Speed of a pulse along a coaxial cable

Flick a switch in an electric circuit and the resulting effect (for example a light coming on) seems instantaneous. Electrons drift slowly in the circuit yet the electromagnetic wave travels through the circuit at unimaginably high speed.
This simple demonstration using a PC based oscilloscope gives a clear picture of the time taken for a pulse to travel 200 m. in a coaxial cable. It also provides graphic evidence of signal attenuation.

What you need

- **signal generator** giving a 100 kHz square wave
- R-C pulse-shaping network
- 200 m of coaxial cable
- **ADC-200/50 PC based oscilloscope (and PicoScope software),** with its timebase set to 2µs per div

Carrying out the Experiment

The circuit diagram is given below.

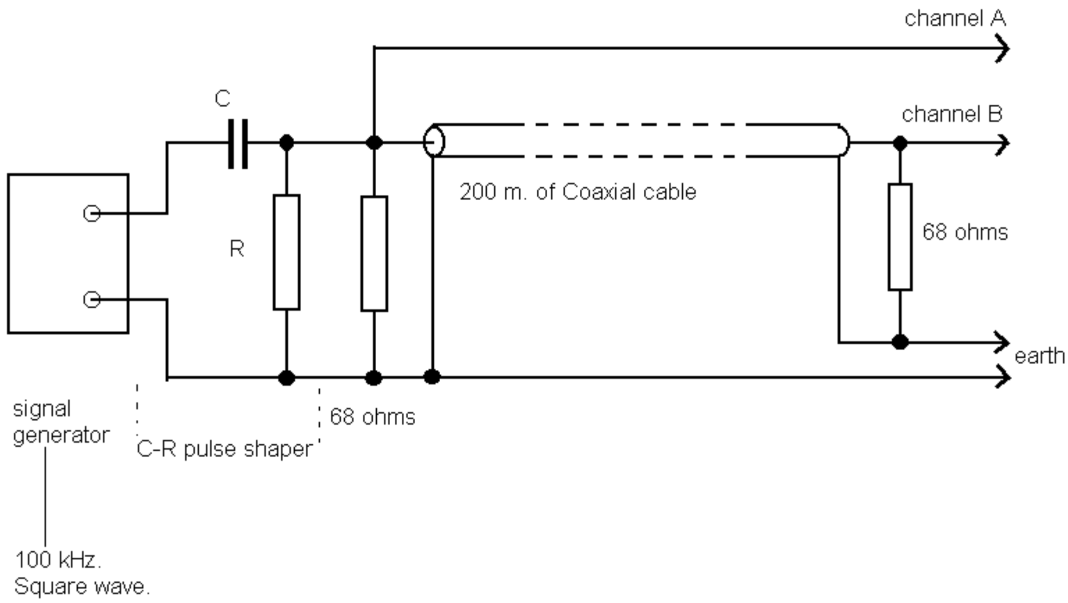
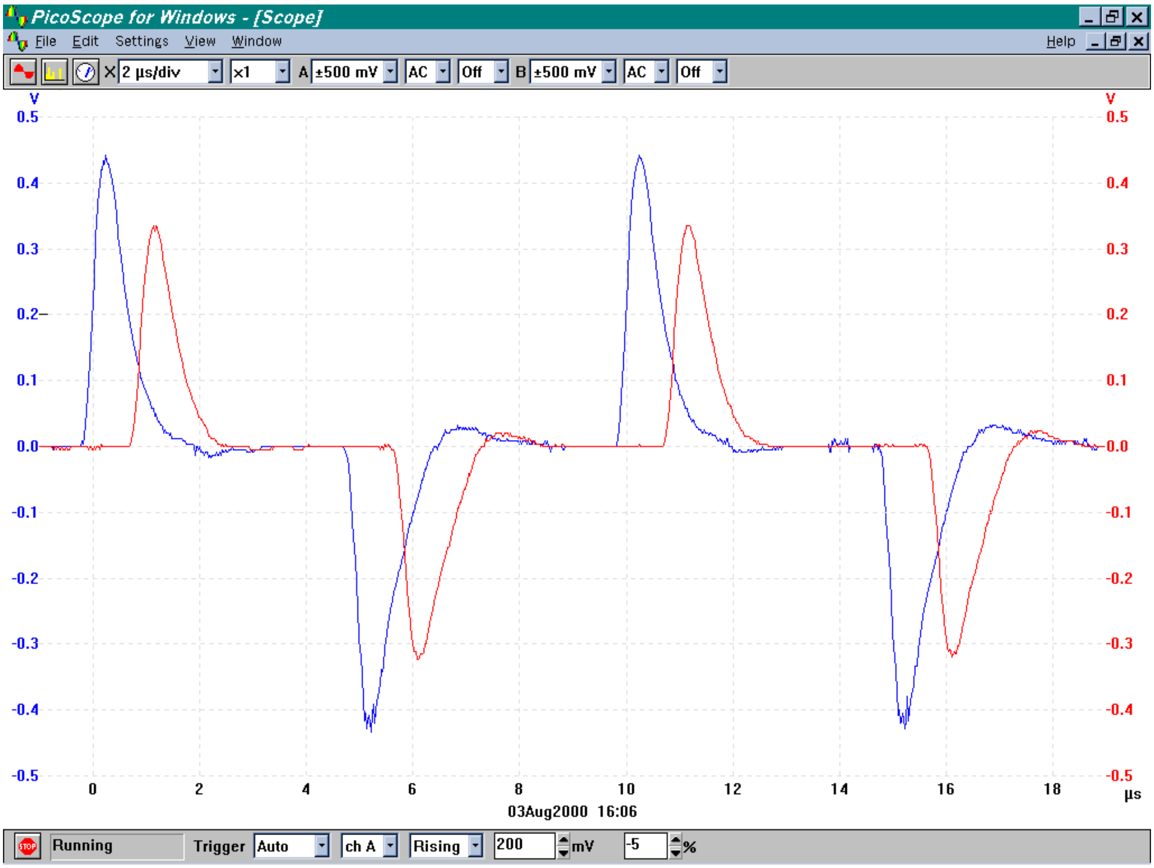


Figure 1. Pulse speed measurement - circuit diagram.

The 68 Ω resistors equal the characteristic impedance of the cable and prevent reflections.
Note : Both ends of the outer sheath of the coaxial cable are connected to earth.
The signal generator produced square waves with an amplitude of 1 volt at a frequency of 100 kHz.

Channel A on the scope then shows the pulses before they enter the coax, Channel B shows the corresponding pulses as they arrive after travelling 200m in the cable – a satisfying 1µs later, equivalent to a speed of 2×10^8 ms^{-1}.

Waveform as seen on PicoScope



Notes : 10 kHz square wave "differentiated" by RC network (see further note)

Positive peaks represent the leading edge of the square wave

Period (read from scope) is 10 µs (ie. 10kHz frequency)

BLUE trace is pulse at start of coax cable

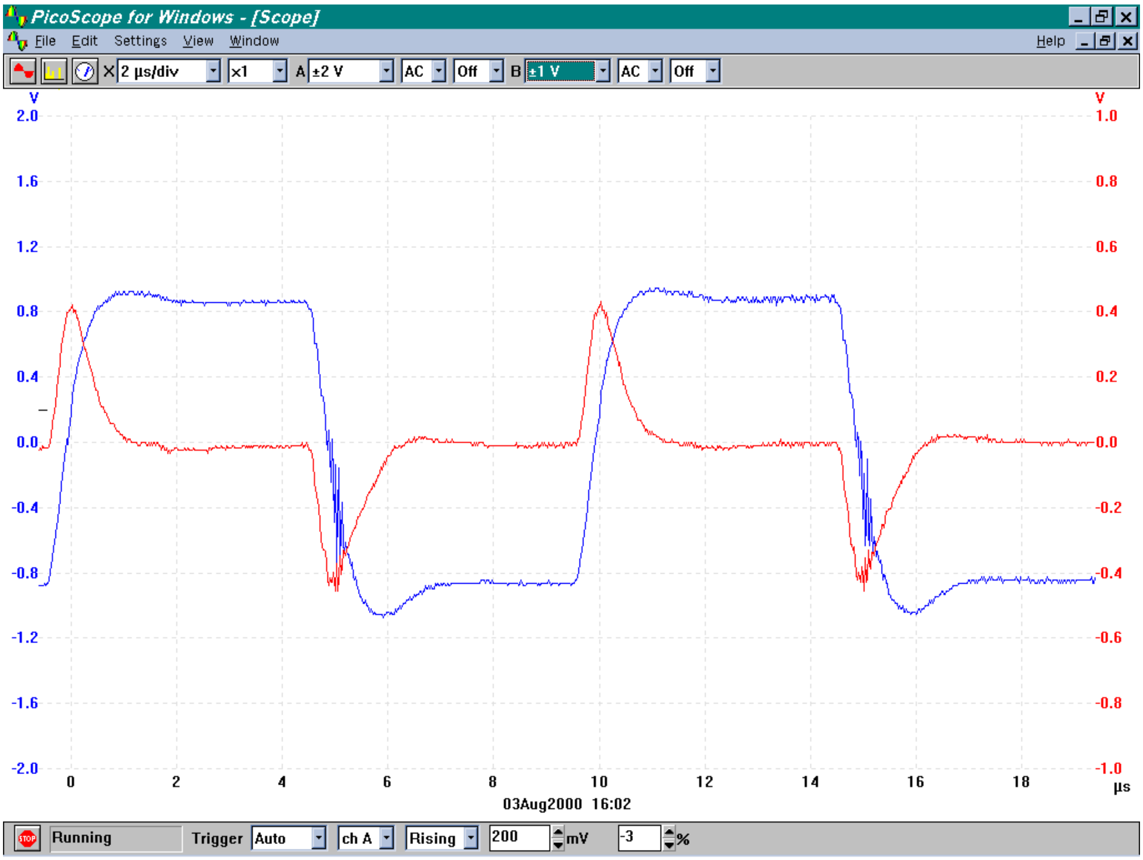
RED trace is pulse detected after 200m of travel down cable

Time delay between red and blue is 1µs

200 m in 1µs = 2 x 10^8 ms^{-1}.

The Y-gain for both channels is 500mV – so that attenuation of the red pulse is nicely shown – another good discussion point.

Converting the 10kHz Squarewave to Pulses – PicoScope view



The 10 kHz square-wave (blue trace/channel A) is produced at the signal generator .
The pulses are produced by the resistance, R, and capacitance, C.
Suitable values for R and C are 10 kΩ and 4700pF – substitution boxes were used.
The R-C network effectively differentiates the square-wave, a good discussion point for mathematically-inclined students (and teachers).

Files provided

Nil

Getting it to work

In view of the limited number of applications for a pulse generator in the 'A' level syllabus and the relatively large requirement for signal generators, suitable pulses were produced by a **signal generator** giving a 100 kHz square wave through an R-C pulse-shaping network. (A note is included on pulse shaping- see below)

An **ADC-200/50 PC based oscilloscope (and PicoScope software),** with its timebase set to 2µs per div., was employed.

The coaxial cable was purchased from RS components (a considerable time ago). It is much easier to use if kept on its drum!

Alternative approaches

nil

Social and Human context

nil

Level

LH

Safety

nil