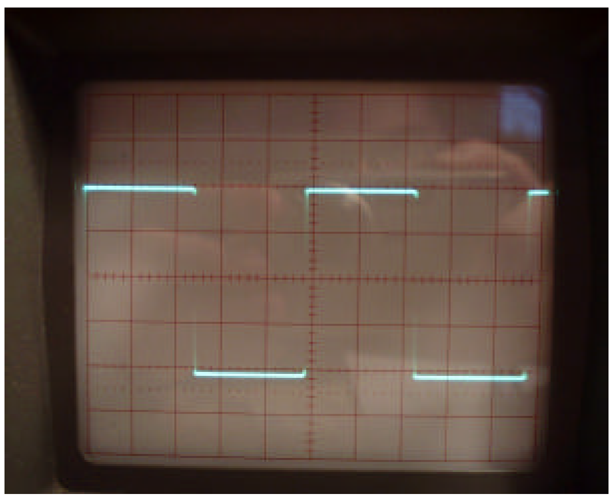
Messing about with Fourier series:

I've done an experiment to try and demonstrate the principles of Fourier series. I fed a series of square waves at different frequencies through a simple RC filter circuit, and then looked at the output on an oscilloscope.

The background to this is that a square wave is a made up of an infinite series of odd harmonics of decreasing amplitude (from Fourier)
By passing the wave through a filter, I can remove some of them, and change the shape of the waveform.

The filter used consisted of a 33k resistor and a 3.3nF capacitor, and the wave was a 4v pk-pk square wave. The break frequency (the point at which the filter attenuates by 3dB) is about 1.5kHz.

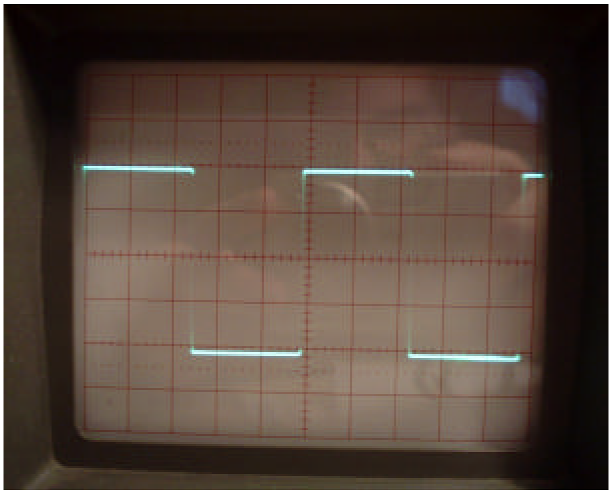
Here's the incident wave at 100Hz:



The 'scope was set to 1v/div and a 2ms/div sweep time.

The Results:

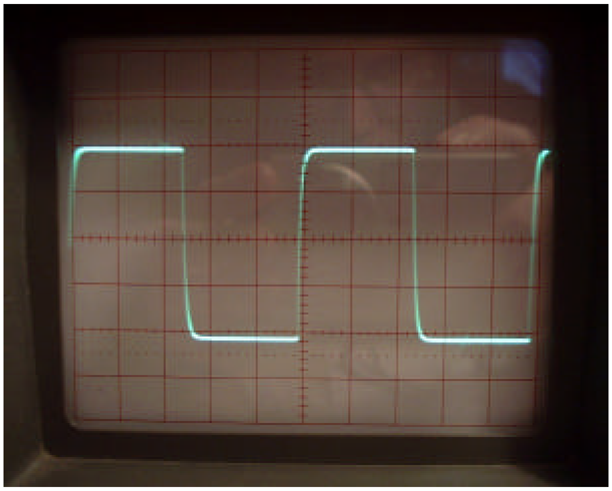
Feeding this wave through the filter (which has a –3dB frequency of about 1.5kHz) produced the following:



Again, the scope has a 2ms/div sweep time.

There’s relatively little difference at this frequency- most of the significant terms in the series aren’t going to be attenuated.

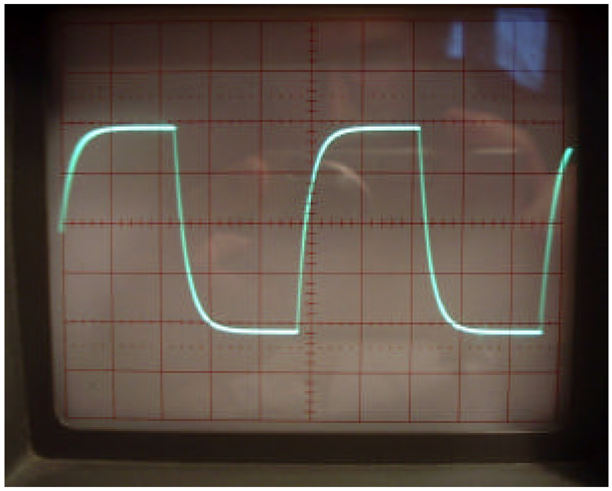
Here’s the result at 1kHz:



This has a 0.2ms/div sweep time.

Note that the filter has attenuated the highest frequencies, and has rounded off the corners of the waveform.

Going up to 4kHz:

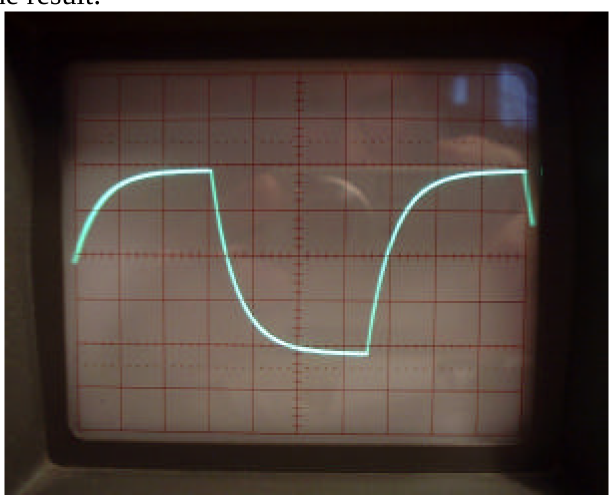


This is on a 50μs/div sweep time

You can see my reflection in the ‘scope screen…

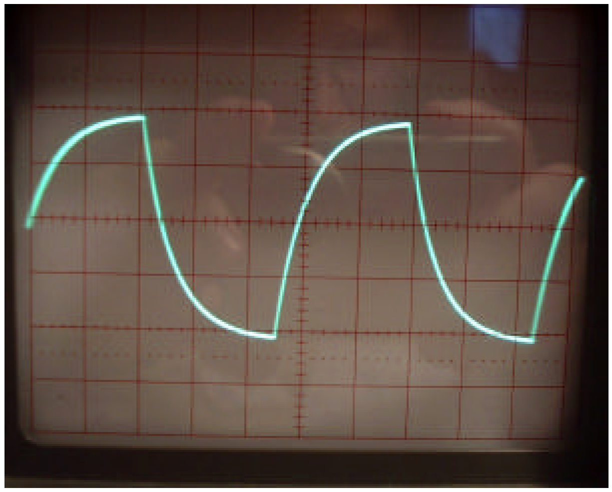
The edges are becoming very much more rounded.

At 7kHz, this is the result:



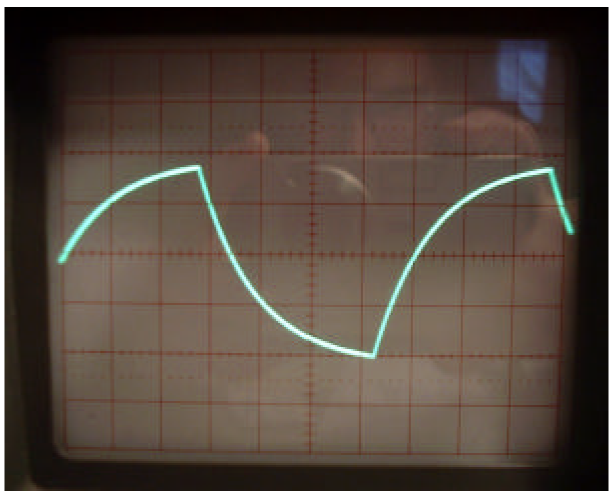
This is a 20μs/div sweep time.

And 10kHz:



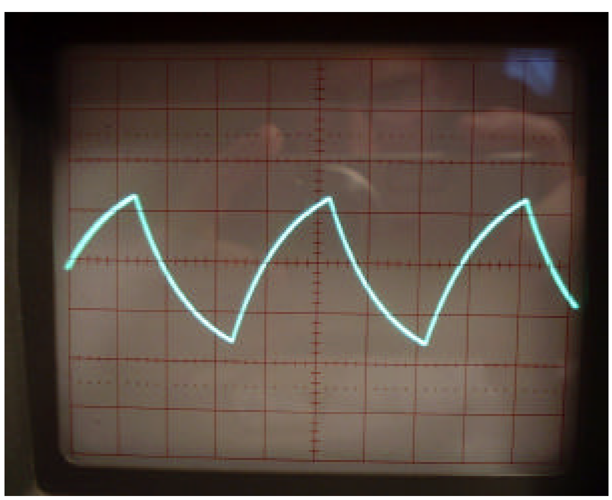
Again, 20µs/div sweep time.

14kHz:



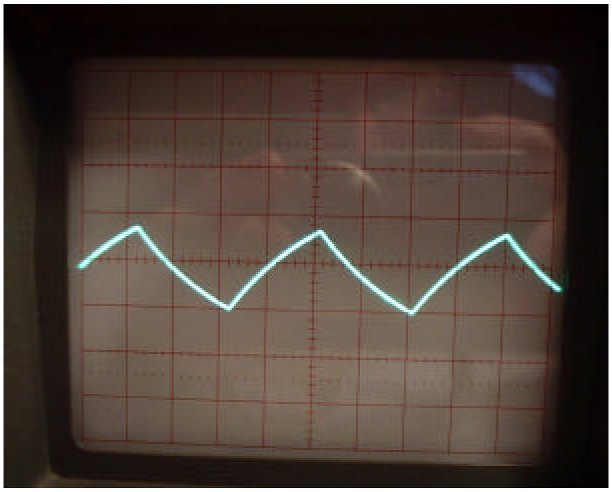
10µs/div sweep time.

25kHz:



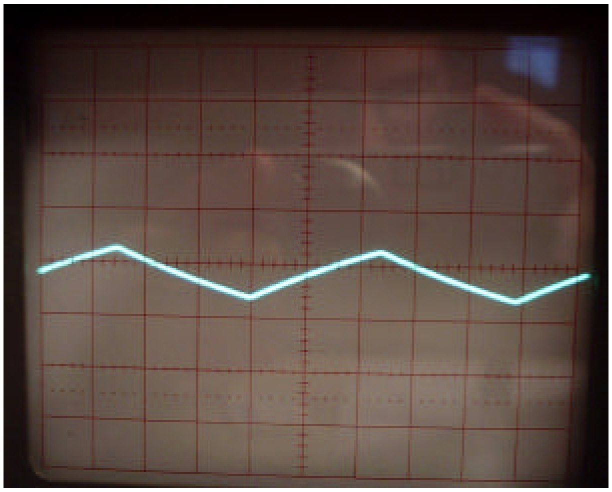
10µs/div sweep time.

50kHz:



5µs/div sweep time.

100kHz:



2µs/div sweep time.

Because this is only a single-pole filter (20dB/decade roll-off) the result isn't a sinewave. Using a bandpass filter you get a closer approximation to a sinewave, but you should get the idea as to what's happening- the higher frequencies are attenuated, making the wave more like a sinusoid at the fundamental frequency.
Just in case you're curious, the pictures were taken with Dad's new digital camera in macro-mode, close to the screen of my 'scope.

I've also enclosed an Excel spreadsheet which contains scatter-plots of the theoretical spectra at some of the above frequencies.

Enjoy!

Michael