

# EMONA tims

## ADVANCED EXPERIMENT PLATFORM

The best experiment system for teaching difficult math and theory to engineering students

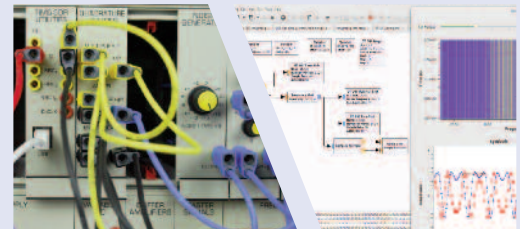
### EXPERIMENTS COVERING THE PRINCIPLES BEHIND:

LTE, 4G and 5G  
 IoT  
 TETRA  
 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  
 DVB-S  
 Satellite Modems  
 Satellite Links  
 EBEM  
 Deep Space Telemetry  
 GPS  
 RADAR Signals  
 OFDM (DVB-T, ADSL, WLAN)  
 Software Defined Radio  
 and much more . . .

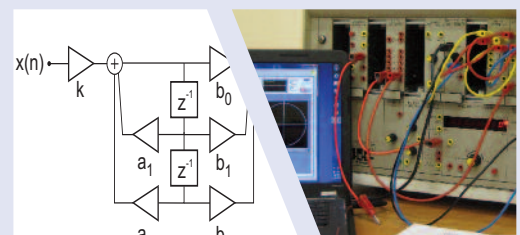


ADVANCED WIRELESS COMMUNICATIONS

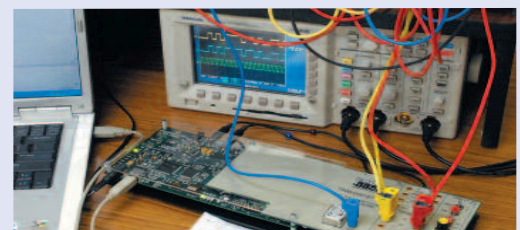
**NEW**



SDR FOR EDUCATION with GNURadio



SIGNALS & SYSTEMS EXPERIMENTS

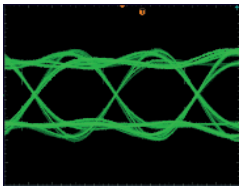
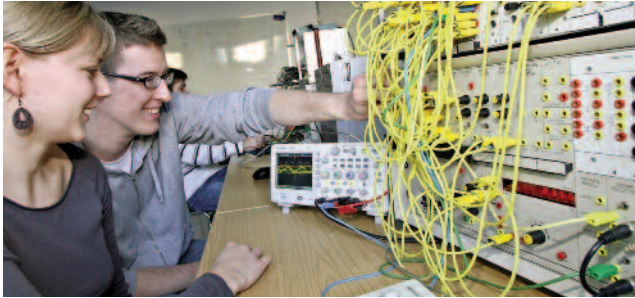


STUDENT PROJECTS - DSP & CIRCUITS

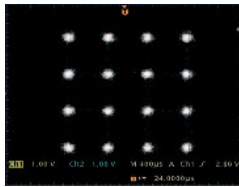
# EMONA INSTRUMENTS

[www.emona-tims.com](http://www.emona-tims.com)

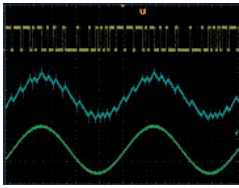
TIMS is laboratory teaching hardware for Wireless, Digital Communications, SDR, Fiber Optics, Signals & Systems and Student Projects.



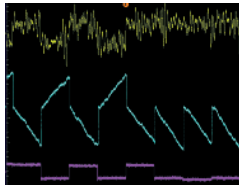
Eye Patterns



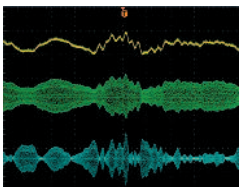
16-QAM



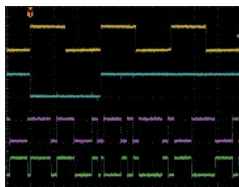
Delta Modulation



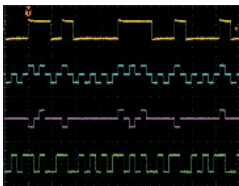
Integrate & Dump



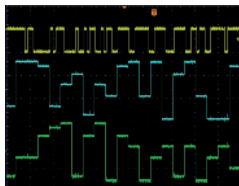
Speech AM & DSB



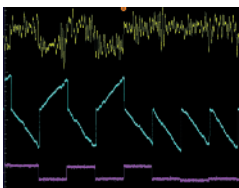
DSSS



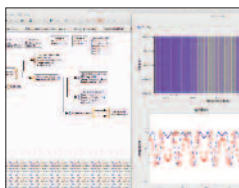
Line Code Encodes



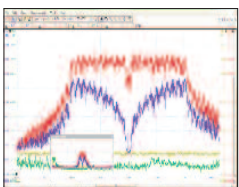
Multi-Level I & Q



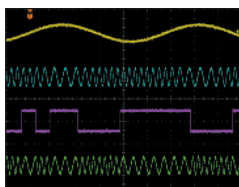
Matched Filter



SDR - GNURadio



OFDM



FM and PM

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

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.

- OPEN ENDED & EASILY EXPANDABLE
- ALL-IN-ONE COMPLETE SYSTEM
- IN-BUILT PC-INTERFACE INSTRUMENTATION
- IDEAL FOR STUDENT CAPSTONE PROJECTS

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

# COMMUNICATIONS SYSTEMS THEORY

## TIMS is a True Hardware Math Modeling System

... with Easily Expandable Experiments

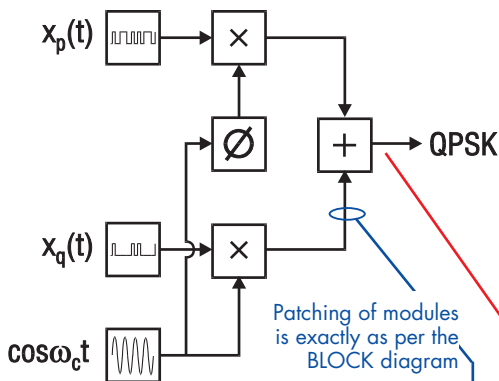
### START WITH MATH OR THEORY

$$x_p(t) \cdot \cos \omega_c t + x_q(t) \cdot \sin \omega_c t = \text{QPSK}$$

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

Telecommunications text books are a source of equations and theories.

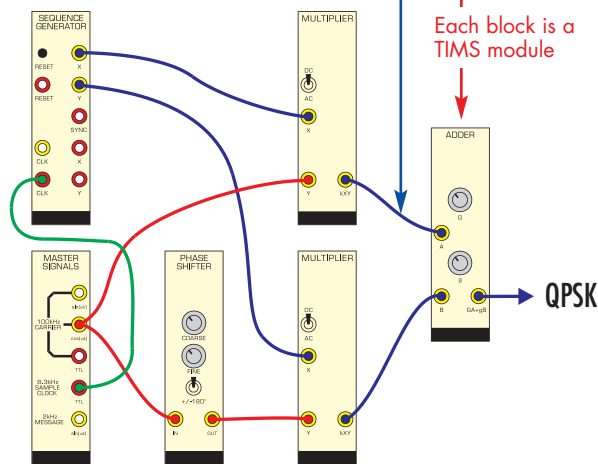
### REPRESENT IT AS A BLOCK DIAGRAM



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

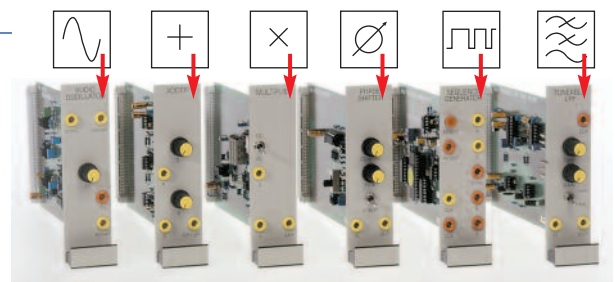
Telecommunications engineers make sense of math and theory through BLOCK DIAGRAMS.

### STUDENTS BUILD IT USING MODULES



Students follow the BLOCK DIAGRAMS to build experiments to view and measure REAL TIME SIGNALS.

### ONE MODULE FOR EACH BLOCK



70+ BLOCKS TO CHOOSE FROM

*Students build each experiment, step-by-step*

# Fully documented, turn-key solutions for your lab

## • USER MANUALS

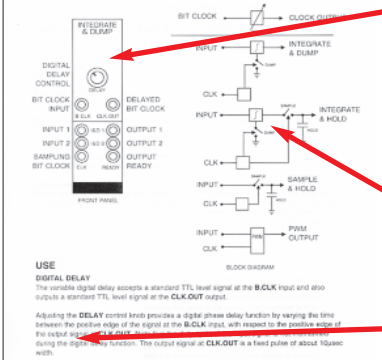
All module capabilities and specifications are outlined in the TIMS User Manuals. Module descriptions are presented in a common format making it very easy for students to quickly grasp the use of any module.

**INTEGRATE & DUMP** ← **Module name**

Two independent functional blocks are provided. The first block is a variable digital delay for TTL level clock signals, and may be used for aligning the phase of a bit clock to a data stream. The second block includes dual channel sampling, integrate & dump and holding functions which can be switched in three combinations.

Sample & Hold, Integrate & Dump, Integrate & Hold

A fourth, switch selectable function is only available on channel 1. Pulse Width Modulation which can be used in PWM, and along with other TIMS modules, in PWM applications.



← **Concise description of module's function**

← **Labelled front panel illustration**

← **Labelled block diagrams**

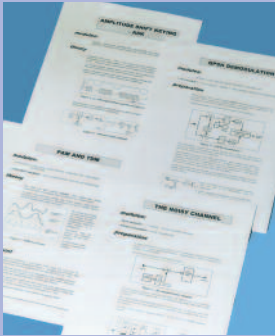
← **Detailed user information**

**USE**

**DIGITAL DELAY**  
The variable digital delay accepts a standard TTL level signal at the BIT CLK input and also outputs a standard TTL level signal at the CLK OUT output.

Adjusting the DELAY control knob provides a digital phase delay function by varying the time between the positive edge of the signal at the BIT CLK input with respect to the positive edge of the output signal at the CLK OUT output. The output signal at CLK OUT is a fixed pulse of about 10µsec width.

## • 2-PAGE QUICK START "LABSHEET EXPERIMENTS"



TIMS LabSheet Experiments are 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 professors.

**CONVOLUTIONAL CODING**

**ACHIEVEMENTS:** setting up and testing of a convolutional encoder and decoder pair. Inclusion, test or setup, functional connection system, observation and measurement of changes to BPSK.

**PREREQUISITES:** completion of the experiment entitled BER measurement in the only channel in this Volume.

**ADVANCED MODULES:** CONVOLUTIONAL ENCODER, JMS20150-08 8-bit convolutional encoder; JMS20150-09 16-bit convolutional encoder; CONVOLUTIONAL ENCODER, LINE-CODE ENCODER, JMS20150-04 8-bit convolutional encoder; CONVOLUTIONAL ENCODER, LINE-CODE ENCODER, JMS20150-05 16-bit convolutional encoder; CONVOLUTIONAL ENCODER, LINE-CODE ENCODER, JMS20150-06 8-bit convolutional encoder; CONVOLUTIONAL ENCODER, LINE-CODE ENCODER, JMS20150-07 16-bit convolutional encoder; CONVOLUTIONAL ENCODER, LINE-CODE ENCODER, JMS20150-08 8-bit convolutional encoder; CONVOLUTIONAL ENCODER, LINE-CODE ENCODER, JMS20150-09 16-bit convolutional encoder.

**PREPARATION**

The experiment is divided into two parts - A and B.

Part A involves the CONVOLUTIONAL ENCODER module and a pair of modules which together perform the decoding. These modules are connected in relative isolation.

Part B places these into a communication system, where their contribution is to reduce the error rate caused by the noise, bandwidth and delay.

**convolutional encoding**

It is assumed you have had some introduction to the concept of coding in general and of convolutional coding in particular. Suffice to say, for this experiment, that it is used to take one of the binary digits and use it to generate several bits, although it is not, of course, used to generate the entire message.

The idea of the experiment is to show that:

- the form of convolutional coding implemented is such that extra bits are added to a word to make a message (data stream)
- also encoding the message into a series of bits that are spaced in time

**EXPERIMENT - PART A**

In Part A of this experiment, the encoder and decoder of Part A will become part of a transmission system operating from the 4.000 kHz clock of the MASTER SIGNALS module.

Part of this system is the LINE-CODE ENCODER module, which produces a clock at one-quarter of its rate, namely 2.000 kHz.

The convolutional coding scheme to be implemented requires four data bits at half this rate, i.e. in this experiment a 1-bit data clock, or the message, provided by a SEQUENCE GENERATOR.

Detailed information about this system available to be assembled is the CONVOLUTIONAL ENCODER, the TRANSDUCER, and the 1970S/1910S/08 may be found in the Appendix Section 1.0. There are also several on-board settings to be made, but it is assumed that you will have been advised by your Laboratory Manager to make these.

**encoding**

A model of the encoding section of the block diagram of Figure 2 is shown in Figure 3 below.

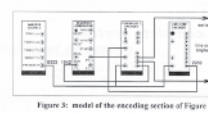


Figure 3: model of the encoding section of Figure 1

To verify this set-up the following steps are recommended:

T1 set the SEQUENCE GENERATOR for a short sequence (both outputs of the one-bit message output should be 0's)

T2 push up as shown in Figure 2.

T3 check that the clock and synchronization signals are present, and set the Proprietary module as shown in Figure 2.

The LINE-CODE ENCODER is being switched for the purpose of the coding to be implemented. There is no need, then, to make the data input '1'.

## • 14 VOLUMES OF DETAILED "STUDENT TEXT" EXPERIMENTS



The fourteen volumes, across more than 4,500 pages, of TIMS Student Text Experiments, providing an in-depth coverage of a broad range of communications theory, wireless, fiber optics and software defined radio experiments.

**BPSK**

**modules**

basic modules: QUADRATURE UTILITY, SEQUENCE GENERATOR, TUNABLE LPF

advanced modules: DECISION MAKER, LINE-CODE DECODER, LINE-CODE ENCODER

optional basic: PHASE AND 180°

optional advanced: 16MHz CHANNEL FILTERS

**preparation**

This Lab Sheet involves the generation of a binary phase shift modulated carrier, transmission via a bandwidth channel, followed by demodulation and 'bitting up' of the received waveform by a DECISION MAKER.

This experiment is complete in itself, and will serve to reproduce the related Lab Sheet entitled BPSK and QPSK.

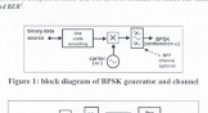


Figure 1: block diagram of BPSK generator and channel

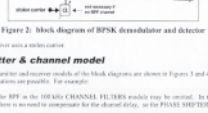


Figure 2: block diagram of BPSK receiver and detector

The receiver uses a delay circuit.

**transmitter & channel model**

The transmitter and receiver models of the block diagrams are shown in Figures 1 and 2. Some simplifications are made. For example:

- the BPF in the 16MHz CHANNEL FILTERS module may be omitted. In this case there is no need to compensate for the channel delay, so the PHASE SHIFTER may be set to 0°.

**receiver model**

Before starting module:

- set the on-board SWP to LP (short experiment on each SEQUENCE GENERATOR)
- set the on-board mode SW of the DECISION MAKER to NZL-L (or NZL-CP or 191°)

Then push up the receiver

Note both carrier and bit clock are visible from the receiver<sup>1</sup>. Set the carrier bandwidth (centered on the 10.000 MHz LPF) and modulation gain. Adjust the PHASE SHIFTER for maximum signal at the DECISION MAKER. Check the gain at 100 or 20 gain, using a 40MHz BANDPASS filter. Observe the eye pattern at this point to help you to get a good idea of the modulation level at the bit clock, and adjust the decision gain of the receiver.

Verify the receiver of the LINE-CODE DECODER setup. In its inverted<sup>2</sup> 180° polarity can be corrected by a 180° change of the carrier phase by the rotation of the PHASE SHIFTER on a unity gain, to correct any part of the signal path.

Observe a spectrum of the carrier phase by the rotation of the PHASE SHIFTER and compare the results to the carrier frequency (10MHz) and note when the carrier bandwidth has peaked the decision gain. You may have chosen differently using the 'carrier display'.

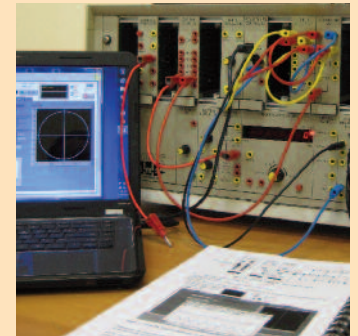
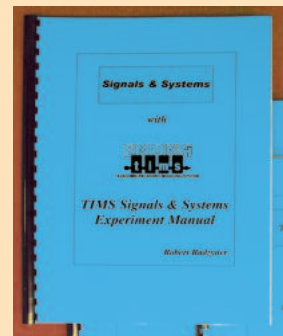
Check your preferred display (scope or spectrum) and adjust the receiver bandwidth and carrier gain to match the carrier bandwidth for maximum signal. Check the decision circuit performance under these conditions. A number of threshold settings will maximize the performance of the receiver under these conditions. Note the results of the receiver decision gain. How do you think you will compare with theoretical expectations?

Change from the NZL-L mode to NZL-CP and note how the carrier spectrum is affected by the carrier phase. The carrier phase is adjusted to the carrier frequency by the rotation of the PHASE SHIFTER. Note the effect of the carrier phase on the carrier frequency.

<sup>1</sup> BPSK carrier and bit clock

<sup>2</sup> Inverted through the PHASE SHIFTER which is connected to the receiver.

## • SIGNALS & SYSTEMS V2 EXPERIMENTS MANUAL



The TIMS Signals & Systems Experiments Manual makes it possible for students to experience at first hand the interaction between the theory and mathematics of the signals and systems textbook with the real world of hardware and of signals in wires and waves.

# Select experiments to suit your curriculum

## TIMS DOCUMENTED EXPERIMENTS:

- Adaptive Delta Modulation
- AM - Amplitude Modulation
- Amplifier Overload
- Armstrong's Phase Modulator
- ASK - Modulation & Demodulation
- Baseline Wander and Line Coding
- BER Instrumentation & measurement
- NEW**  **Binary signal detection in Gaussian noise**
- Bit Clock Regeneration
- Block Coding and Decoding
- Block Coding Gain
- Block Coding - error correcting
- NEW**   **$\pi/2$ -BPSK used in 5G mobile**
- BPSK - Introduction
- BPSK and BER
- Broadcasting - AM and FM
- Carrier Acquisition - PLL
- CDMA - 2 Channel
- CDMA - Introduction
- CDMA - Multichannel
- CDMA - Processing Gain
- CDMA at Carrier Frequencies
- Complex Analog Messages
- Convolutional Coding
- Costas Loop
- Delta Demodulation
- Delta Modulation
- Delta-sigma Modulation
- Digital Signal Recovery
- Digital Noise in Baseband & Block Coded Channels
- DPSK and BER
- DPSK and Carrier Acquisition
- DSP Intro and Applications
- DSBSC - Generation & Demodulation
- DSSS - Spread Spectrum
- Envelopes and Envelope Detection
- Equalization for ISI
- Eye Patterns & BER
- Fading, Multi-path Channel
- FDM - Frequency Division Multiplex
- FHSS: Fast & Slow Hopping
- FHSS and Bit Error Rate Performance
- FHSS: Hybrid DSSS/FHSS System
- Fiber Optic Transmission, Splitting and Combining
- Fiber Optic - Bidirectional Transmission
- Fiber Optic - WDM Transmission
- FM - Demodulation by PLL
- FM - Demodulation by Zero Crossing Counting
- FM - Deviation Multiplication
- FM, Wideband - Generation by VCO
- FM - Synchronous Demodulation
- FM and Bessel Zeros
- Frequency Synthesis with the PLL
- FSK - Generation & Envelope Demodulation
- NEW**  **BFSK - coherent signalling & BER**
- NEW**  **BFSK - non-coherent signalling & BER**
- GFSK - Gaussian FSK
- NEW**  **IoT - ASK+DSSS Physical Layer**
- NEW**  **IoT - Chirp Spread Spectrum Application**
- NEW**  **IoT - Ultra Wide Band Application**
- ISB - Independent Sideband
- ISI: PAM & ASK in band-limited ch.
- Line-Coding & Decoding
- Matched Filter Detection
- MSK, OQPSK,  $\pi/4$ -QPSK,  $\pi/4$ -DQPSK
- Modeling Equations
- Modem: Binary Data via Voiceband
- Modem: Multi-Level Data via Voiceband
- Modem: Data Rates & Voiceband Modems
- Multi-channel Digital Fiber Link
- Multi-level QAM & PSK
- NEW**  **Multi-path - Time-invariant fading channel characteristics**
- NEW**  **Multi-path - ISI rejection in DS SS**
- Noisy Channel
- Noise Generation - Binary Sequences
- OFDM Principles - Introduction
- NEW**  **OFDM, Cyclic Prefix & PAPR**
- NEW**  **OFDM & Channel Equalisation with BER Measurement**
- NEW**  **OFDM in band limited, multipath, time-invariant channel with BER measurements**
- NEW**  **OFDM - IDFT, Complex Exponent & Complex Quad Signals**
- PAM & TDM
- Parseval's Theorem: Harmonic & Non-harmonic Signals
- PCM & Bit Clock Regeneration
- PCM Encoding & Decoding
- PCM TDM
- PCM-TDM 'T1' Implementation
- PDM - Phase Division Multiplex
- PLL - Phase Lock Loop
- Power Measurements
- PPM - Pulse Position Modulation
- PRBS Messages & Sequence Synchronization
- Product Demodulation
- Pulse Shaping - Introduction
- Pulse shaping for band-limited channels
- PWM - Pulse Width Modulation
- Random Variables & AWGN
- NEW**  **Radar signals:**
- Constant-frequency pulse**
- Linear-frequency modulated pulse**
- Coherent train of LFM pulses**
- Phase-coded pulse**
- Coherent train of identical Unmodulated pulses**
- Stepped-frequency pulse**
- NEW**  **16-QAM - as used in 4G and 5G LTE**
- NEW**  **16-QAM - LTE BER measurement**
- QAM - Generation & Demodulation
- QAM and 4-PSK
- QASK - Modulation & Demodulation
- QPSK - Modulation & Demodulation
- NEW**  **QPSK - BER of Coherent QPSK in distortionless channel**
- Sampling & Reconstruction
- Sampling with Sample-&Hold
- Signal Analysis: relationship between time and frequency domains
- NEW**  **SDR - Intro to GNURadio**
- NEW**  **SDR - Exploring sampling & resampling**
- NEW**  **SDR - Software Defined Radio in TX**
- NEW**  **SDR - Software Defined Radio in RX**
- Signal Constellations 4/8/16QAM and 4/8/16PSK
- SNR in AM Demodulated Signals
- SNR performance of SSB and DSBSC
- SONET - TDM and Byte Interleave Mux
- SONET Data Frame
- SONET transmission via an optical link
- Spread Spectrum Principles
- Spread Spectrum: Direct Sequence, Frequency Hop, Time Hop Hybrid FH-DS, FH-CDMA,
- Speech in Telecommunications
- SSB Generation and Demodulation
- SSB Linear Amplifier Measurements
- Superheterodyne
- System fault finding
- TCM - Coding Gain
- TCM - Trellis Coding
- TDM
- Timing jitter in Band Limited Channels
- NEW**  **Turbo coding**
- UWB - Pulse Shapes & Spectra
- UWB - with BER
- UWB - Multiband Modulation
- UWB - Multiple Access Orthogonal Pulse Modulation with MHP
- UWB - OOK, PPM, BPM & OPM
- Wave Analyzer - Spectrum Analysis
- Weaver's SSB Mod and Demodulator

## SIGNALS & SYSTEMS EXPERIMENTS MANUALS:

- Special Signals - characteristics and applications
- Modeling Linear and Non-linear Systems
- Unraveling Convolution
- Integration, correlation & matched filters
- Exploring complex numbers and exponentials
- Comparing Responses in the Time and Frequency Domains
- A Fourier Series Analyzer
- Spectrum Analysis of Various Signals
- Poles and Zeros in the Laplace Domain
- Sampling and Aliasing
- Analog-Digital Conversion
- Discrete-Time Filters - Finite Impulse Response
- Poles and Zeros in the z plane: Discrete-time Filters
- Discrete-time Filters - Practical

## STUDENT PROJECT CAPABILITIES:

- Building electronic circuits with the **TIMS-820 Wire-wrapping Project Module**
- Solderless breadboarding of electronic circuits with the **TIMS-840 Experimenter**
- Programming DSP implementations with the **TIMS-DSP-6713 Module**

## 4 System Unit Options

**4-channel Multi-instrument PC-Instrument System, 2-channel PC-Instrument System, the original Standard System, and a Compact System**

### TIMS-304C - PC-ENHANCED System Unit



**MODEL TIMS-304C 4 Channel PC-ENHANCED includes:**

- 4 Channel PC-based virtual instrument oscilloscope spectrum analyzer displays, frequency counter true RMS voltmeter
- Function and Arbitrary Waveform Generator
- 12 Slots for PLUG-IN MODULES
- Frequency and Event Counter
- 8 Standard Fixed Modules
- System Power Supply
- 5 Channel TIMS Trunks Lab Network Option

### TIMS-301C - PC-ENABLED System Unit



**MODEL TIMS-301C 2 Channel PC-ENABLED includes:**

- 2-channel PC-based virtual instrument oscilloscope spectrum analyzer displays, frequency counter true RMS voltmeter
- 12 Slots for PLUG-IN MODULES
- Frequency and Event Counter
- 7 Standard Fixed Modules
- System Power Supply
- 3 Channel TIMS Trunks Lab Network Option

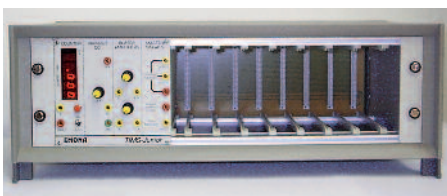
### TIMS-301 - STANDARD System Unit



**MODEL TIMS-301 Standard System includes:**

- 2-channel switched BNC-4mm scope selector for connection to external oscilloscope
- 12 Slots for PLUG-IN MODULES
- Frequency and Event Counter
- 7 Standard Fixed Modules
- System Power Supply
- 3 Channel TIMS Trunks Lab Network Option

### TIMS-801 JUNIOR - Compact System Unit



**MODEL TIMS-801 Junior System includes:**

- 8 Slots for PLUG-IN MODULES
- 5 digit Frequency and Event Counter
- 4 Standard Fixed Modules
- System Power Supply

## TIMS-300-SERIES and the BASIC Module Set

Complete TIMS-300-Series BASIC Kit



### The TIMS-300-Series BASIC KIT includes:

- A TIMS-304C / 301C / 301 or 801 System Unit

PLUS

- TIMS BASIC Module Set
- Basic and Advanced modules **User Manuals**;
- Detailed **Student Text** experiment manuals;
- Short-cut **LabSheet** experiment manuals;
- Perspex Modules Storage Box
- Standard accessories

### TIMS BASIC Module Set (PLUG-IN modules)

- TIMS-147 **Adder**
- TIMS-148 **Audio Oscillator**
- TIMS-149 **Dual Analog Switch**
- TIMS-150 **Multiplier**
- TIMS-151 **Phase Shifter**
- TIMS-152 **Quadrature Phase Splitter**
- TIMS-153 **Pseudorandom Sequence Generator**
- TIMS-154 **Tuneable Low Pass Filter**
- TIMS-155 **Twin Pulse Generator**
- TIMS-156 **Utilities**
- TIMS-157 **Voltage Controlled Oscillator**
- TIMS-158 **60kHz Low Pass Filter**
- TIMS-425 **Quadrature Utilities**

### TIMS-300-SERIES SIMULATION OPTION

#### TutorTIMS PreLab Simulation Software

A modern graphical, easy to use software simulator to help students prepare at home. Available as **TutorTIMS-BASIC** for "BASIC SYSTEM" experiments.

### TIMS "BASIC SYSTEM" EXPERIMENTS:

- |                               |                                 |                              |
|-------------------------------|---------------------------------|------------------------------|
| • Introduction to TIMS        | • Armstrong's Phase modulator   | reconstruction               |
| • Modeling of math equations  | • PAM generation                | • QAM generation or demod    |
| • AM modulation (2 methods)   | • TDM generation                | • BPSK mod and demodulation  |
| • Envelopes/envelope recovery | • FDM generation or recovery    | • QPSK mod or demodulation   |
| • DSBSC mod and demod         | • PDM generation or recovery    | • ASK mod and demodulation   |
| • SSB mod - phasing method    | • PWM mod and recovery          | • QASK mod or demodulation   |
| • SSB demod - phasing method  | • Eye diagrams                  | • FSK modulation (2 methods) |
| • Product demodulation        | • Introduction to Pulse shaping | • Carrier acquisition - PLL  |
| • Phase lock loop             | • Noise generation              | • Complex analog messages    |
| • FM modulation & demod       | • Sampling Theorem and          | • Spread spectrum generation |

## ADVANCED building blocks to enhance experiment capabilities now and into the future

A broad and growing range of additional TIMS Modules used for implementing any modulation or coding scheme.

TIMS ADVANCED modules include over 70 specialised building blocks to expand the range of analog, digital, digital signal processing (DSP) and SDR experiments.

New ADVANCED modules are continuously being developed to include the latest in telecommunications and signal processing theory.



### Advanced Modules Alphabetical List

- TIMS-410 **100kHz Channel Filters**
- TIMS-401 **Baseband Channel Filters**
- TIMS-420 **Bit Clock Regeneration**
- TIMS-414 **Block Code Encoder**
- TIMS-415 **Block Code Decoder**
- NEW** TIMS-447 **Carrier Acquisition PLL/Costas**
- TIMS-427 **CDMA Encoder (Multi-Sequences Source)**
- TIMS-428 **CDMA Decoder**
- TIMS-840 **Circuit Experimenter**
- TIMS-416 **Convolutional Code Encoder**
- TIMS-417 **Convolutional Decoder Firmware**
- TIMS-402 **Decision-Maker Module**
- TIMS-403 **Delta Modulation Utilities**
- TIMS-404 **Delta Demodulation Utilities**
- TIMS-435 **Digital Channel Error Generator**
- TIMS-424 **Digital Utilities**
- TIMS-DSP-6713 **Floating Point DSP Development Module**
- TIMS-405 **Error Counting Utilities**
- TIMS-240 **Expansion Rack**
- TIMS-210 **Extender Card**
- TIMS-505 **Fiber Optic Coupler**
- TIMS-503R **Fibre Optics Transmitter (red)**
- TIMS-503G **Fibre Optics Transmitter (green)**
- TIMS-504 **Fibre Optics Receiver**
- TIMS-506 **Fiber Optic WDM Filters**
- TIMS-421 **FM Utilities**
- TIMS-434 **Frequency Hop Spread Spectrum**
- TIMS-418 **Integrate & Dump, Sample & Hold**
- TIMS-436 **Laplace**
- NEW** TIMS-442 **Laplace V2 (used with TIMS-445)**
- TIMS-406 **Line-Code Encoder**
- TIMS-407 **Line-Code Decoder**
- TIMS-422 **M-Level Encoder**
- TIMS-423 **M-Level Decoder**
- TIMS-438 **MSK, $\pi$ /4-DQPSK,OQPSK Encoder (& RRC)**
- TIMS-439 **MSK, $\pi$ /4-DQPSK,OQPSK Decoder**
- NEW** TIMS-446 **Multi-Path Channel Module**
- TIMS-408 **Noise Generator**
- NEW** TIMS-449 **OFDM for DSP-6713 Module**
- NEW** TIMS-445 **PC Modules Controller**
- TIMS-412 **PCM Encoder**
- TIMS-413 **PCM Decoder**
- TIMS-250 **Perspex Module Storage Box**
- TIMS-830 **Programmable CPLD Project Module**
- TIMS-820 **Project Module (Wire-wrapping)**
- TIMS-425 **Quadrature Utilities**
- TIMS-429 **SONET/SDH STS-1 Multiplexer**
- NEW** TIMS-451 **SDR with GNUradio**
- TIMS-430 **SONET/SDH STS-1 Demultiplexer**
- TIMS-431 **SONET/SDH STS-3 Multiplexer**
- TIMS-432 **SONET/SDH STS-3 Demultiplexer**
- TIMS-433 **SONET/SDH STS-1/3 Clock Regenerator**
- TIMS-411 **Spectrum Utilities**
- NEW** TIMS-448 **SSB Filters for DSP-6713 Module**
- TIMS-426 **Speech Module**
- TIMS-419 **Trellis-Coded Modulation Firmware**
- NEW** TIMS-444 **Triple Adder (requires PC Modules Controller)**
- TIMS-409 **True RMS Voltmeter**
- TIMS-201 **Trunks Driver**
- TIMS-202 **Trunks Receiver and TIMS-BUS**
- TIMS-440 **Tuneable Data Comms Filters (dual lin.phase)**
- NEW** TIMS-450 **Turbo Coding**
- TIMS-441 **Ultra Wideband**
- TIMS-437 **z-Transform**
- NEW** TIMS-443 **z-Transform V2 (used with TIMS-445)**
- TIMS-501/502 **100kHz Tx & 100kHz Rx Antenna Set**



## The most popular expansion option: "EVAL-16 KIT" to add a range of quantitative, SNR, BER & digital modulation experiments

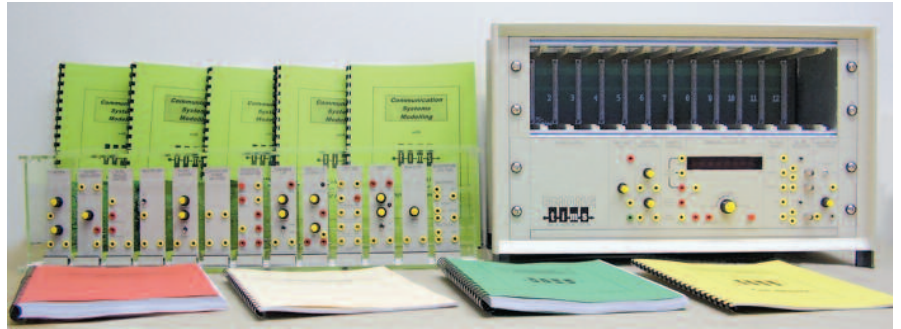
Add another 16 x BASIC and ADVANCED modules to the TIMS-300 BASIC to build a comprehensive and advanced telecommunications laboratory system

### TIMS-300 BASIC KIT

The Basic TIMS-30X/C System which includes -

- TIMS-30X/C System Unit and 13 x BASIC modules

Complete TIMS-300 BASIC KIT



### PLUS

### TIMS EVAL-16 KIT

A kit of 16 additional TIMS modules:

Additional BASIC modules include

- TIMS-153 Sequence Generator
- TIMS-154 Tuneable LPF
- TIMS-157 VCO

Additional ADVANCED modules

- TIMS-402 Decision Maker
- TIMS-405 Error Counting Utilities
- TIMS-406 Line-Code Encoder
- TIMS-407 Line-Code Decoder
- TIMS-408 Noise Generator
- TIMS-409 TRMS Volt Meter
- TIMS-410 100kHz Channel Filters
- TIMS-412 PCM Encoder
- TIMS-413 PCM Decoder
- TIMS-420 Bit Clock Regeneration
- TIMS-422 M-Level Encoder
- TIMS-423 M-Level Decoder
- TIMS-425 Quadrature Utilities



PLUS these 16 BASIC and ADVANCED modules

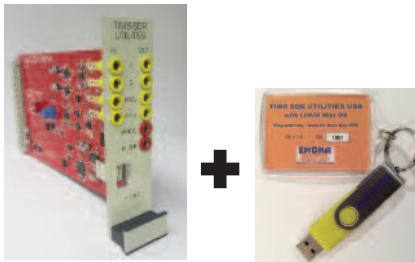
### Additional EVAL-16 KIT EXPERIMENTS documented in the TIMS Experiment Manuals:

- Experiment capabilities include all of the TIMS-300 BASIC Experiments listed on PAGE 7, PLUS the following ADVANCED Experiments:
  - Carrier acquisition - PLL
  - The noisy channel
  - BER instrumentation
  - Bit clock regeneration
  - Signal Constellations - 4/8/16-QAM and 4/8/16-PSK
  - Eye diagrams & BER
  - FM demodulation - PLL
  - Detection with the Decision Maker
  - BER measurement
  - QAM and 4-PSK detailed
  - FSK - envelope demodulation
  - BPSK and BER
  - PRBS Sequence Synchronization
  - Line Coding and Decoding
  - PCM Encoding and Decoding
  - ASK - advanced experiments
  - BPSK - advanced experiments
  - DPSK and BER

## TIMS Software Defined Radio Experiments

With **LINUX** and **GNURadio** pre-installed, run TIMS-SDR in minutes

**NEW**

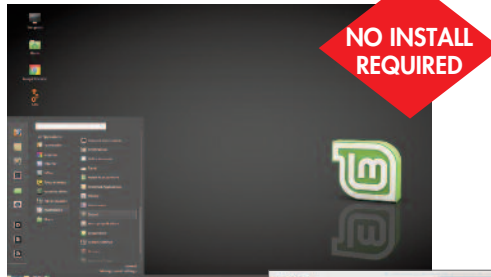


### TIMS-SDR & plug-and-play USB Stick

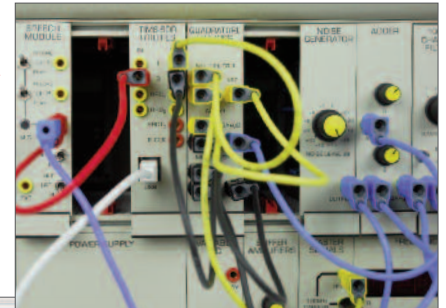
TIMS-SDR Kit is a zero-install, plug-and-play, hardware and software package which enables the student to quickly and easily experiment with the graphical GNU Radio Companion software tools in the TIMS telecommunications platform with real signals.

Requires the TIMS-300 SYSTEM UNIT plus:

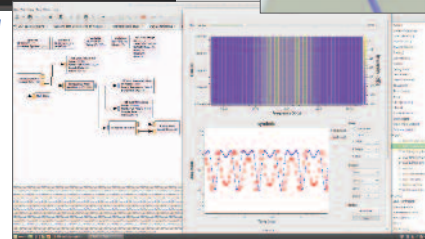
- TIMS-451 **TIMS-SDR Utilities Module** and **TIMS-USB** with **pre-installed LINUX and GNURadio**



LINUX MINT pre-installed



REAL SDR HARDWARE



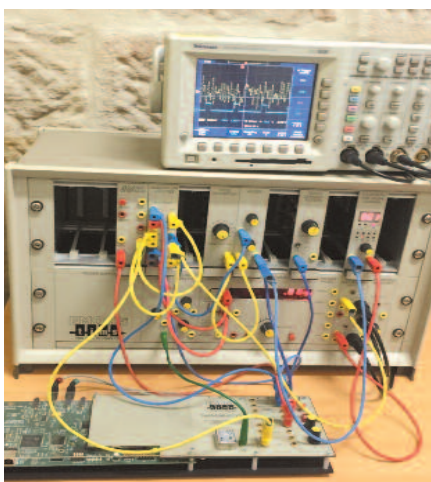
GNURadio pre-installed

### EXPERIMENTS documented in the TIMS Experiment Manuals:

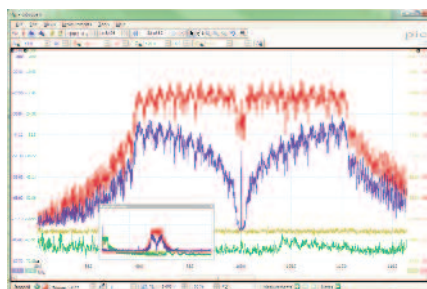
- Familiarization with GNURadio
- Exploring Sampling and Resampling in SDR
- TX with SDR and RX with Hardware: FM applications
- TX with hardware, RX with SDR: QAM applications
- TX and RX with SDR: BPSK, QPSK, MSK, FSK, OFDM, and more

## TIMS OFDM Experiments

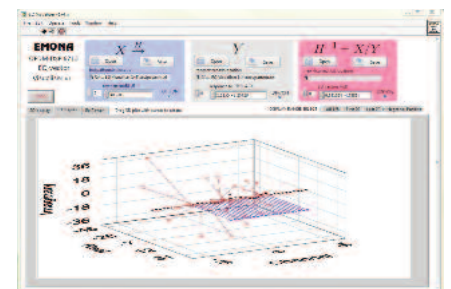
TIMS offers both introductory experiments to demonstrate the principles of OFDM without DSP, as well as a suite of advanced DSP-based experiments



TIMS OFDM requires the TIMS-300 SYSTEM UNIT, a TIMS-DSP-6713 DSP module and a selection of TIMS-400 Series Advanced modules.



TIMS OFDM spectrum at channel input (red) and at output of a multipath channel (blue)



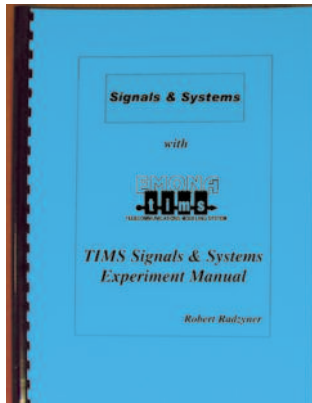
TIMS Visualiser Software, shows students 2D and 3D vector displays of each sub-carrier, at channel input and at receiver.

### EXPERIMENTS documented in the TIMS Experiment Manuals:

- Introduction to OFDM using discrete modules (non-DSP)
- OFDM, Cyclic Prefix & PAPR
- OFDM & Channel Equalisation with BER
- OFDM in band limited, multipath with BER
- Experiments utilizing the **TIMS-DSP-6713 Module**
- IDFT, Complex Exponent & Complex Quadrature Signals

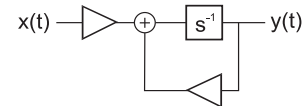
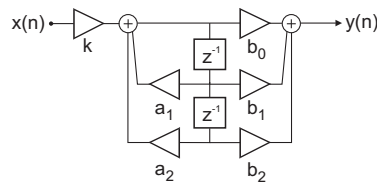
## Signals & Systems OPTION

Real signals - No simulation: no DSP. Hardware experiments to help students relate the complex S&S math to the real-world

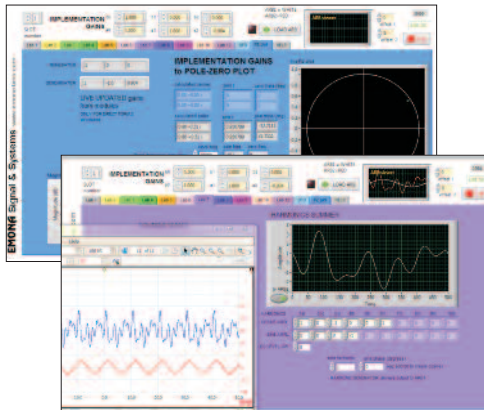


### A COMPLETE COURSE OF EXPERIMENTS

The TIMS Signals & Systems Experiments Manual makes it possible for students to experience at first hand the interaction between the theory and mathematics of the signals and systems textbook with the real world of hardware and of signals in wires and waves.



PLUS

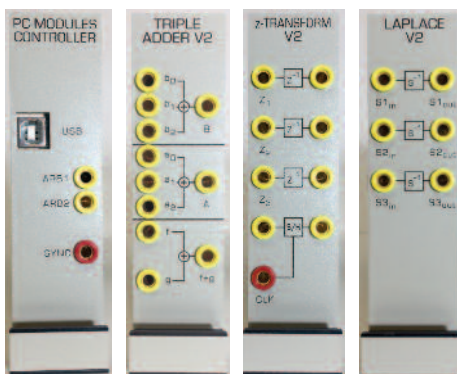


### Experiment Control Software

The TIMS Signals & Systems Experiments Manual includes graphical software with all the control instrumentation and data presentation tools required.

- Immediate, on-screen control of ADDER gains (coefficients) and arbitrary waveform GENERATOR.
- Interactive digital filter design tools with z-plane presentation of poles & zeros.
- In-built instrumentation display with time domain, frequency domain & tables.

PLUS



### Signals & Systems Hardware

The TIMS Signals & Systems Module Set includes four fundamental modules:

- **TIMS-445 PC-Modules Controller**  
USB interface to control coefficient plus 2 channel Arb waveform generator.
- **TIMS-444 Triple Adder**  
Three independent, software controlled summing junctions.
- **TIMS-443 z-Transform-V2**  
For implementing IIR or FIR discrete time structures.
- **TIMS-442 Laplace-V2**  
For implementing continuous-time structures.

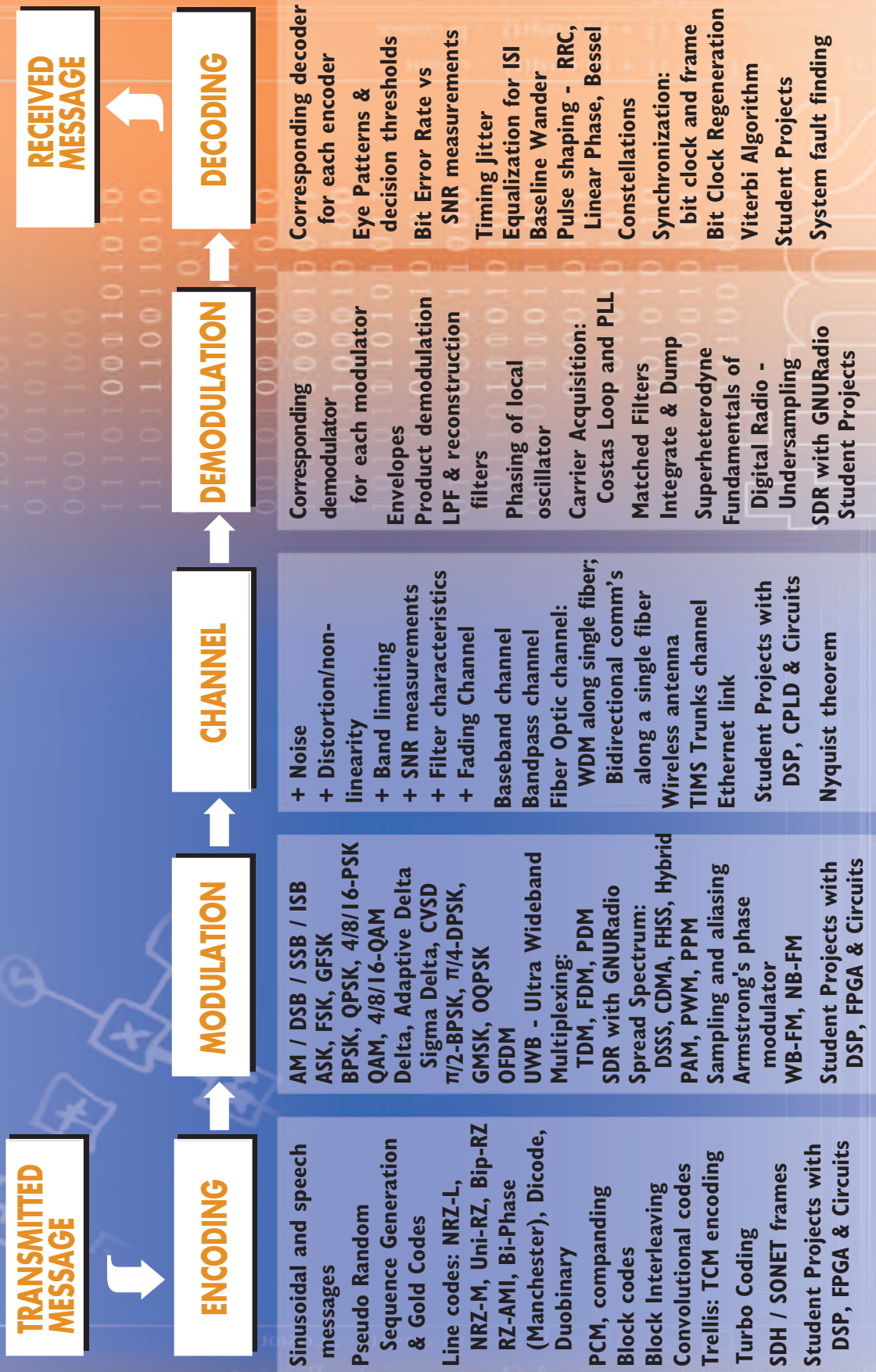
### EXPERIMENTS documented in the TIMS Signals & Systems Experiment Manual:

Lab 1: Intro to the Signals & Systems V2 module set  
 Lab 2: Special signals - characteristics & applications  
 Lab 3: Systems: Linear and non-linear systems  
 Lab 4: Unraveling convolution  
 Lab 5: Integration, correlation & matched filters  
 Lab 6: Exploring complex numbers and exponentials  
 Lab 7: Build a Fourier series analyzer

Lab 8: Spectrum analysis of various signal types  
 Lab 9: Poles and zeros in the Laplace domain  
 Lab 10: Sampling and aliasing  
 Lab 11: Getting started with analog-digital conversion  
 Lab 12: Discrete-time structures: FIR  
 Lab 13: Poles and zeros in the z plane with IIR systems

# TIMS EXPERIMENTS AND THE TRANSMISSION MODEL

*TIMS experiment capabilities*



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