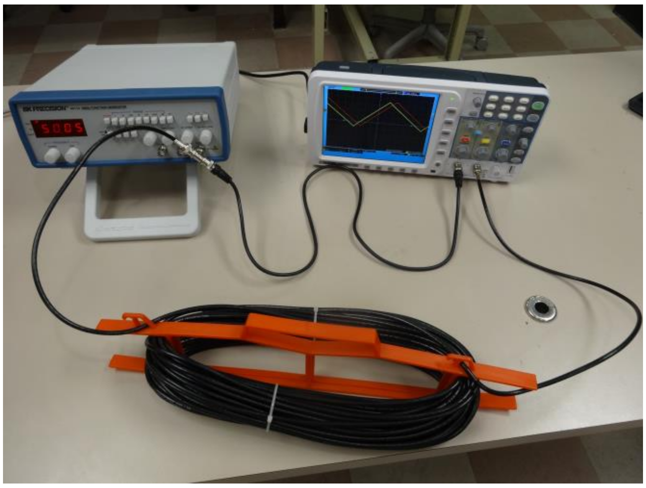
How: A radio wave generator is used to create an identical wave going through two cables of different lengths that are connected at their other ends to an oscilloscope which displays the wave profiles.

Equipment

Oscilloscope, waveform generator, coaxial cables, tee and barrel connectors, meter stick.

Procedure & Questions

The apparatus is set up so the waveform generator (left) is producing a triangular-shaped electromagnetic radio wave at a frequency of about 50 kHz (50,000 vibrations per second) This wave is split into 2 identical waves by the T-connector, one wave is send down a short cable and one down the long cable. Each cable is connected to a different channel (1 & 2) on the oscilloscope (right) so the two parts of the wave are displayed in time there together.



The vertical scale on the oscilloscope screen is not important for this experiment (you can adjust it to whatever is most convenient to see the waves). The horizontal scale on the oscilloscope measures time, and has been set initially so that each centimeter (large square) on the screen's horizontal axis equals 10 μs. (1 μs = 10^{-6} sec = 1 millionth of a second.) At this setting, you will not yet be able to see that the arrival of one wave is delayed relative to the other because of the extra distance it traveled.

> **1.** On graph paper, sketch what you see on the oscilloscope for channel #1 only. Mark the horizontal scale on your sketch.

Now adjust the horizontal scale on the oscilloscope until each centimeter equals 5 μs. (You can do this by turning the "Time/Div" or "Timesweep" knob).

2. Now sketch again on graph paper what you see for channel #1 and again indicate the horizontal scale. How does the oscilloscope display for channel #1 compare to the one for the previous time scale?

Adjust the time scale on the oscilloscope so that each square is now about 0.2 μsec or 200 nsec, (1ns = 10^{-9} sec = 1 billionth of a second.) Compare the waveforms for channel #1 and channel #2. The top row of knobs allow you to move the waveforms up/down independently and left/right together; this will make comparison easier. Look for the tip of the triangular wave in each channel and use their locations to measure the time delay of one wave relative to the other. You may want to adjust the vertical scale to make the tip of each wave sharper. (Note: the signal from the short cable will also show a second, lower tip that is an artifact due to a reflection of the wave from the long cable that traveled back to the short cable; you should ignore this artifact.)

3. Sketch what you see from channels #1 and #2 on the same graph and mark the time delay.

4. Unplug and measure the short cable length (the long cable should have its length marked). Then calculate the <u>difference</u> in cable lengths for the two cables; this is the extra distance the wave has to travel down the long cable.

Now connect a second long cable (borrow from another lab pair if necessary) to the first one to make a very long cable. The following questions should be answered by each group using their own oscilloscope/generator.

5. Sketch what you see now on the oscilloscope, measure and mark the time delay between the short and very long cable.

6. Calculate the <u>difference</u> in cable lengths for the short and very long cables.

7. Using the time delay and difference in cable lengths from the short and long cable calculate the speed of light in meters/sec in the particular kind of cable used.

8. Repeat this calculation for the speed of light using the results from the very long cable.

9. Why do you expect your two values for the speed of light to be the roughly the same? If they are nearly the same, average these two values and quote your result with an uncertainty. If they are very different, recheck your measurements and calculations.

Remember, as a rule-of-thumb, the uncertainty should be written to only 1 significant digit and the average written to the same number of decimal places and power of 10 as the uncertainty.

<u>Conclusions</u>

Write a paragraph summarizing the key things you *learnt from your data*, quoting data to support your conclusions.