

tims

**Telecommunications
Signals & Systems
Lab Equipment**

**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 . . .**



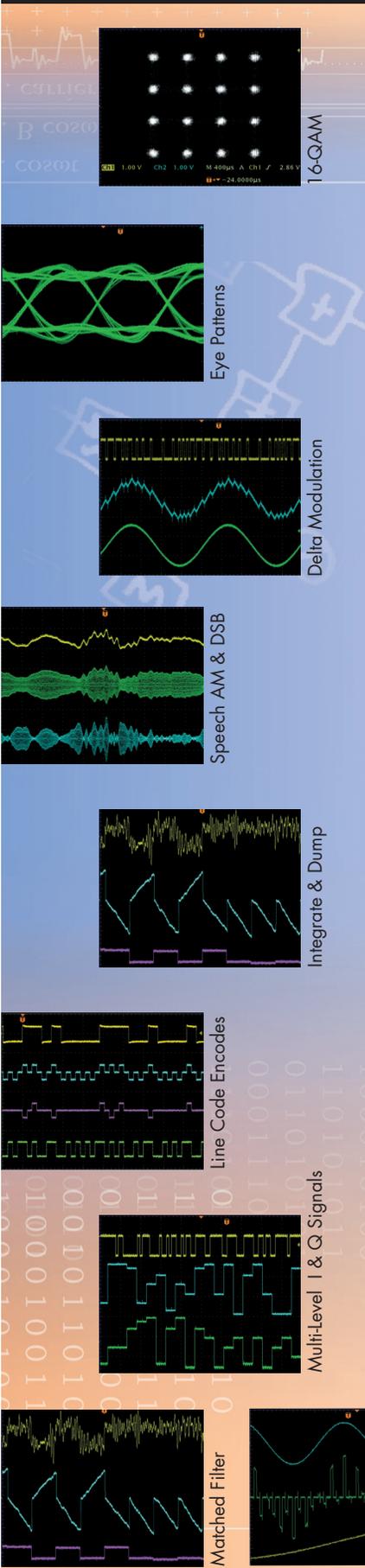
University Level Experiments in

- **Wireless Communications**
- **SDR running GNURadio** **NEW**
- **Signals & Systems & DSP**
- **Fiber Optics**
- **Student Projects**

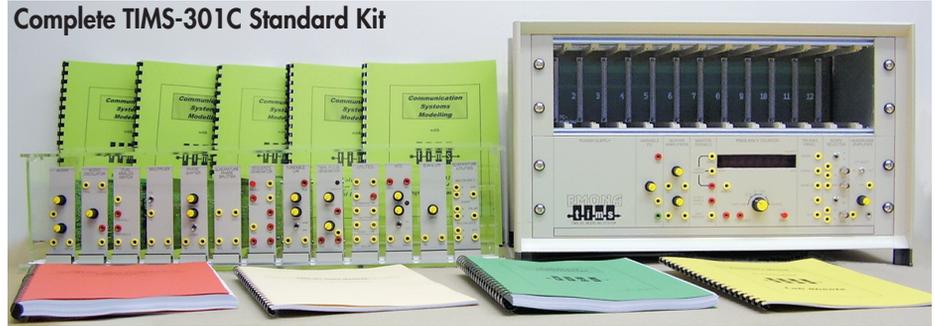
EMONA INSTRUMENTS

www.emona-tims.com

ACTUAL TIMS WAVEFORMS



TIMS is laboratory teaching hardware for courses in - Wireless, Digital Communications, SDR, Fiber Optics and Signals & Systems.



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 & EXPANDABLE ARCHITECTURE**

As TIMS is an open-ended architecture system, TIMS can implement from the most basic communications systems theory, through to the very latest in coding and modulation.

- **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 CAPSTONE PROJECTS**

TIMS is the ideal system to allow students to conveniently develop, build 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.

COMMUNICATIONS SYSTEMS THEORY

TIMS is a True Hardware Math Modeling System almost infinitely expandable

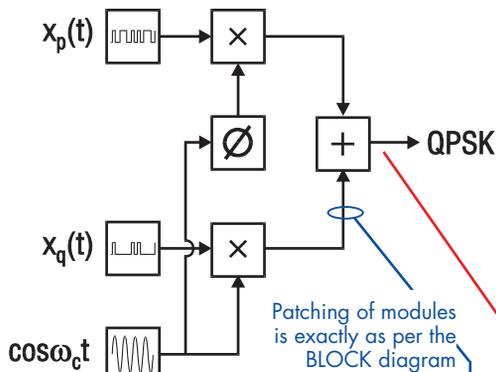
START WITH MATH OR THEORY

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

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

Telecommunications text books are a source of equations and theories.

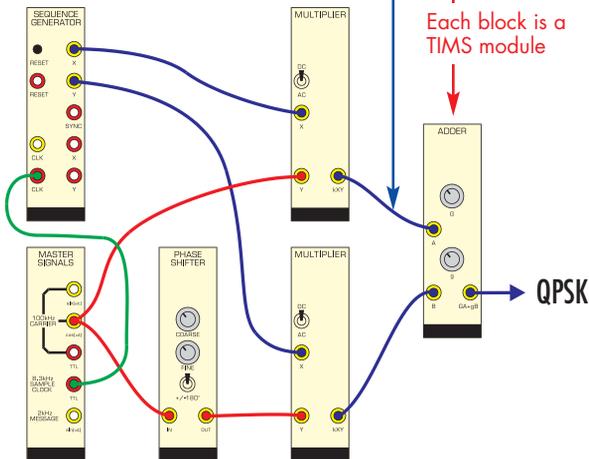
REPRESENT IT AS A BLOCK DIAGRAM



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

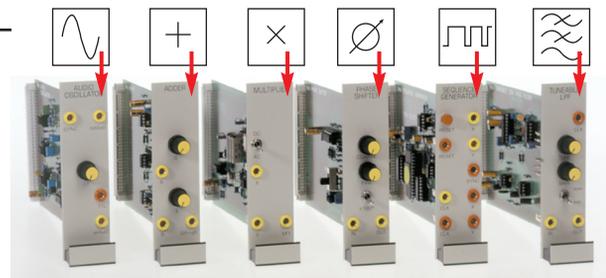
Telecommunications engineers make sense of math and theory through BLOCK DIAGRAMS.

STUDENTS BUILD IT USING MODULES



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

ONE MODULE FOR EACH BLOCK



70+ MODULES TO CHOOSE FROM

STUDENTS PATCH OUTPUTS TO INPUTS TO BUILD THE MODULATION SCHEME and HAND ADJUST EACH PARAMETER: gain, phase, frequency, coupling, alignment, synchronization....

Students build each experiment, step-by-step



TIMS PRODUCT RANGE

The TIMS block-diagram approach is implemented in TIMS hardware, software & via the internet hardware.

1. Emona TIMS-301, 301C & 304C Lab Hardware TIMS-300 Hands-on, communications theory experiments

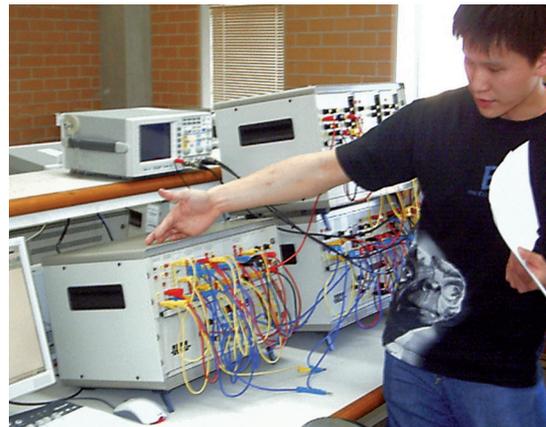
The TIMS-300 System is a true, real-time, hardware mathematical modeling system.

TIMS 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 realises a fundamental communications/signals building block and these **blocks are used and re-used in different experiments**.

No single TIMS module is a complete experiment.

TIMS modules include a wide variety of analog, digital and DSP building block functions.



2. TutorTIMS-R2 - PreLab Simulation Software

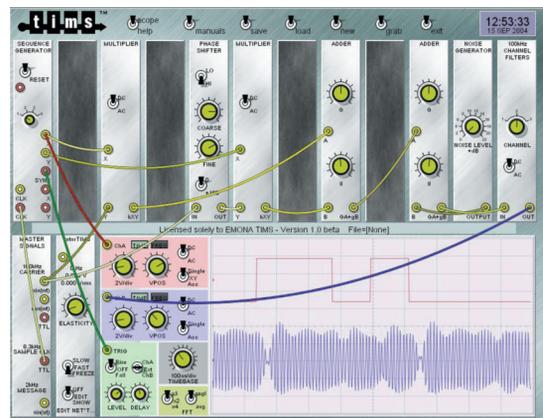
TIMS Simulator for pre-lab learning with Signals & Systems Experiments

TutorTIMS-R2 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.

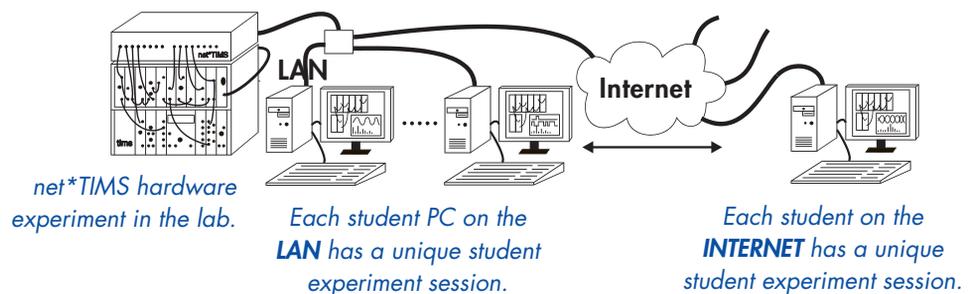
TutorTIMS-R2 is ideal for helping students **prepare at home** before attending hands-on labs at college.



3. net*TIMS - Simultaneous, multi-user lab-in a box

Simultaneously serves 30+ students, each running their own experiment

net*TIMS allows professors to set-up **real TIMS telecommunications experiments** in their own laboratory. Many students can **simultaneously access** and control from within the lab or from any location (from campus or from home) to carry out these hardware experiments.





TIMS IMPLEMENTS ALL OF THIS AND MORE

Select your curriculum from the experiment list below.

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**

NOTE: This list is constantly expanding as new modules are released and new experiments are written.



TIMS USER & EXPERIMENT MANUALS

Fully documented, turn-key solutions for your lab.

The experiment manuals supplied with TIMS provide a rich source of teaching resources, from introductory to advanced laboratory coursework.

• 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

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 PPM applications.

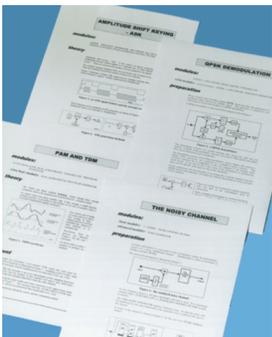
USE

DIGITAL DELAY
The variable digital delay accepts a standard TTL level signal at the **B-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 edges of the signal at the **B-CLK** input and the positive edges of the signal at the **CLK-OUT** output. The output signal at **CLK-OUT** is a fixed pulse of 10µsec width.

- Module name
- Concise description of module's function
- Labelled front panel illustration
- Labelled block diagrams
- Detailed user information

• 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.

BPSK

modules
basic modules: QUADRATURE UTILITIES, SEQUENCE GENERATOR, TUNEABLE LPF
advanced modules: DECISION MAKER, LINE-CODE DECODER, LINE-CODE ENCODER
optional basic: PHASE SHIFTER
optional advanced: 100 kHz CHANNEL FILTERS

preparation

This Lab Sheet involves the generation of a binary phase shift modulated carrier¹, transmission via a bandwidth channel, followed by demodulation and "cleaning up" of the recovered waveform by a DECISION MAKER.

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

Figure 1: block diagram of BPSK generator and channel

Figure 2: block diagram of BPSK demodulator and detector

The transmitter and receiver modules of the block diagrams are shown in Figures 3 and 4. Some simplification is possible. For example:

- the BPF in the 100 kHz 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;

¹ BPSK - binary phase shift keying
² BPSK - differential binary phase shift keying, which is insensitive to polarity changes

Lab Sheet

transmitter model

No adjustments are necessary. With a short sequence and the multimeter supported by the SEQUENCE GENERATOR SYNC output, confirm transmitter performance by comparing the appropriate waveforms.

receiver model

Some both carrier and bit clock are visible from the transmitter¹. Set the receiver bandwidth measurement of the TUNEABLE LPF and measure gain. Adjust the PHASE SHIFTER the maximum signal of the detector stage, then re-adjust the gain to set the 2V peak from receiver terminal level. Observe the eye pattern at eye point (1V signal) by comparing the multimeter to the bit clock, and adjust the decision point to the eye centre.

Verify the sequence at the LINE-CODE DECODER output. It is assumed² that you are recovering a 100 kHz carrier phase by the receiver via a BUFFER AMPLIFIER, not using gain, and using any part of the signal path.

Display a snapshot of the waveform at the DECISION MAKER, since (theoretically) the multimeter to the sine-frequency SYNC signal, and note where the eye-pattern method has placed the decision point. Would you have chosen differently using this alternative display?

Change your preferred display (eye pattern or snapshot) and reduce the receiver bandwidth and you consider if your receiver provides for suitable responsiveness. Check the decision-decoder performance under these conditions. **remember**, a bandwidth change will encounter compensation of the local carrier phase, so expect an evolution of the decision decision point. How do results compare with theoretical expectations?

Change from the SYNC line code to NRZ-L and note now that a priority inversion in the signal path no longer causes the decoded output. **remember**, any change of the code requires a change of the channel width BW of the DECISION MAKER, followed by a reset of the LINE-CODE DECODER (four press buttons).

¹ This feature is available on the Lab Sheet entitled BPSK and Carrier Acquisition

Lab Sheet

• 14 DETAILED LAB MANUALS



The seven volume TIMS Student Texts, over 4,500 pages in total, provide an in-depth coverage of a broad range of wireless and telecommunications experiments. I

CONVOLUTIONAL CODING

ACHIEVEMENTS: setting up and testing of a convolutional encoder and decoder pair. Inclusion into a ready, bandwidth-limited communication system, observation and measurement of changes to BER.

PREREQUISITES: completion of the experiment entitled BER measurement in the next chapter in this Volume.

ADVANCED MODULES: CONVOLUTIONAL ENCODER, TMS320 DSP-DB (with decoding EPROM), and TMS320 DSP. *plus all these modules required for the pre-occupant experiment, namely LINE-CODE ENCODER, LINE-CODE DECODER, DECISION MAKER, ERROR COUNTING UTILITIES, WIDEBAND TONE GENERATOR, an extra SEQUENCE GENERATOR, BASEBAND CHANNEL FILTERS, NOISE GENERATOR. TRUNGS are optional.*

PREPARATION

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

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

Part B places them into a communication system, where their contribution is to reduce the error introduced by the noisy, bandwidth-limited channel.

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 that for this experiment there is no need to know any of the theory which goes into this coding scheme, although it would, of course, add to your appreciation of the experiment.

The aim of the experiment is to show that:

- the form of convolutional encoding implemented is such that extra bits are added to a serial input message stream
- after encoding the output bit rate is twice that of the input bit rate

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EXPERIMENT - PART A

In Part B of the experiment the encoder and decoder of Part A will become part of a transmission system operating from the 8.193 kHz clock of the MASTER SIGNALS module.

Part of this system is a LINE-CODE ENCODER module, which produces a clock at one quarter of this rate, namely 2.048 kHz.

The convolutional encoding scheme to be implemented requires input data at half this rate again, so it in turn produces a 1.024 kHz clock for the message, provided by a SEQUENCE GENERATOR.

Detailed information about these two modules to be examined - the CONVOLUTIONAL ENCODER, the TMS320 DSP, and the TMS320 DSP-DB may be found in the Advanced Student User Manual. However, it is not necessary to refer to this for the purposes of the experiment. There are several on-board settings to be made, but it is assumed this will have been done by your Laboratory Manager.

encoding

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

Figure 3: model of the encoding section of Figure 1

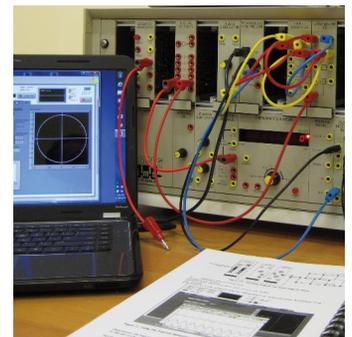
To set this model up the following steps are recommended:

- 1) set the SEQUENCE GENERATOR for a short sequence (both signals of the on-board master SYNC should be UP).
- 2) patch up as shown in Figure 3.
- 3) check that the clock and synchronization signals are present, and on the frequencies indicated in Figure 3.

The LINE-CODE ENCODER is being used although for the present no line coding is being implemented. There is no need, then, to press its (1x) button.

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• 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.



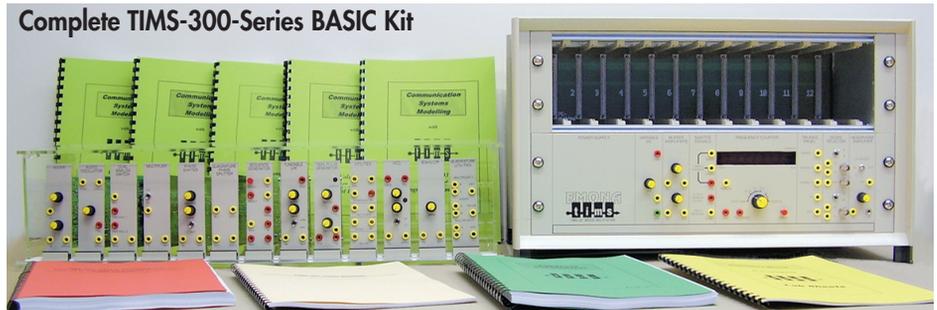
TIMS-300 SYSTEM UNITS and BASIC MODULE SET

TIMS-301, 301C and 304C SYSTEM UNITS

The starting point. Includes the System Unit (FIXED modules) and the most useful set of multi-useable plug-in modules (BASIC Module Set)

The TIMS-300-Series kit includes:

- The TIMS-300 System Unit
- 13 plug-in modules of the BASIC Module SET (see BASIC module list below)
- User Manuals;
- Student Text experiment manuals
- LabSheet experiment manuals;
- Modules Storage Box
- Standard accessories-



• 3 VERSIONS OF THE TIMS-300-SERIES SYSTEM UNIT



TIMS-301 Standard System



TIMS-301C with 2 channel Instrument



TIMS-304C with 4 channel Instrument, Function and Arbitrary generator

NEW

TIMS-300-Series SYSTEM UNITS

The FIXED MODULES are the most commonly used modules.

MODEL TIMS-301 Standard System includes:

- Master Oscillators
- Buffer Amplifiers
- Frequency and Event Counter
- Variable DC Voltage Output
- Oscilloscope Display Selectors
- TIMS Trunks Outputs
- Power Supply

MODEL TIMS-301C PC-ENABLED also includes:

- PC-based virtual instrument - 2 channel oscilloscope and spectrum analyzer displays, true RMS voltmeter.

NEW MODEL TIMS-304C PC-ENHANCED also includes:

- PC-based virtual instrument & ARB generator - 4 channel oscilloscope and spectrum analyzer displays, true RMS voltmeter and single channel function/arbitrary generator.

TIMS-301 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 EXPERIMENTS documented in the TIMS Experiment Manuals:

- | | | |
|---|--|--|
| <ul style="list-style-type: none"> • Introduction to TIMS • 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 | <ul style="list-style-type: none"> • 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 | <ul style="list-style-type: none"> 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 |
|---|--|--|



TIMS ADVANCED PLUG-IN MODULES (options)

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

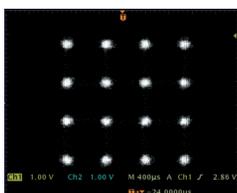
TIMS ADVANCED modules include over 70 specialised building blocks to expand the range of analog, digital, digital signal processing (DSP) and SDR experiments.

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

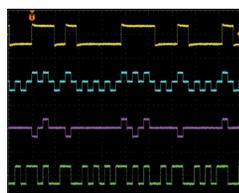


Advanced Modules Alphabetical List

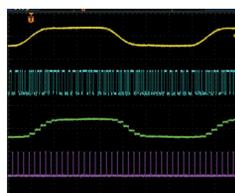
- TIMS-410 **100kHz Channel Filters**
- TIMS-401 **Baseband Channel Filters**
- TIMS-420 **Bit Clock Regeneration**
- TIMS-414 **Block Code Encoder**
- TIMS-415 **Block Code Decoder**
- NEW** TIMS-447 **Carrier Acquisition PLL/Costas**
- TIMS-427 **CDMA Encoder (Multi-Sequences Source)**
- TIMS-428 **CDMA 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**



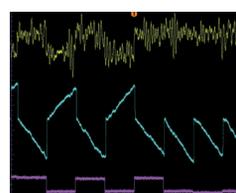
16-QAM



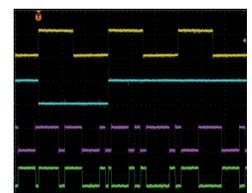
Line Code Encoding



PCM



Matched Filter



DSSS



EXPANDING THE TIMS-300 BASIC KIT

- To add to the TIMS-300 experiment capabilities, either -
- Choose from predefined kits listed here, or
 - Choose from a list of TIMS experiments and Emona will prepare a custom proposal.

EVAL-16 KIT: adds a range of quantitative, SNR, BER & digital modulation experiments

Add another 3 x BASIC and 13 x ADVANCED modules to the TIMS-301/C to build a comprehensive and advanced telecommunications laboratory system

TIMS-300 KIT

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

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

and ADD

TIMS EVAL-16 KIT

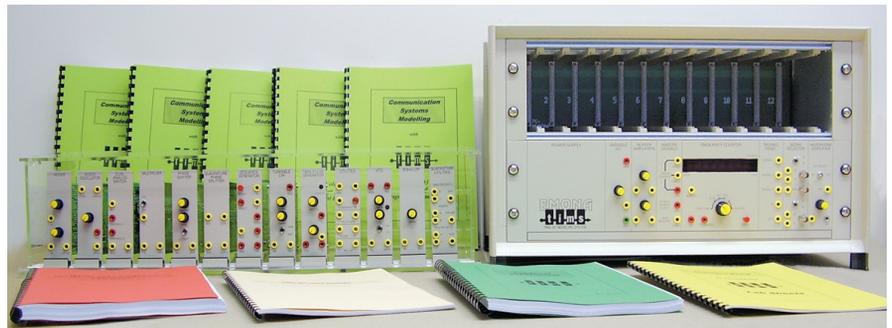
A kit of 16 additional TIMS modules:

Additional BASIC modules include

- TIMS-153 **Sequence Generator**
- TIMS-154 **Tunable LPF**
- TIMS-157 **VCO**

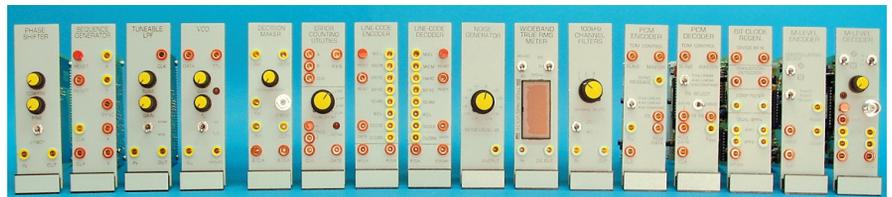
Additional ADVANCED modules

- 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**



Complete TIMS-300 Kit

PLUS



PLUS these additional BASIC and ADVANCED modules

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

- **Experiment capabilities include all of the TIMS-301/C Experiments listed on PAGE 7, plus all of the following:**
- 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



EXPANDING THE TIMS-300 BASIC KIT - expansion examples

TIMS Software Defined Radio Experiments

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

NEW



TIMS-SDR & plug-and-play USB Stick

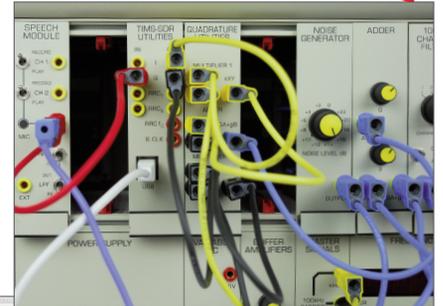
TIMS-SDR Kit is a zero-install, plug-and-play, hardware and software package which enables the student to quickly and easily experiment with the graphical GNU Radio Companion software tools in the TIMS telecommunications platform with real signals.

Requires the TIMS-301C/304C BASIC System plus:

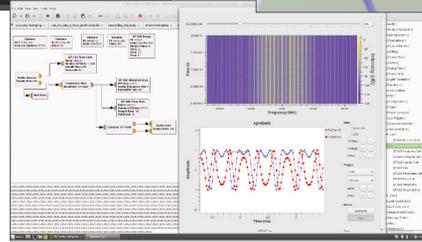
- TIMS-451 **TIMS-SDR Utilities Module** and **TIMS-USB** with **pre-installed LINUX and GNURadio**



LINUX MINT pre-installed



REAL SDR HARDWARE



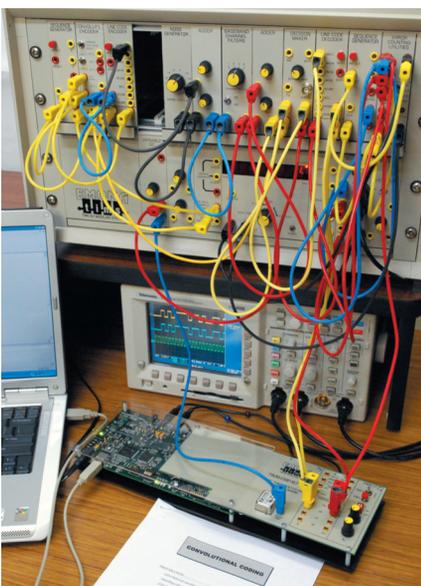
GNURadio pre-installed

EXPERIMENTS documented in the TIMS Experiment Manuals:

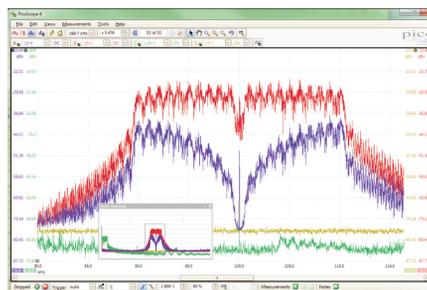
- Familiarization with GNURadio
- Exploring Sampling and Resampling in SDR
- TX with SDR and RX with Hardware: FM applications
- TX with hardware, RX with SDR: QAM applications
- TX and RX with SDR: BPSK, QPSK, MSK, FSK, OFDM, and more

TIMS OFDM Experiments

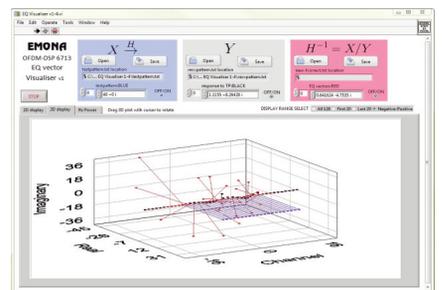
TIMS offers both introductory experiments to demonstrate the principles of OFDM without DSP, as well as a suite of advanced DSP-based experiments



TIMS OFDM requires the TIMS-301C/304C Basic System, 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:

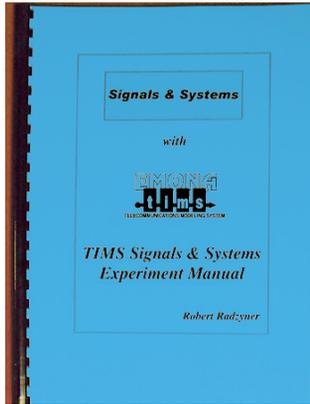
- Introduction to OFDM using discrete modules (non-DSP)
- OFDM, Cyclic Prefix & PAPR
- OFDM & Channel Equalisation with BER
- IDFT, Complex Exponent & Complex Quadrature Signals
- OFDM in band limited, multipath with BER



TIMS SIGNALS & SYSTEMS - expansion examples

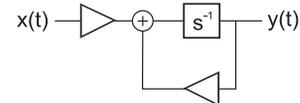
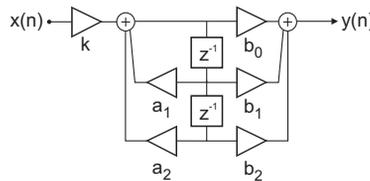
SIGNALS & SYSTEMS EXPERIMENTS

Real signals - No simulation. Hardware experiments to help students to relate the complex math of Signals & Systems to the real-world



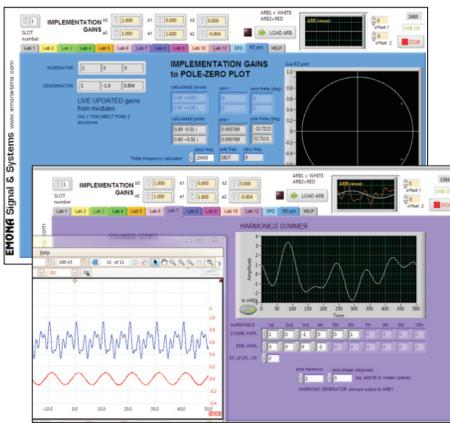
A COMPLETE LAB MANUAL - pick the labs for your course

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.



EXPERIMENT CONTROL SOFTWARE

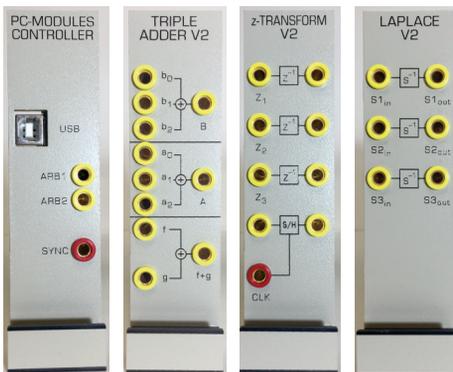
The TIMS Signals & Systems Experiments Manual includes graphical software with all the control instrumentation and data presentation tools required.



- 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.

SIGNALS & SYSTEMS REAL EXPERIMENT 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 an FIR discrete time structures.
- **TIMS-442 Laplace-V2**
For implementing continuous-time structures.

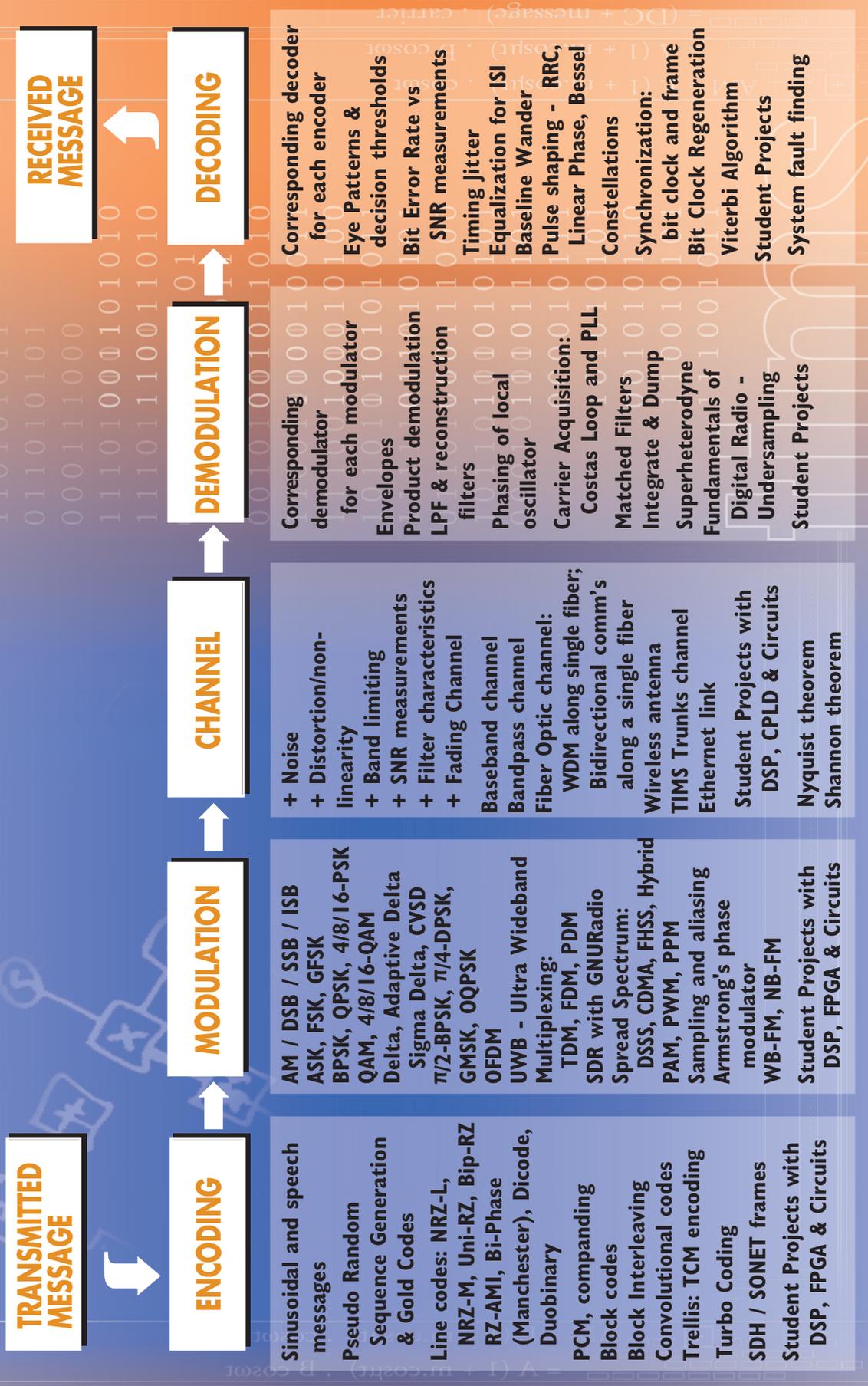
TIMS SIGNALS & SYSTEMS EXPERIMENTS

- 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

A summary of TIMS experiment capabilities



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