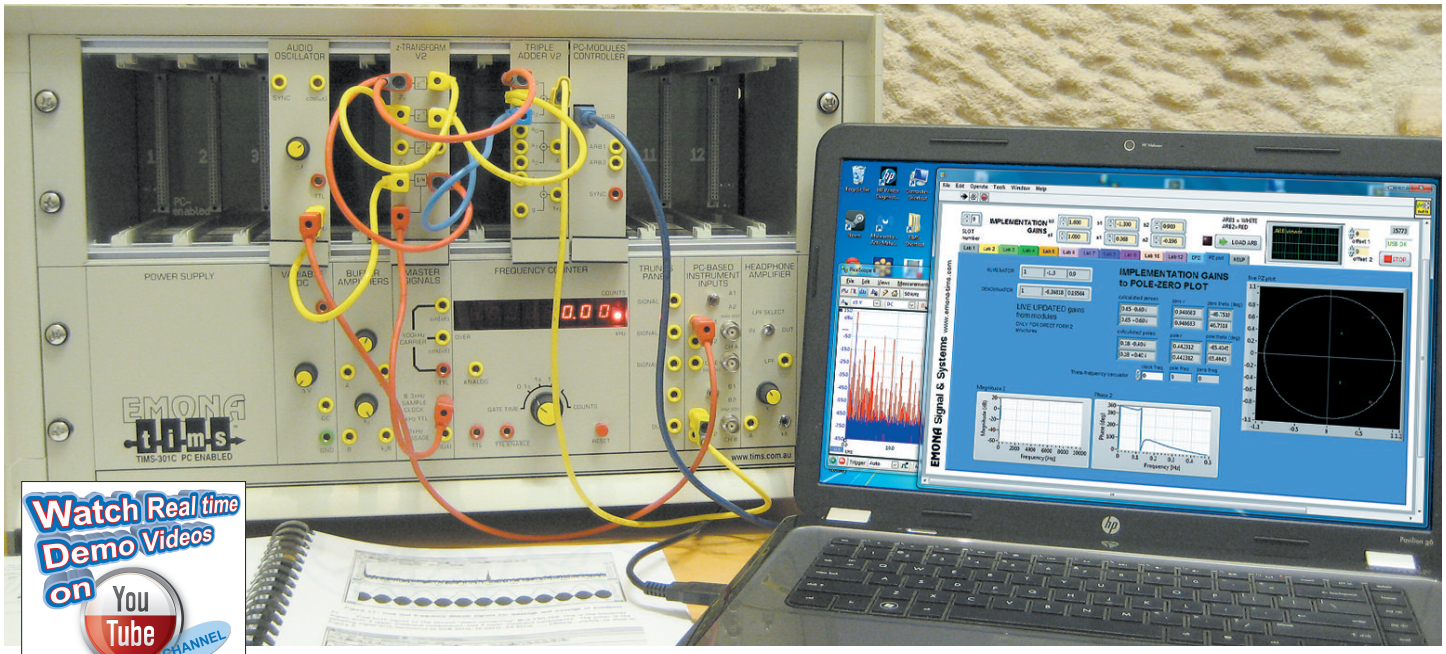
A HARDWARE LAB COMPANION PROGRAM

Emona Signals & Systems Experiments

Hands-on hardware experiments teaching complex math concepts easily with real signals in real time



HARDWARE EXPERIMENTS EXPLORE

- Both Continuous-time and Discrete-time systems
- And key topics covering:
  Linearity - Convolution - Correlation - Fourier - Laplace - z-Transforms

Experiments for engineering and science students in:
Electrical Engineering - Engineering Technology - Mechanical Engineering

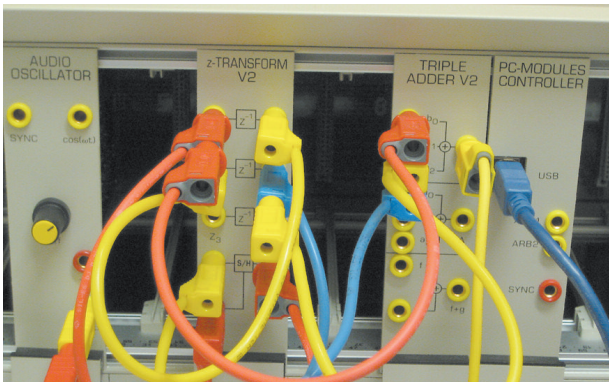
EMONA INSTRUMENTS
www.emona-tims.com

Signals & Systems Lab Program

Signals and Systems is a fundamental course for engineers and scientists which introduces students to analog and digital signal processing, a topic that forms an integral part of engineering systems across many diverse disciplines, including communications, image processing, speech processing, seismic data processing, defense electronics, consumer electronics, biomedical engineering and consumer products.

The Emona TIMS Signals & Systems Lab Manual will facilitate student understanding in:

- The terminology of signals and basic engineering systems.
- Signal representation techniques and signal characteristics.
- The difference and the applications of analog versus discrete signals and the conversion between them.
- The process of sampling and the effects of undersampling.
- Convolution, Complex Numbers, Correlation, Fourier, Laplace and z-plane poles & zeros.
- The application of transforms in signals and systems analysis, characterization, and manipulation.
- The math behind Fourier, Laplace and z-transforms through hands-on experience.



FIR implementation using TIMS modules

TIMS Signals & Systems Lab Manual

The TIMS Signals & Systems lab manual is designed to provide a practical "hands-on", experiential, lab-based component to the theoretical work presented in lectures on the topics typically covered in introductory signals courses for engineering students.

Students take responsibility for the construction of the experiments and "learning by doing" to consolidate their knowledge of the underpinning theory, which at times is particularly **abstract and hard to grasp** for these early engineering students. They are not constrained by the software and need to be systematic in debugging their own systems when results do not meet their expectations.

TIMS Signals & Systems Experiment Topics



Lab 1: Introduction to TIMS S&S modules
Lab 2: Special signals – characteristics and applications
Lab 3: Systems: Linear and non-linear
Lab 4: Unraveling convolution
Lab 5: Integration, convolution, correlation & matched filters
Lab 6: Exploring complex numbers and exponentials
Lab 7: Build a Fourier series analyzer
Lab 8: Spectrum analysis of signals
Lab 9: Poles and zeros in Laplace domain
Lab 10: Sampling and Aliasing
Lab 11: Getting started with analog-to-digital conversion
Lab 12: Discrete-time filters – FIR
Lab 13: Poles and zeros in the z-plane: IIR forms

Appendix: TIMS Lab Manual to Textbook chapter comparison table

Modeling experiments with TIMS clarifies important principles

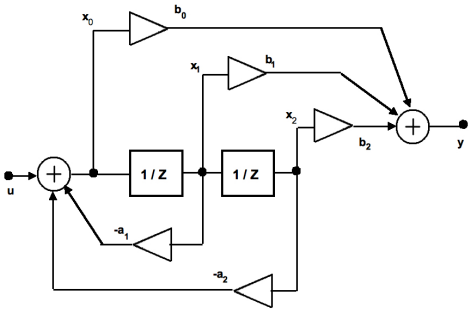
TIMS Signals & Systems Hardware Experiments

TIMS Signals & Systems experiments implement the math and theory taught in lectures.

Each TIMS experiment is built, step-by-step. Nothing is "pre-wired". This TIMS experimental process opens the opportunity for the student to gain insight and familiarity with the key course concepts.

◆ THEORY

Each chapter of the lab manual presents the theory as math and block diagrams, exactly as is given in lectures and in signals & systems textbooks.

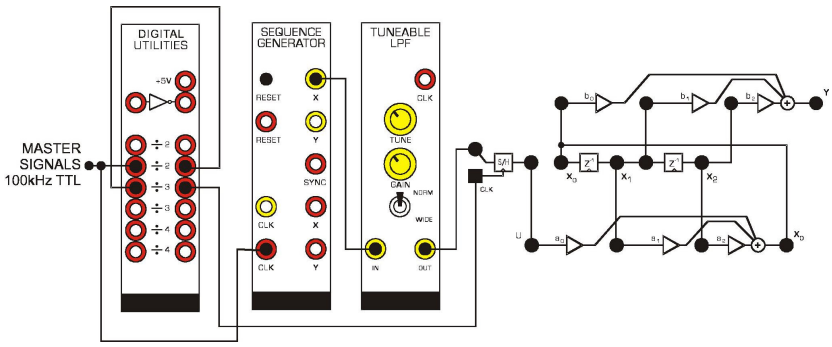


Experiments start at the block diagram - in this example, an 2nd-order Direct-form IIR filter

◆ HANDS-ON

The experiment is then patched together, following the block diagrams presented in the theory.

Each chapter provides clear guidance to students on how to patch together and control the experiment parameters.



Hardware patching diagram

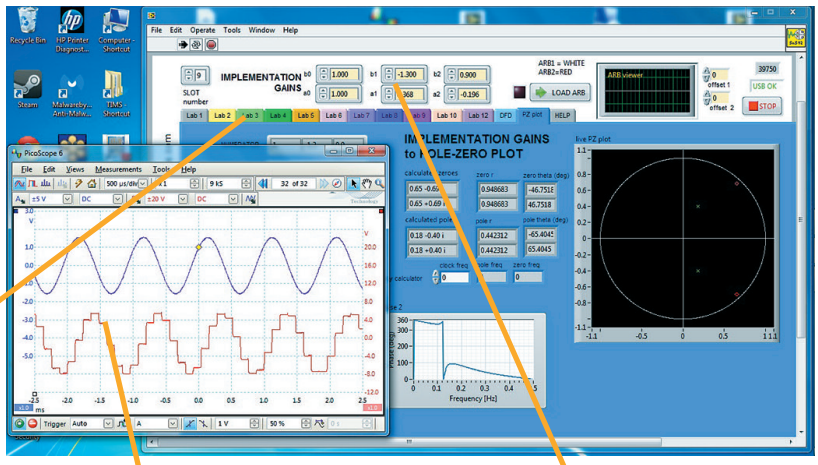
◆ INVESTIGATION

Students investigate, varying physical parameters and observing results, enabling them to contrast theory with real-world measurements.

Virtual instrumentation provides immediate time and frequency domain displays.

Students are empowered to try "what-if" scenarios to consolidate their understanding.

Virtual instrumentation display window, with Soft Front Panel for setting of hardware coefficient parameters



Custom experiment instrumentation is selected via each TAB

Virtual Instrumentation provides real-time oscilloscope and spectrum displays

Adjustable gains of the hardware ADDERS for coefficient setting

Students see the complex math of this essential topic come to life

TIMS Experiments-to-Textbooks Comparison

This table aims to direct users to sections of commonly available text books which contain theory and exercises related to experiments currently documented and implemented with the TIMS Lab Manual.

TIMS Lab Manual Experiments	Lathi.B.P. , "Signal Processing & Linear Systems" , Oxford University Press	Oppenheim.A.V.,Wilsky.A.S., "Signals & Systems" , Prentice Hall, 2nd edition	Ziemer.R.E,Tranter.W.H, Fannin.D.R, "Signals & Systems : Continuous & Discrete" , Prentice Hall, 4th edition	McClellan.J.H, Schafer.R.W., Yoder.M.A.: "DSP First" , Prentice Hall
Lab 02: Special signals – characteristics and applications	1 Introduction to Signals and Systems B.2 Sinusoids 2.4 System response to external input: zero-state response	1 Signals and Systems	1-3 Signal models	1 Mathematical representation of signals
Lab 03: Systems: Linear and non-linear	1 Introduction to Signals and Systems	1 Signals and Systems 2 Linear time-invariant systems	2-2 Properties of systems	2 Thinking about systems
Lab 04: Unraveling convolution	9.4-1 Graphical procedure for the convolution sum	2.1 Discrete-time LTI systems: The convolution sum	8-4 Difference equations and discrete-time systems; Example 8-12 Discrete convolution; 10-6 Convolution	5.3.3 Convolution and FIR filters
Lab 05: Integration, convolution, correlation & matched filters	2.4-1 The convolution integral 3.2 Signal comparison: Correlation	2.2 Continuous-time LTI systems: The convolution integral 2 Linear time-invariant systems;	10-6 Energy spectral density and autocorrelation function	5.6 Convolution and LTI systems
Lab 06: Exploring complex numbers and exponentials	B.1 Complex numbers B.3-1 Monotonic exponentials B.3-2 The exponentially varying sinusoid	1 Signal and systems: Math review 1.3 Exponentials and sinusoidals	1-3 Phasor signals and spectra	2.5 Complex exponentials and phasors
Lab 07: Build a Fourier series analyzer	3.4 Trigonometric fourier series	3.3 Fourier series representation of continuous-time periodic signals	3-3 Trigonometric Fourier series representations for periodic signals 3-4 The complex exponential Fourier series	3.4.1 Fourier series analysis
Lab 08: Spectrum analysis of various signal types	4 Continuous-time signal analysis: The fourier transform	4.1.3 Examples of Continuous-Time Fourier transforms	4.5 Fourier transform theorems	3 Spectrum representation
Lab 09: Poles and zeros in the Laplace domain	6 Continuous-time system analysis using the Laplace transform	9 The Laplace transform 9.4 Geometric evaluation of the Fourier trans. from the pole-zero plot	6-4 Transfer functions	-
Lab 10: Sampling and Aliasing	5 Sampling 8.3 Sampling continuous-time sinusoid and aliasing	7 Sampling	8-2 Sampling 8-2 Impulse-train sampling model	4 Sampling and aliasing
Lab 11: Getting started with analog-digital conversion	5.1-3 Applications of the sampling theorem (Pulse code modulation PCM)	8.6.3 Digital Pulse-Amplitude (PAM) and Pulse-Code modulation (PCM)	8-2 Quantizing and encoding	4.4 Discrete to continuous conversion
Lab 12: Discrete-time filters with FIR systems	11 Discrete-time system analysis using the z-transform; 12.1 Freq response of discrete-time systems; 12.2 Freq response from pole-zero location	6.6 First-order and second-order discrete time systems 6.7.2 Examples of discrete-time nonrecursive filters	9-5 Design of finite-duration impulse response (FIR) digital filters	5 FIR filters
Lab 13: Poles and zeros in the z plane with IIR systems	12 Frequency response and digital filters	10.4 Geometric eval. of the Fourier transform from the pole-zero plot	9-4 Infinite Impulse Response (IIR) filter design	8 IIR filters

ERRORS and OMISSIONS EXCEPTED. The above comparison table is intended as an approximate guide and does not imply endorsement of the authors or publishers.

Available from:

Emona Instruments Pty Ltd
78 Parramatta Road
Camperdown NSW 2050 AUSTRALIA
Tel: +61-2-9519-3933 Fax: +61-2-9550-1378
URL: www.emona-tims.com
Email: sales@emona-tims.com

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