Learning Goals for 'Fourier Methods', ALPhA Immersion 2013

Ch. 0: 'Overview' of Fourier Methods, already sent

Ch. 1: SR770 familiarization
View of a single sine wave; varying frequency, amplitude
View of 10-kHz sine, square, triangle waves

Ch. 2: SR770 internal source
Familiarization
Summing internal and external source;
the 2-peak spectrum, the telegraph metaphor
Resolving power; sinusoids of near-equal, and very unequal, amplitudes
Windowing and its effect on lineshape
Optional: Spectral leakage, precise amplitude measurement

Ch. 3: Modulation – AM
Internal 50-kHz source, external composite for low-frequency 'program'
The Multiplier
The characteristic 3-line spectrum, sidebands – what controls what?

Ch. 4: Mixing – the Heterodyne concept
Mixing by multiplication
Mixers proper – the response to two sinusoids
Punch-through of inputs; main outputs; intermodulation products
Optional: Mixer as phase detector; mixer as frequency doubler

Ch. 5: Modulation – FM
The VCO, and dc verification of its operation
External modulation of the VCO, and the spectrum resulting
Various limiting cases; the modulation index

Ch. 6: Noise waveforms quantified
New settings, new units for the SR770
External and internal noise sources
The meaning of noise units V^2/Hz and $V/\sqrt{Hz}$.
Optional: Exercise in noise

Ch. 7: The LCR system as a model linear time-invariant system
Excitation of it by square-wave source, by sine-wave source
Time-domain view of the system's resonant behavior
Frequency-domain view:
One sinusoid at a time; excitation by noise; excitation by chirp

Ch. 8: The Acoustic Resonator as a model system
The transfer-function concept
Peak-hunting using sinusoids; using noise; using chirp
Optional: theory of resonant frequencies

Ch. 9: Fourier Transforms of transient waveforms
The LCR transient as a model system
Learning triggering, and choosing a timescale, for the SR770
Seeing a ring-down as a Lorentzian
Optional: adding noise; seeing real and imaginary parts

Further projects that are feasible:

Ch. 10: Modulated waveforms – modulation by a pulse

Ch. 11: Down-conversion and demodulation of AM radio

Ch. 12: Deterministic chaos, in time- and frequency-domains

Ch. 13: Harnessing harmonic distortion – the fluxgate magnetometer

Ch. 14: Frequency-domain views of audio waveforms

Ch. 15: Signal Recovery for signals-under-noise

Ch. 16: Coupled Oscillators

Ch. 17: Fourier methods for detecting nonlinearity

Ch. 18: Demodulation of FM signals