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
SDR FOR EDUCATION with GNURadio

SIGNS & SYSTEMS EXPERIMENTS

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

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.
START WITH MATH OR THEORY

Telecommunications text books are a source of equations and theories.

\[ x_p(t) \cdot \cos \omega_c t + x_q(t) \cdot \sin \omega_c t = QPSK \]

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

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
TIMS Detailed Documentation

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.

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

• 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.

• 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.

• 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
- Binary signal detection in Gaussian noise
- Bit Clock Regeneration
- Block Coding and Decoding
- Block Coding Gain
- Block Coding - error correcting
- π/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
- DPKS and BER
- DPKS and Carrier Acquisition
- DSP Intro and Applications
- DSBSBC - 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
- BFSK - coherent signalling & BER
- BFSK - non-coherent signalling & BER
- GFSK - Gaussian FSK
- IoT - ASK+DSSS Physical Layer
- IoT - Chirp Spread Spectrum Application
- IoT - Ultra Wide Band Application
- ISB - Independent Sideband
- ISI: PAM & ASK in band-limited ch.
- Line-Coding & Decoding
- Matched Filter Detection
- MSK, QPSK, π/4-QPSK, π/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
- Multi-path - Time-invariant fading channel characteristics
- Multi-path - ISI rejection in DS SS
- Noisy Channel
- Noise Generation - Binary Sequences
- OFDM Principles - Introduction
- OFDM, Cyclic Prefix & PAPR
- OFDM & Channel Equalisation with BER Measurement
- OFDM in band limited, multipath, time-invariant channel with BER measurements
- 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
- 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
- 16-QAM - as used in 4G and 5G LTE
- 16-QAM - LTE BER measurement
- QAM - Generation & Demodulation
- QAM and 4-PSK
- QASK - Modulation & Demodulation
- QPSK - Modulation & Demodulation
- QPSK - BER of Coherent QPSK in distortionless channel
- Sampling & Reconstruction
- Sampling with Sample & Hold
- Signal Analysis: relationship between time and frequency domains
- SDR - Intro to GNU Radio
- SDR - Exploring sampling & resampling
- SDR - Software Defined Radio in TX
- 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 DSBC
- 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 Line Amplifier Measurements
  - Superheterodyne
  - System fault finding
- TCM - Coding Gain
- TCM - Trellis Coding
- TDM
- Timing jitter in Band Limited Channels
- 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:

- 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
- Soldierless breadboarding of electronic circuits with the TIMS-840 Experimenter
- Programming DSP implementations with the TIMS-DSP-6713 Module

www.emona-tims.com - Telecommunications - Signals & Systems - EMONA TIMS • 5
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

The TIMS-300-Series BASIC KIT includes:

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

<table>
<thead>
<tr>
<th>No.</th>
<th>Module Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIMS-410</td>
<td>100kHz Channel Filters</td>
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<tr>
<td>TIMS-401</td>
<td>Baseband Channel Filters</td>
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<tr>
<td>TIMS-420</td>
<td>Bit Clock Regeneration</td>
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<tr>
<td>TIMS-414</td>
<td>Block Code Encoder</td>
</tr>
<tr>
<td>TIMS-415</td>
<td>Block Code Decoder</td>
</tr>
<tr>
<td>TIMS-447</td>
<td>Carrier Acquisition PLL/Costas</td>
</tr>
<tr>
<td>TIMS-427</td>
<td>CDMA Encoder (Multi-Sequences Source)</td>
</tr>
<tr>
<td>TIMS-428</td>
<td>CDMA Decoder</td>
</tr>
<tr>
<td>TIMS-840</td>
<td>Circuit Experimenter</td>
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<tr>
<td>TIMS-416</td>
<td>Convolutional Code Encoder</td>
</tr>
<tr>
<td>TIMS-417</td>
<td>Convolutional Decoder Firmware</td>
</tr>
<tr>
<td>TIMS-402</td>
<td>Decision-Maker Module</td>
</tr>
<tr>
<td>TIMS-403</td>
<td>Delta Modulation Utilities</td>
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<tr>
<td>TIMS-404</td>
<td>Delta Demodulation Utilities</td>
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<tr>
<td>TIMS-435</td>
<td>Digital Channel Error Generator</td>
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<tr>
<td>TIMS-424</td>
<td>Digital Utilities</td>
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<tr>
<td>TIMS-DSP-6713</td>
<td>Floating Point DSP Development Module</td>
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<tr>
<td>TIMS-405</td>
<td>Error Counting Utilities</td>
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<tr>
<td>TIMS-240</td>
<td>Expansion Rack</td>
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<tr>
<td>TIMS-210</td>
<td>Extender Card</td>
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<tr>
<td>TIMS-505</td>
<td>Fiber Optic Coupler</td>
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<tr>
<td>TIMS-503R</td>
<td>Fibre Optics Transmitter (red)</td>
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<tr>
<td>TIMS-503G</td>
<td>Fibre Optics Transmitter (green)</td>
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<tr>
<td>TIMS-504</td>
<td>Fibre Optics Receiver</td>
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<tr>
<td>TIMS-506</td>
<td>Fiber Optic WDM Filters</td>
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<tr>
<td>TIMS-421</td>
<td>FM Utilities</td>
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<tr>
<td>TIMS-434</td>
<td>Frequency Hop Spread Spectrum</td>
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<tr>
<td>TIMS-418</td>
<td>Integrate &amp; Dump, Sample &amp; Hold</td>
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<tr>
<td>TIMS-436</td>
<td>Laplace</td>
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<tr>
<td>TIMS-442</td>
<td>Laplace V2 (used with TIMS-445)</td>
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<tr>
<td>TIMS-406</td>
<td>Line-Code Encoder</td>
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<tr>
<td>TIMS-407</td>
<td>Line-Code Decoder</td>
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<tr>
<td>TIMS-422</td>
<td>M-Level Encoder</td>
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<tr>
<td>TIMS-423</td>
<td>M-Level Decoder</td>
</tr>
<tr>
<td>TIMS-438</td>
<td>MSK,(^{2}/4)-DQPSK, OQPSK Encoder (&amp; RRC)</td>
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<tr>
<td>TIMS-439</td>
<td>MSK,(^{2}/4)-DQPSK, OQPSK Decoder</td>
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<tr>
<td>TIMS-446</td>
<td>Multi-Path Channel Module</td>
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<tr>
<td>TIMS-408</td>
<td>Noise Generator</td>
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<tr>
<td>TIMS-449</td>
<td>OFDM for DSP-6713 Module</td>
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<tr>
<td>TIMS-445</td>
<td>PC Modules Controller</td>
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<tr>
<td>TIMS-412</td>
<td>PCM Encoder</td>
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<tr>
<td>TIMS-413</td>
<td>PCM Decoder</td>
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<tr>
<td>TIMS-250</td>
<td>Perspex Module Storage Box</td>
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<tr>
<td>TIMS-830</td>
<td>Programmable CPLD Project Module</td>
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<tr>
<td>TIMS-820</td>
<td>Project Module (Wire-wrapping)</td>
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<tr>
<td>TIMS-425</td>
<td>Quadrature Utilities</td>
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<tr>
<td>TIMS-429</td>
<td>SONET/SDH STS-1 Multiplexer</td>
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<tr>
<td>TIMS-451</td>
<td>SDR with GNURadio</td>
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<tr>
<td>TIMS-430</td>
<td>SONET/SDH STS-1 Demultiplexer</td>
</tr>
<tr>
<td>TIMS-431</td>
<td>SONET/SDH STS-3 Multiplexer</td>
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<tr>
<td>TIMS-432</td>
<td>SONET/SDH STS-3 Demultiplexer</td>
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<tr>
<td>TIMS-433</td>
<td>SONET/SDH STS-1/3 Clock Regenerator</td>
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<tr>
<td>TIMS-411</td>
<td>Spectrum Utilities</td>
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<tr>
<td>TIMS-448</td>
<td>SSB Filters for DSP-6713 Module</td>
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<tr>
<td>TIMS-426</td>
<td>Speech Module</td>
</tr>
<tr>
<td>TIMS-419</td>
<td>Trellis-Coded Modulation Firmware</td>
</tr>
<tr>
<td>TIMS-444</td>
<td>Triple Adder (requires PC Modules Controller)</td>
</tr>
<tr>
<td>TIMS-409</td>
<td>True RMS Voltmeter</td>
</tr>
<tr>
<td>TIMS-201</td>
<td>Trunks Driver</td>
</tr>
<tr>
<td>TIMS-202</td>
<td>Trunks Receiver and TIMS-BUS</td>
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<tr>
<td>TIMS-440</td>
<td>Tuneable Data Comms Filters (dual lin.phase)</td>
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<tr>
<td>TIMS-450</td>
<td>Turbo Coding</td>
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<tr>
<td>TIMS-441</td>
<td>Ultra Wideband</td>
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<tr>
<td>TIMS-437</td>
<td>z-Transform</td>
</tr>
<tr>
<td>TIMS-443</td>
<td>z-Transform V2 (used with TIMS-445)</td>
</tr>
<tr>
<td>TIMS-501/502</td>
<td>100kHz Tx &amp; 100kHz Rx Antenna Set</td>
</tr>
</tbody>
</table>

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.
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

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

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

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

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

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.

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

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.
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.

\[
x(n) \rightarrow \sum \frac{b_0}{a_1} x(n) \rightarrow y(n)
\]

\[
x(t) \rightarrow s^2 y(t)
\]

Signals & Systems OPTION

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

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 an 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**

**Transmitted Message**
- **Encoding**: Sinusoidal and speech messages, Pseudo Random Sequence Generation & Gold Codes, Line codes: NRZ-L, NRZ-M, Uni-RZ, Bip-RZ, RZ-AMI, Bi-Phase (Manchester), Dicode, Duobinary, PCM, companding, Block codes, Block Interleaving, Convolutional codes, Trellis: TCM encoding, Turbo Coding, SDH / SONET frames, Student Projects with DSP, FPGA & Circuits.


**Channel**: + Noise, + Distortion/non-linearity, + Band limiting, + SNR measurements, + Filter characteristics, + Fading Channel, Baseband channel, Bandpass channel, Fiber Optic channel: WDM along single fiber, Bidirectional comm's along a single fiber, Wireless antenna, TIMS Trunks channel, Ethernet link, Student Projects with DSP, CPLD & Circuits, Nyquist theorem.

**Demodulation**: Corresponding demodulator for each modulator, Envelopes, Product demodulation, LPF & reconstruction filters, Phasing of local oscillator, Carrier Acquisition: Costas Loop and PLL, Matched Filters, Integrate & Dump, Superheterodyne, Fundamentals of Digital Radio - Undersampling, SDR with GNURadio, Student Projects.

**Received Message**
- **Decoding**: Corresponding decoder for each encoder, Eye Patterns & decision thresholds, Bit Error Rate vs SNR measurements, Timing Jitter, Equalization for ISI, Baseline Wander, Pulse shaping - RRC, Linear Phase, Bessel Constellations, Synchronization: bit clock and frame, Bit Clock Regeneration, Viterbi Algorithm, Student Projects, System fault finding.