UNIVERSITY OF LOUISIANA AT LAFAYETTE

STEP Committee

Technology Fee Application

Electrical Engineering Communication Systems Lab Equipment

Dr. Zhongqi Pan/Mr. Shelby A. Williams, Jr.
(submitters)

William Hansen Hall Electrical and Computer Engineering Dept.
Organization

Title: Electrical Engineering Communication Systems Lab Equipment

Date: January 14th, 2020

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Department/College/Org: William Hansen Hall Electrical and Computer Engineering

ABSTRACT (250 Words or less):

The current equipment used for Communication Systems Lab (EECE-453) was purchased in 2006, and originally designed as the lab component for EECE-458G. The equipment was discontinued by Feedback Instruments several years ago, plus its supporting OS (Windows XP) has also been discontinued by Microsoft. It is imperative to upgrade this laboratory due to the following reasons.

1. Current lab equipment has only 3 stations that can function properly, which limit the enrollment to maximum 8 students, while the overall enrollment had been reached to over 20 in past few years.

2. EECE curriculum has been updated lately to accommodate the enormous industry advancements, such as WiFi, IoT, and 5G technologies. EECE-453 need to be modified to reflect these advancements, and be expanded to support students in communications, robotics, and signal processing areas. The aged equipment no longer has the capacity to meet the demands for students with different backgrounds.

3. The proposed equipment will give students not only the up-to-date knowledge of wired/wireless communications systems, but also a tool for time/spectral analysis of various signals. It will better prepare students for the most advanced information related industry, and stimulate their curiosity.

4. The open ended architecture of the new equipment can be easily expanded to support many other information-related courses, such as signal processing, IoT technologies, robotics, etc.

5. The new equipment can be expected as of great value for graduate students as well, for both training and thesis research. It will be a great tool for graduate students recruit.

Purpose of the Grant and Impact to the Student Body as a Whole

In order to comply with the electrical engineering students' academic curriculum, EECE department provides a specific laboratory for engineering students to apply the theoretical knowledge and get a better understanding of the basic principles and techniques of the modern communication systems. This lab is mandatory for electrical engineering students with the concentration in communication engineering. Students enrolled in all other concentration areas can also take this course as an elective.

The lab is currently equipped with Analog & Digital Communications Workstation from Feedback Instruments, and intended for teaching only the basic concepts of analog and digital communications. The available equipment is about 15 years old and no longer has any support from the vendor, since they has discontinued this product for several years. Depending on the experiments we are running, we can hardly get 2 to 3 fully operating stations for students enrolled per section. Because of lack of properly working equipment, students have been met with great difficulty sharing the proper equipment available to accomplish the experiments, and more importantly to meet ABET outcomes addressed in this laboratory.

Moreover, EECE curriculum has been updated recently to accommodate the enormous industry advancements, such as WiFi, IoT, and 5G technologies. There is a very high demand of laboratory experiments from students in communications, robotics, and signal processing fields. The aged equipment that originally designed for EECE-453 no longer has the capacity to meet the high demands for students with different backgrounds.

The proposed equipment is Telecommunications Instructional Modeling System (TIMS) from Emona Instruments, as shown in Figure.1. TIMS is laboratory hardware & software for experiments in wireless theory, communications systems and signals & systems theory. It is a flexible and versatile communications trainer that incorporates all of the instruments needed to quickly and easily carry out every communications laboratory experiment required in a range of courses, from ITEC to EECE, and graduate level. TIMS can implement practically any form of modulation or coding - keeping pace with the rapid development of telecommunications theory. Here we highlight some features that TIMS can provide.

- Open ended and expandable architecture: TIMS can implement from the most basic communications systems theory, through to the very latest in coding and modulation - OFDM, Turbo Coding and more.
- Self contained: TIMS is self contained requiring only an additional oscilloscope for waveform display and PC for detailed spectrum display and measurements.
- PC-interface instrumentation: TIMS can interface to a PC providing data acquisition and spectrum analysis facilities and a range of supporting math applications. It can also provide friendly interface to LabVIEW and MATLAB,
- Student projects: TIMS is the ideal system to allow students to conveniently develop, built and analyze the performance of their thesis projects. With the new equipment, the communication lab can really be a senior undergraduate and 1st year graduate lab in communications engineering.

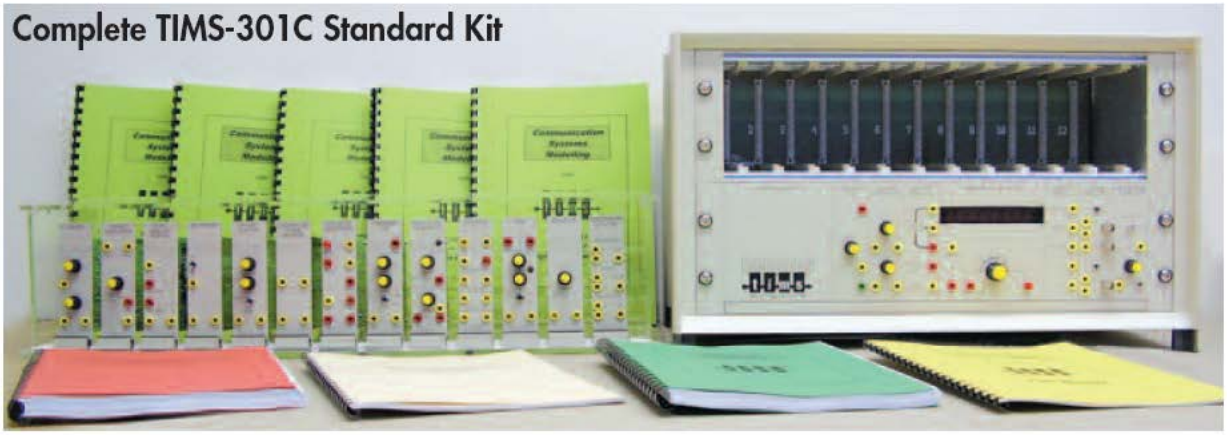


Fig. 1. TIMS-301C standard kit.

In addition to better accommodating students, we intend to extend their knowledge by incorporating the state-of-the-art wireless communication systems. TIMS can exactly meet our teaching requirements. It is a true real-time hardware mathematical modeling system, almost infinitely expandable. It can be continuously and inexpensively expanded to implement the very latest developments in telecommunications and signal theory. The TIMS system is made up of different plug-in and fixed modules. Each TIMS plug-in module realizes a fundamental communications/signals building block and these blocks can be used and re-used in different experiments. The modules include a wide variety of analog, digital, and DSP building block functions. All module capabilities and specifications are outlined in the TIMS user manuals. Module descriptions are presented in a common format making it very easy for students to quickly grasp the use of any module. The following modules will be included in our proposal for the Communication System Laboratory.

TIMS-147 Adder
TIMS-148 Audio Oscillator
TIMS-149 Dual Analog Switch
TIMS-150 Multiplier
TIMS-151 Phase Shifter
TIMS-152 Quad Phase Splitter
TIMS-153 Sequence Generator
TIMS-154 Tuneable LPF
TIMS-155 Twin Pulse Generator
TIMS-156 Utilities
TIMS-157 VCO
TIMS-158 60 kHz LPF
TIMS-425 Quadrature Utilities
TIMS-250 Module Storage Box

With these modules, TIMS 301C can implement the following experiments including modulation/demodulation, coding/decoding, transmission, and performance evaluation for both analog and digital communication systems, as shown in Figure 2.

Modeling of math equations
AM modulation (2 methods)
Envelopes/envelope recovery
DSBSC mod and demod
SSB mod - phasing method
SSB demod - phasing method
Product demodulation
Phase lock loop
FM modulation & demod
Armstrong's Phase modulator
PAM generation
TDM generation
FDM generation or recovery
PDM generation or recovery
PWM mod and recovery
Eye diagrams
Introduction to Pulse shaping
Noise generation

Sampling Theorem and reconstruction
QAM generation or demod
BPSK mod and demodulation
QPSK mod or demodulation
ASK mod and demodulation
QASK mod or demodulation
FSK modulation (2 methods)
Carrier acquisition - PLL
Complex analog messages
Spread spectrum generation

These experiments covering the principles behind LTE, 4G and 5G, IoT, wideband-CDMA, Wi-Fi, cordless telephone, ZigBee™, Bluetooth, near field communications, UWB, RFID, digital radio DAB, satellite modems, satellite links, GPS, RADAR signals, OFDM, software defined radio, and many other most advanced communication systems.

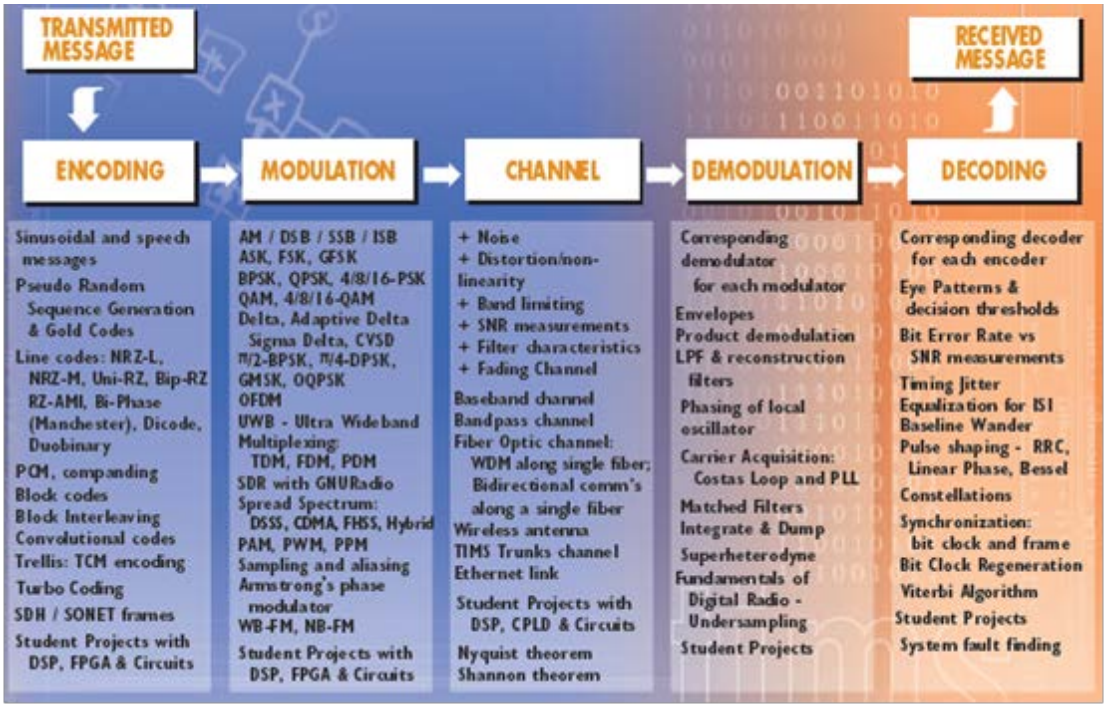


Fig. 2. Summary of TIMS experiment capabilities.

TIMS has the distinction of being the only telecommunications lab equipment that can implement practically any form of modulation or coding – keeping pace with the rapid development of telecommunications theory. It can implement from the most basic communications systems theory, through to the very latest in coding and modulation. As shown in Figure 3, students start from the fundamental theory and end up the real hand-on hardwire system demonstrations by simply following the step-by-step experiment process in each experiment.

TIMS also provide the LabSheet Experiments, a massive library of over 160 concise, single sheet experiments which provide a rich source of experiment ideas and serve to provide an accelerated familiarization for instructors to accommodate different course requirements. There Meanwhile, the seven volume detailed lab manuals provide an in-depth coverage of a broad range of wired/wireless telecommunications experiments for students.

We will also request the TutorTIMS-R2 - PreLab Simulation Software. It is a TIMS telecommunications experiments simulator which looks just like the TIMS lab equipment. All front panel controls mimic the TIMS lab hardware system, with true point-and-click technology.

No programming or syntax entry is required. So students can start patching telecommunications experiments in minutes. TutorTIMS-R2 is ideal for helping students prepare at home before attending hands-on labs at school.

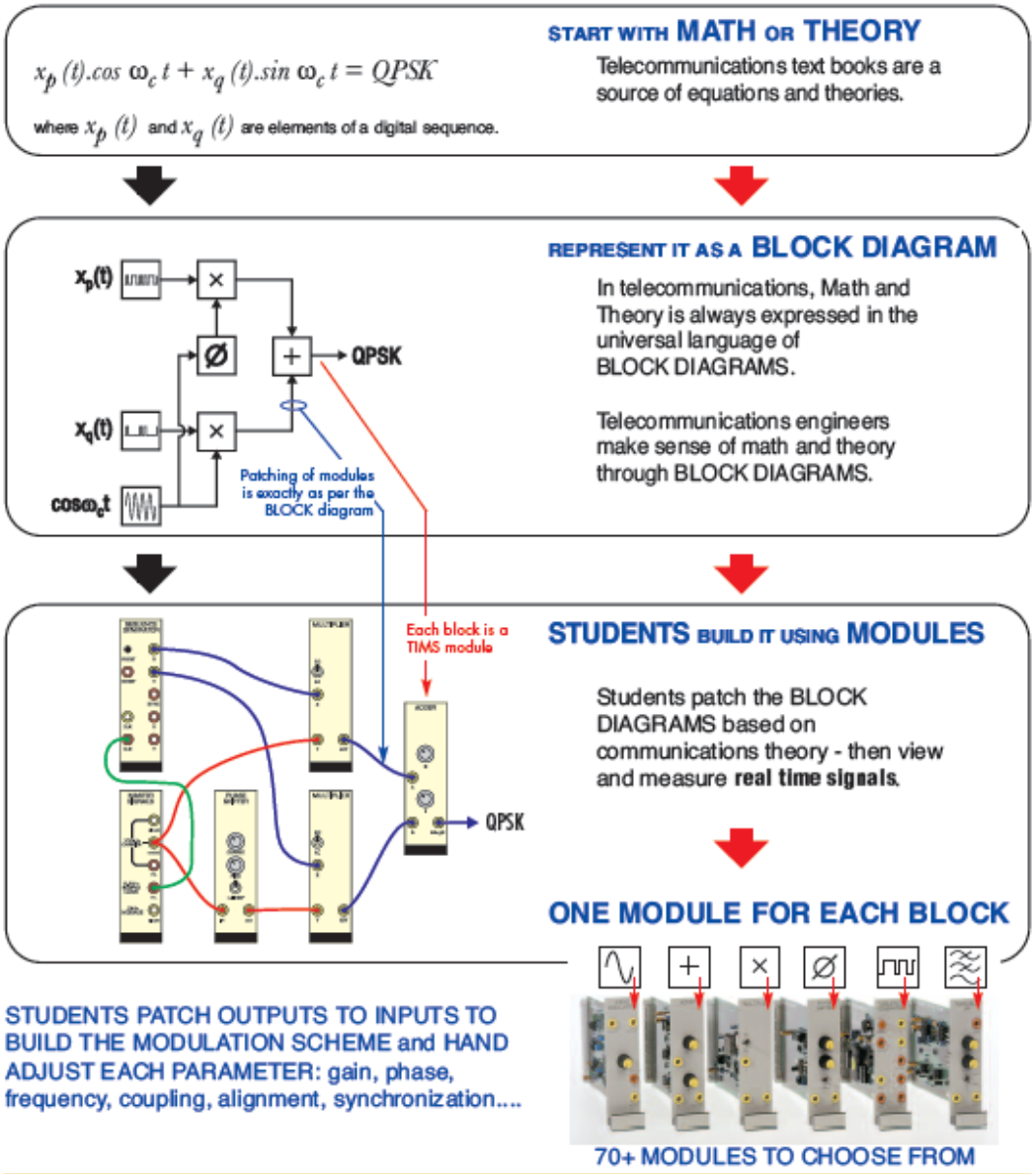


Fig. 3. Step-by-step experiment process.

We expect that all students will be greatly benefited by the new laboratory, especially for the students who enrolled in the following course EECE-452/458 (Communication Engineering I and II), EECE-430 (Digital Signal Processing), EECE-431 (Intelligent Cyber Physical Systems), EECE-434(G) (Data Communications), EECE 435(G) (Wireless Communications), and EECE-464 (Internet of Things). Furthermore, the laboratory will also be a great tool to support our senior design projects and undergraduate student research projects. Meanwhile, a number of graduate courses, such as EECE-502 (Digital Signal Processing), EECE-510 (Communication Networks), EECE-520 (Digital Communication Systems), EECE-530 (Optical Networks), and EECE-540 (Wireless Communications), can also utilize the equipment for both teaching and

research purposes.

Since TIMS can interface to a PC providing data acquisition and spectrum analysis facilities a range of supporting math applications. In addition to TIMS laboratory hardware/software, a standard Desktop computer will be needed for each work station.

In summary, EECE department requests funding to furnish the Communication Systems laboratory with this up-to-date TIMS-301C equipment. This proposal requests 6 laboratory workstations, with each workstation consists of one TIMS-301C and one Dell Desktop Enhanced Computers w/ Monitor.

Projected Lifetime of Enhancement

The projected lifetime of the equipment requested is three to five years.

Persons Responsible for

Implementation -Mr. Shelby Williams is the laboratory manager for the Electrical and Computer Engineering department. He will see to the acquisition of the computers, the TIMS-301C.

Installation - Mr. Shelby Williams is the laboratory manager for the Electrical and Computer Engineering Department. He will be responsible for the installation and provisioning of the equipment

Maintenance - Trainer: There is a one-year warranty on parts and labor.

Dell Desktop Enhanced Computers w/monitor, malfunctions that occur with the laboratory equipment shall be covered.

Operation - The EECE 453 instructor will provide additional support as needed.

Training - Necessary software training will be provided by the EECE 453 instructor.

Description of Each Budgeted Category

Equipment:

- TIMS-301C PC-Enabled Fixed System and Fundamental modules
  Quantity: 6 stations Price for each station: $13,200.00 Total: $79,200.00
  Door-to-door shipping and insurance: $1,990.00
  Total: $81,190.00
- EMONA TIMS Software defined radio hardware and software option for TIMS-301C
  Quantity: 6 stations Price for each station: $525.00 Total: $3,150.00
  TIMS-451 offered at half price with TIMS-301C purchase -$1,575.00
  Total: $1,575.00
- TutorTIMS-Basic Release 2 pre-lab learning simulation software
  Unlimited 1 user license Total $2,000.00

- Dell Desktop Enhanced Computers w/ Monitor
  Quantity: 6 stations Price for each computer: $1,295.00 Total: $7,770.00

Total Budget Requested **Total: $92,535**

$81,190.00 + 1,575.00 + 2,000 + 7,770 = $92,535

See attached price quote from Emona, and the product brochure.

EMONA INSTRUMENTS

Emona Instruments' representative office:
1557 Cattleman Ct. Milliken, CO 80543
Telephone: 1 877 237 8181 (Toll Free)
Fax: 1 877-751-0232

September 04, 2019

Prof Zhongqi Pan
Department of Electrical and Computer Engineering
University of Louisiana at Lafayette
131 Rex St.
Lafayette, LA 70503

Dear Prof Pan,

Proposal for 6 sets of Advanced TIMS Telecom's Signals Modelling Equipment: LOUISIANA090419/EVAL

I would like to thank you for your interest in the Emona TIMS signals modelling equipment. My colleague, Shiela Woodson, has asked me to prepare the following proposal for SIX sets of TIMS-301C System with the EVAL-16 advanced module set and two options.

This proposal is divided into three sections.
Section "A" includes the TIMS-301C PC-Enabled system, to implement over 40 fundamental experiments and BLOCK DIAGRAMS.
Section "B" offers the EVAL-16 set of additional 3 x BASIC and 13 x ADVANCED modules required to implement more advanced experiments including BER and SNR in baseband and passband schemes.
Section "C" includes the TIMS-SDR kit and TutorTIMS PreLab learning software.

TIMS is a modular, block-diagram based system, so you can pick and choose the experiments covering topics in Communications Systems, Wireless and Signals & Systems courses, to suit your curriculum. We offer predefined sets of TIMS modules, such as the EVAL-16 set below, or we can propose the plug-in modules (building blocks) that are required to implement your chosen experiments.

Each TIMS system comes complete with all User and Student Experiment manuals and patching leads. The only additional piece of equipment recommended to carry out the experiments is a basic 20MHz oscilloscope

The first option includes new TIMS Software Defined Radio (SDR) with plug-and play, pre-installed GNU Radio. The second option includes the very powerful Pre-Lab learning simulation software, TutorTIMS, which helps students to prepare at home for the hands-on TIMS labs.

Please feel free to call Shiela Woodson (1- 877-237 8181) or email me (abreznik@emona.com.au) for further details, clarification, or to assist with experiment and module selection to suit your requirements.

ITEM	QTY	EACH	TOTAL
A - TIMS PC-ENABLED SYSTEM			
1 TIMS-301C PC-Enabled Fixed System and	6	$13,200.00	$79,200.00
Fundamental modules which include all of the following			
TIMS-147 Adder	6		
TIMS-148 Audio Oscillator	6		
TIMS-149 Dual Analog Switch	6		
TIMS-150 Multiplier	6		
TIMS-151 Phase Shifter	6		
TIMS-152 Quad Phase Splitter	6		
TIMS-153 Sequence Generator	6		
TIMS-154 Tuneable LPF	6		
TIMS-155 Twin Pulse Generator	6		
TIMS-156 Utilities	6		
TIMS-157 VCO	6		
TIMS-158 60 kHz LPF	6		
TIMS-425 Quadrature Utilities	6		
TIMS-250 Module Storage Box	6		
Standard Accessories & Manuals. In-built 2 channel, 500MS/s PC-based multi-instrument. Including USB PC interface cable and Windows software for scope, spectrum analyzer, DVM and counter. (PC is required for operation of PC-based instrument but is not included in above price.)			
2 Door-to-door shipping and insurance			$1,990.00
		TOTAL FOR TIMS-301C:	**$81,190.00**

- TIMS PC-ENABLED SYSTEM EXPERIMENTS and BLOCK DIAGRAM CAPABILITIES

L-01 Introduction to TIMS
L-02 Modelling equations
L-03 DSBSC - generation - detailed
L-04 Product demodulation - intro
L-05 AM - amplitude modulation - I - detailed
L-06 AM - amplitude modulation - II - detailed
L-07 Envelope detection - detailed
L-08 SSB generation - detailed
L-09 SSB demodulation
L-11 Armstrong`s phase modulator - detailed
L-12 FM - generation by VCO - detailed
L-14 FM - demodulation by ZX counting - detailed
L-15 Sampling - intro
L-17 FDM - frequency division multiplex
L-18 Phase division multiplex - generate - intro
L-19 Phase division multiplex - demod - intro
L-20 PWM - pulse width modulation - detailed
L-21 Carrier acquisition - PLL - detailed
L-23 Complex analog messages
L-26 ASK - generation
L-28 BPSK - modulation - intro
L-29 BPSK - demodulation - intro
L-30 QPSK - generation - intro
L-31 QPSK - demodulation - intro
L-32 FSK - generation - detailed
L-36 Eye patterns - intro
L-48 QAM - generation
L-49 QAM - demodulation
L-68 non-linearity & distortion - PICO
L-83 customizable digital sequences
L-104 Introductory PAM-TDM
L-105 Quadrature amplitude shift keying - QASK
L-106 Introduction to pulse shaping
L-107 Noise generation using binary sequences
L-108 Principles of spread spectrum

C1 - EMONA TIMS SOFTWARE DEFINED RADIO hardware and software option for TIMS-301C

21 TIMS-451 SDR UTILITIES hardware module and Kit 6 $525.00 $3,150.00

Includes plug-and-play, bootable USB thumb drive with pre-installed GNU Radio on LINUX Mint

SPECIFICATIONS:

TIMS-451 SDR UTILITIES software includes:

- USB thumb drive with bootable LINUX Mint operating system and latest GNU Radio pre-installed
- Suite of analog and digital modulation/demodulation GNU Radio program examples

TIMS-451 SDR UTILITIES hardware functions:

- 2 x I & Q analog baseband inputs
- 2 x I & Q analog baseband outputs
- Dual, tuneable RRC LPFs, with LPF Fc clock output
- Data bit clock output
- USB 2.0 port and USB cable

21.1 ***Special offer:***

TIMS-451 offered at half price with TIMS-301C purchase **-$1,575.00**

EMONA TIMS-SDR typical experiment capabilities

- Familiarization with GNU Radio software.
- Familiarization with SDR hardware.
- Implementing a modulator in GNU Radio and SDR hardware, and implementing demodulator with standard TIMS hardware modules.
- Exploring sampling and resampling in SDR.
- Modulator implemented in standard TIMS hardware module and demodulating in SDR hardware & GNU Radio.
- Modulation and demodulation implement in GNU Radio and SDR hardware with a real TIMS hardware channel.
- Exploring digital modulation schemes in GNU Radio and SDR hardware.

EMONA TIMS-SDR Explorative Experiments

#1 - FM reception using SDR

AIM: Step-by-step guide to creating a GNURadio program.

Insights into principles of FM radio reception using SDR and familiarity with GNU Radio concept.

C2 - TutorTIMS-Basic Release 2 pre-lab learning simulation software

22 **TutorTIMS-Basic Release 2 - Unlimited** 1 $2,000.00 **$2,000.00**

On-screen version of the TIMS hardware lab equipment, intended for student preparation and learning at home and in the lab.

Simulates TIMS Basic modules.

UNLIMITED USER SITE LICENSE for any number of enrolled students and professors.

TERMS:

1) Warranty period is 24 months from date of invoice. Support is co-ordinated by our approved service provider, Shiela Woodson, in Milliken, CO.
2) Delivery charge quoted is for a single delivery to the Department.
3) Prices quoted exclude State and Federal Taxes.
4) Standard Accessories include: one set of User Manuals per System, one copy of the 5 Volume Student Text, Instructors Guide, one copy of the 164 x LabSheet Experiments, all manuals on CD in PDF format, 30 x multi-strand stackable Patch Cords, 3 x BNC to BNC Scope Cables, Mains Cord.
5) Payment Terms: 30 days from date of invoice.
6) Availability: 8 weeks after receipt of order.
7) This quotation originates from Emona's Australian office. The quotation may be accepted by emailing or faxing your order to Emona at sales@qpsk.com or fax 011-61-2-9550-1378. Fax orders sent to the toll free 877-751-0232 fax number will be forwarded to Emona Instruments' Australian office.

Alfred Breznik
Technical Director

Emona Instruments Pty Limited, acn 069 417 563, 78 Parramatta Road Camperdown Australia 2050

tims

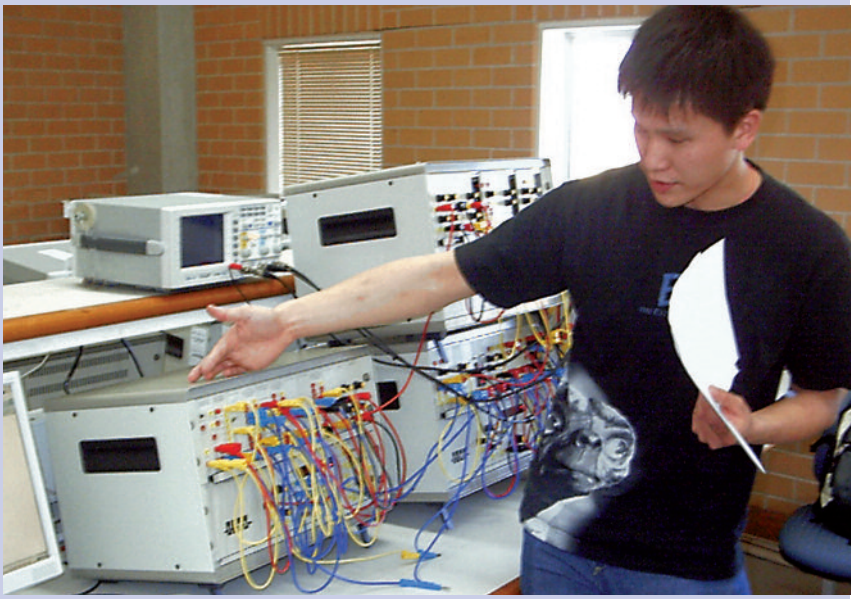
Telecommunications
Signals & Systems
Lab Equipment

EMONA Information Sheet

EXPERIMENTS COVERING THE PRINCIPLES BEHIND:

- 3G, 4G
- LTE
- Wideband-CDMA
- HSDPA
- CDMA2000®
- EDGE
- cdmaOne (IS-95)
- GSM
- Wi-Fi
- WiMAX
- Cordless Telephone
- ZigBee™
- DECT
- Bluetooth®
- Near Field Communications
- UWB
- RFID
- Digital Radio DAB
- Satellite Modems
- Satellite Links
- Deep Space Telemetry
- GPS
- OFDM (DVB-T, ADSL, WLAN)
- Turbo Coding
- Software Defined Radio

and much more . . .



University Level Experiments in

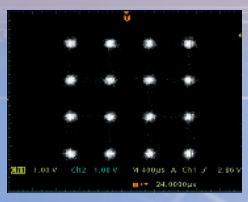
- Wireless Communications
- Signals & Systems
- DSP and SDR
- Fiber Optics
- Student Projects

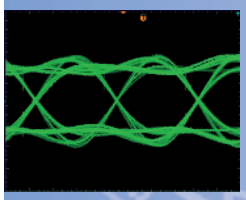
EMONA INSTRUMENTS

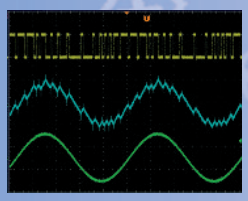
www.emona-tims.com

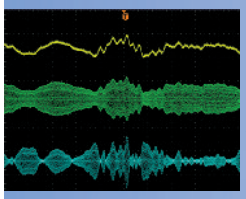
THE BEST LAB SOLUTION

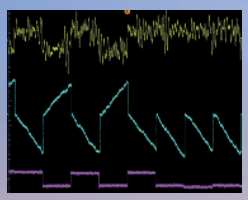
ACTUAL TIMS WAVEFORMS

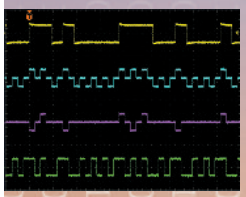

16-QAM

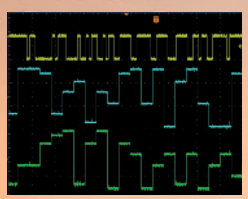

Eye Patterns

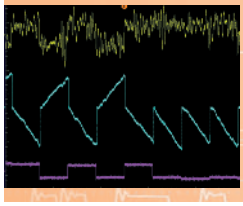

Delta Modulation


Speech AM & DSB

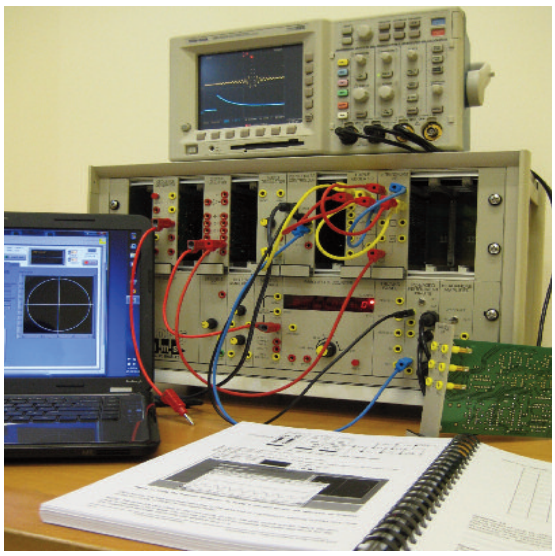

Integrate & Dump


Line Code Encodes


Multi-Level I & Q Signals


Matched Filter

TIMS is laboratory hardware & software for experiments in wireless theory, communications systems and signals & systems theory.



TIMS, Telecommunications Instructional Modeling System, is laboratory teaching equipment for EE and EET students in wireless, telecommunications and signal processing courses.

TIMS is a hardware engineering modelling system that can implement **practically any form of modulation or coding** - keeping pace with the rapid development of telecommunications theory.

• OPEN ENDED & EXPANDABLE ARCHITECTURE

TIMS can implement from the most basic communications systems theory, through to the very latest in coding and modulation - OFDM, Turbo Coding and more.

• SELF CONTAINED

TIMS is self contained requiring only an additional oscilloscope for waveform display and PC for detailed spectrum display and measurements.

• PC-INTERFACE - INSTRUMENTATION, LabVIEW™ & MATLAB™

As well, TIMS can interface to a PC providing data acquisition and spectrum analysis facilities and a range of supporting math applications.

• STUDENT PROJECTS

TIMS is the ideal system to allow students to conveniently develop, built and analyse the performance of their thesis projects.

TIMS is a 'hands-on' lab system where engineering students learn mathematics "by-doing" through practical experience.

TIMS is a True Engineering Modeling System . . . . . more than just a "trainer"

START WITH MATH OR THEORY . . . . .

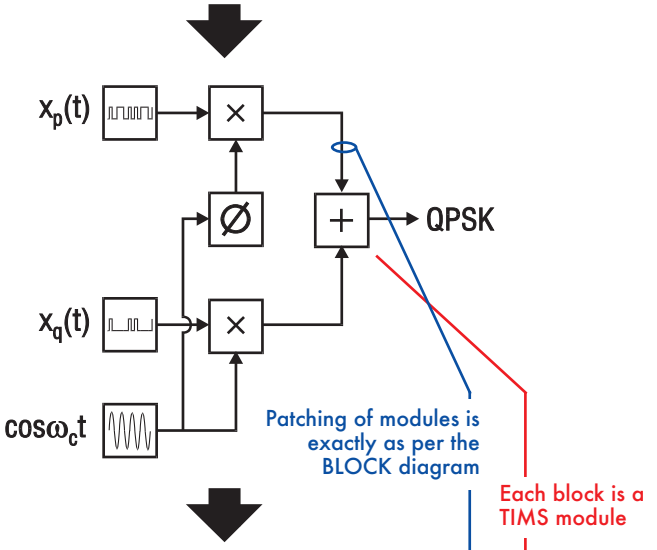
Telecommunications text books are full of equations and theories. This is the starting point for a TIMS experiment.

$$x_p(t).\cos \omega_c t + x_q(t).\sin \omega_c t = QPSK$$

where $x_p(t)$ and $x_q(t)$ are alternate elements of a digital sequence.

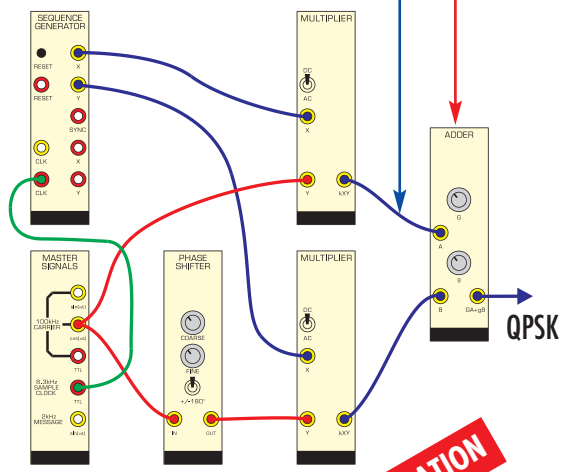
REPRESENT IT AS A BLOCK DIAGRAM

In telecommunications, Math and Theory is always expressed in the universal language of BLOCK DIAGRAMS.

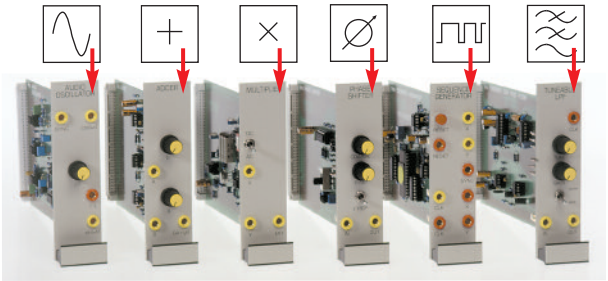


STUDENTS BUILD IT USING TIMS MODULES

Students patch the BLOCK DIAGRAMS based on communications theory - then view and measure real-time signals.



ONE MODULE FOR EACH BLOCK



60+ FUNCTIONAL BLOCKS TO CHOOSE FROM

FOR MORE INFORMATION

Watch Real time Demo Videos on YouTube CHANNEL

www.youtube.com/EmonaTIMS

EMONA TIMS GUARANTEE OF SATISFACTION

• WELL ESTABLISHED

Used daily in hundreds of universities* for over 25 years. Modules and experiments added every year. TIMS is always up to date.

* Contact Emona for user lists near you.

• HIGH RELIABILITY

TIMS plug-in modules are hot-swappable & TIMS is covered by a 24 month warranty with a proven history of lifetime customer support.