Communications Technologies Training Systems
8087-00

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General Description

The Communications Technologies Training Systems are specifically designed for hands-on training in a wide range of communication technologies. Training starts from the basic pulse modulation techniques (PAM, PWM, PPM, PCM, DPCM, and delta modulation), covers the various digital modulation schemes used in data transmission (ASK, FSK, BPSK, QPSK, and QAM), and extends to modern, spectrally efficient, digital communication techniques such as the asymmetric digital subscriber line (ADSL) and spread spectrum technologies (direct-sequence spread spectrum and frequency-hopping spread spectrum).

The courseware consists of a series of student manuals covering the different technologies, as well as instructor guides that provide the answers to procedure step questions and review questions. The training systems and the accompanying courseware provide a complete study program.

Through the study of ADSL, the training systems also introduces various essential underlying technologies such as discrete multi-tone (DMT) modulation, orthogonal frequency division multiplexing (OFDM), data scrambling, convolutional coding, trellis-coded modulation (TCM), forward error correction (FEC) using Reed-Solomon codes, data interleaving, and Viterbi decoding. Similarly, study of the spread spectrum technologies using the training systems allows coverage of several other relevant topics such as the principles of code-division multiple access (CDMA), Gold code sequence generation, auto-correlation and cross-correlation properties of code sequences, as well as an introduction to modern applications of these technologies such as CDMA-based cellular telephony, Global Positioning System (GPS), residential cordless telephone sets, Bluetooth specification for wireless personal area networks (WPAN), etc. Whenever possible, the systems are designed to reflect the standards commonly used in modern communications systems. Unlike conventional, hardware-based training systems that use a variety of physical modules to implement different technologies and instruments, the Communications Technologies Training Systems are based on a Reconfigurable Training Module (RTM) and the Communications Technologies (LVCT) software, providing tremendous flexibility at a reduced cost.

Each of the communications technologies to be studied is provided as an application that can be selected from a menu. Once loaded into the LVCT software, the selected application configures the RTM to implement the communications technology, and provides to students a specially designed user interface. A wide variety of applications are available, covering many current and evolving communications technologies. Because the Communications Technologies Training Systems are open, reconfigurable systems, they can be upgraded at any time to cover additional technologies simply by purchasing additional applications. The LVCT software provides settings for full user control over the operating parameters of each communications technology application. Functional block diagrams for the circuits involved are shown on screen. The digital or analog signals at various points in the circuits can be viewed and analyzed using the virtual instruments included in the software. In

addition, the most important of these signals are made available at physical connectors on the RTM and can be displayed and measured using conventional instruments.
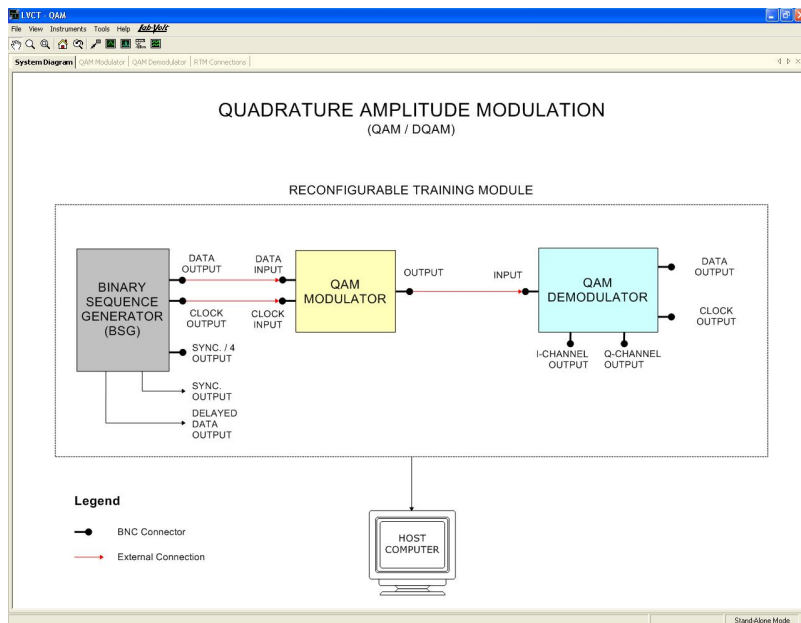
Detailed Screenshots of the Application
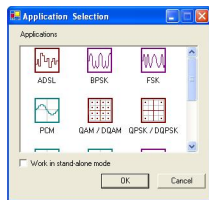
On start-up, the user selects a communications technology application to be studied.
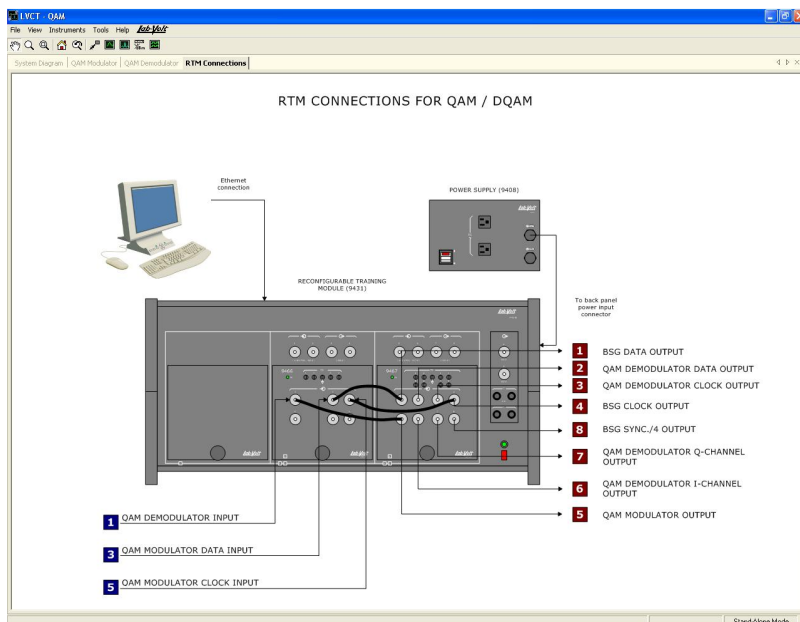
The RTM Connections diagram identifies the RTM inputs and outputs and shows the external connections.

The System Diagram shows the overall system and interconnections for the selected application.
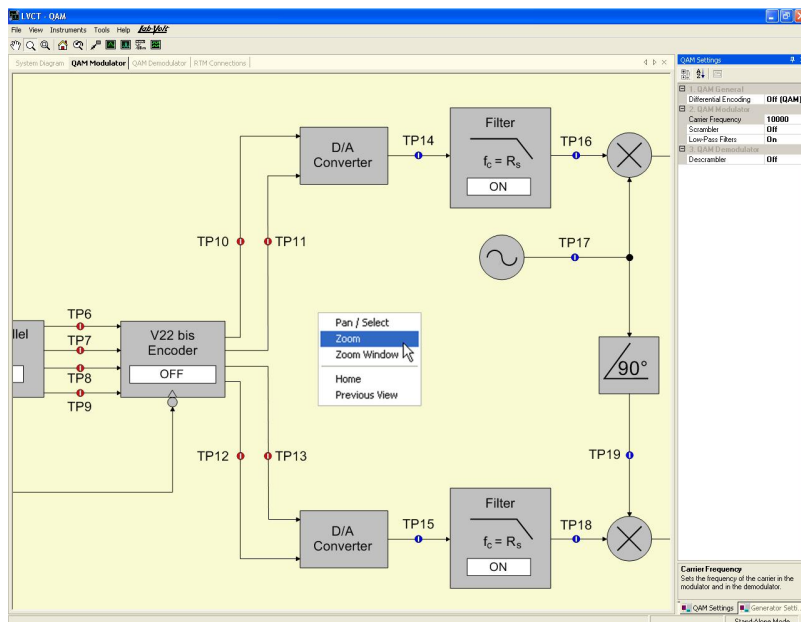
Circuit diagrams show the functional blocks of each circuit. Pan and Zoom functions allow easy navigation.
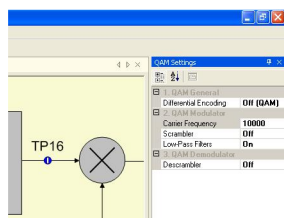
Settings tables provide full control of operating parameters.
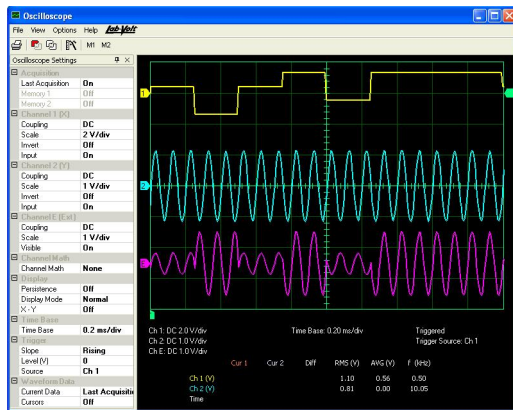
The virtual Oscilloscope allows observation and measurement of analog and digital signals.
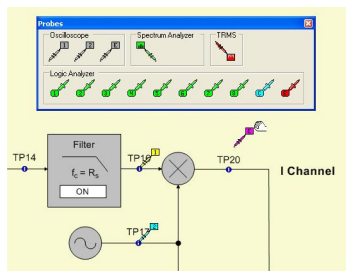
Probes can be dragged from the Probes bar and connected to circuit Test Points (TPs) in order to observe signals using the virtual instruments.
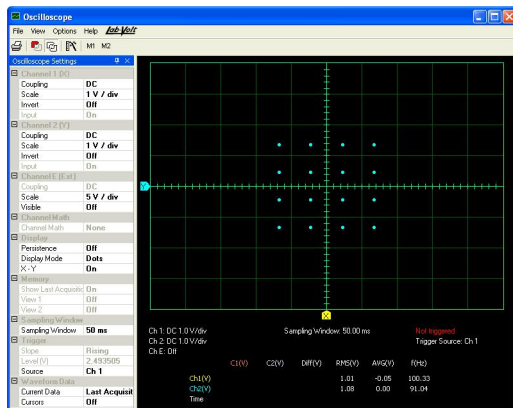
In the X-Y mode, the Oscilloscope can display the signal constellation, such as this 16-QAM constellation.
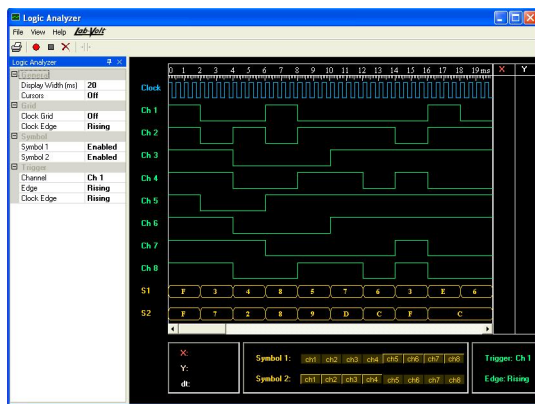
The Logic Analyzer records and displays digital data from multiple test points.
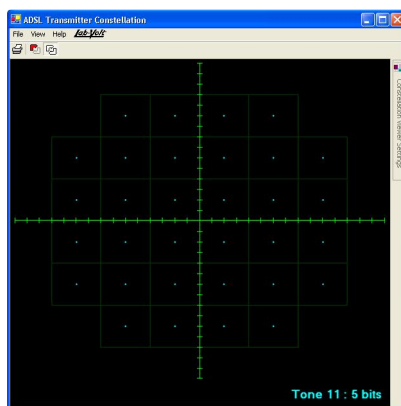
The Constellation Viewer in the ADSL application displays complex signal constellations.
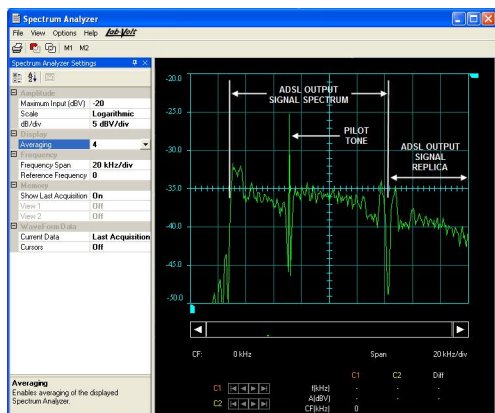
The Spectrum Analyzer displays frequency spectra, such as this spectrum of an ADSL signal.

The True RMS Voltmeter displays signal levels in volts or dBm.
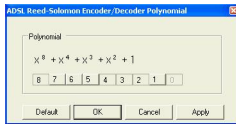
The system is highly configurable. This dialog box allows changing the polynomial used for the ADSL Reed-Solomon Encoder and Decoder.
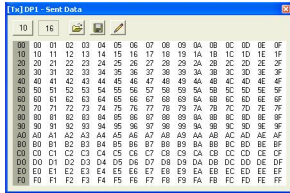
The data at some Data Points can be edited, saved in a MATLAB®-compatible file, or loaded from a file.
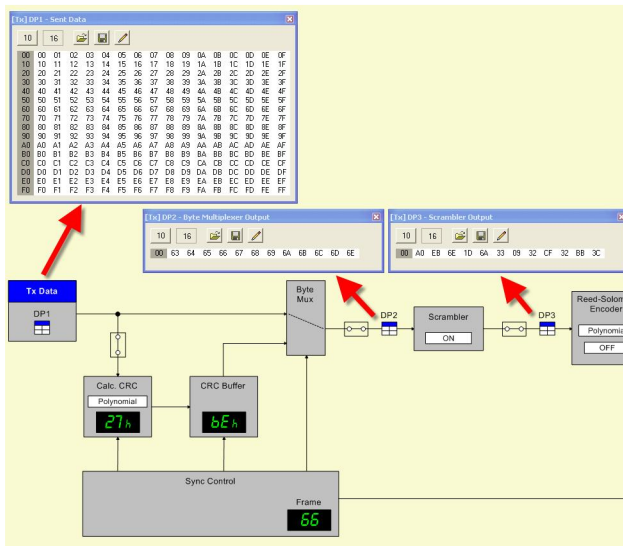
Data Points are provided where digital data is present in a circuit. Double-clicking a Data Point opens a table displaying the data as decimal or hexadecimal values.
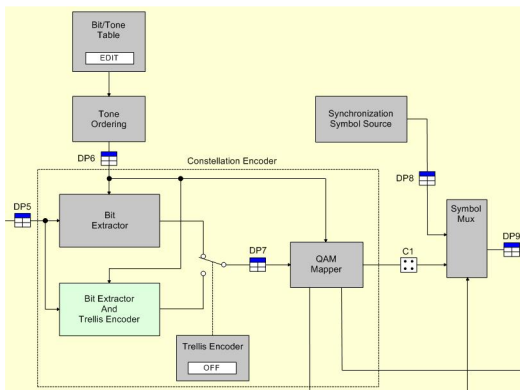
The ADSL application performs constellation encoding with or without Trellis Coding and allows modifying the number of bits allocated to each tone (subcarrier).

Model	Name	Included in System 8087-X				
		-1	-2	-3	-4	-5
9408	Power Supply	●	●	●	●	●
9431-1	Reconfigurable Training Module (RTM)	●	●	●	●	●
9466	Data Acquisition Interface	●	●	●	●	
9467	Analog/Digital Output Interface	●	●	●	●	●
9468	Vocoder					●
9483	Cables and Accessories	●	●	●	●	●
9432 39862-E	LVCT Software Communications Technologies Training System User Guide	●	●	●	●	●
9432-1 39862 39862-1	PAM / PWM / PPM Applications Student Manual Instructor Guide	●	●	●	●	●
9432-2 39863 39863-1	PCM / DPCM / Delta Modulation Applications Student Manual Instructor Guide		●	●	●	●
9432-3 39864 39864-1	ASK / FSK / BPSK Applications Student Manual Instructor Guide			●	●	●
9432-4 39865 39865-1 39866 39866-1 39866-P 39867 39867-1 39867-P	QPSK / QAM / ADSL Applications QPSK Student Manual QPSK Instructor Guide QAM Student Manual QAM Instructor Guide QAM Quick Start Guide ADSL Student Manual ADSL Instructor Guide ADSL Quick Start Guide				●	●
9432-5 85031 85031-1	DSSS / FHSS / CDMA Applications Spread Spectrum Student Manual Spread Spectrum Instructor Guide					●

Note: A separate copy of the LVCT software and of each desired application package must be purchased for each RTM. One copy of the User Guide is included with the LVCT software. Every application package includes one copy of each of the associated manuals.

Topic Coverage

- Pulse Modulation and Sampling (PAM / PWM / PPM)
- Digital Modulation (PCM / DPCM / Delta)
- Basic Modems and Data Transmission (ASK / FSK / BPSK)
- Quadrature Phase Shift Keying (QPSK / DQPSK)
- Quadrature Amplitude Modulation (QAM / DQAM)
- Asymmetric Digital Subscriber Line (ADSL)

- Spread Spectrum (DSSS/FHSS/CDMA)
- Troubleshooting

Features & Benefits

- Provides hands-on, system-level training in communications technologies
- Real system and real frequencies, not simulations, reflecting the standards commonly used in modern communications systems
- Flexible, open system using a high performance DSP-based Reconfigurable Training Module (RTM)
- A variety of communications technology applications allow studying many different communications technologies
- Comprehensive courseware provides theory and step-by-step laboratory procedures for each technology
- Fault-insertion capability allows the teaching of troubleshooting
- MATLAB® Import/Export in ADSL applications
- Short-circuit-proof, low-power for safety and compatibility
- Front-panel access to signals
- Windows-based Communications Technologies (LVCT) software provides the user interface and configures the RTM to implement the communications technology selected by the user

List of Available Training Systems

Qty	Description	Model number
1	Communications Technologies Training System 4 _____	582032 (8087-40)
1	Communications Technologies Training System 5 _____	582036 (8087-50)

Additional Equipment Required to Perform the Exercises

Qty	Description	Model number
1	Communications Technologies Host Computer _____	587467 (9695-A0) [1]

Optional Equipment

Qty	Description	Model number
1	Dual Trace Oscilloscope _____	580849 (797-20) [2]
1	Communications Technologies Training System (Manuals on CD-ROM) _____	584877 (39862-A0)

Available Training Systems

Communications Technologies Training System 4
582032 (8087-40)

The Communications Technologies Training System 4 includes the PAM/ PWM/PPM applications, the PCM/ DPCM/Delta Modulation applications, the ASK/FSK/BPSK applications, and the QPSK/QAM/ADSL applications, as well as the corresponding courseware.

[1] Refer to the Computer Requirements in the System Specifications section of this datasheet if the computer is to be provided by the end-user.
[2] A conventional, dual-trace oscilloscope, such as the Model 797-20, can be used to observe the signals (including the signal constellation for QPSK and QAM) available at the BNC connectors and physical Test Points on the RTM.

List of Equipment

Qty	Description	Model number
1	RTM Power Supply	593595 (9408-1X)
1	Reconfigurable Training Module (RTM)	587443 (9431-20)
1	LVCT Software	581621 (9432-00)
1	Data Acquisition Interface	581692 (9466-00)
1	Analog/Digital Output Interface	581693 (9467-00)
1	Cables and Accessories	581797 (9483-00)
1	Power Cord - Type B	789405 (95451-00)

List of Manuals

Description	Manual number
Pulse Modulation and Sampling (PAM / PWM / PPM) (Student Manual)	584875 (39862-00)
Communications Technologies Training System (User Guide)	584879 (39862-E0)
Pulse Modulation and Sampling (PAM / PWM / PPM) (Instructor Guide)	584881 (39862-10)
Digital Modulation (PCM / DPCM / Delta) (Student Manual)	584883 (39863-00)
Digital Modulation (PCM / DPCM / Delta) (Instructor Guide)	584885 (39863-10)
Basic Modems and Data Transmission (ASK / FSK / BPSK) (Student Manual)	584887 (39864-00)
Basic Modems and Data Transmission (ASK / FSK / BPSK) (Instructor Guide)	584889 (39864-10)
Quadrature Phase Shift Keying (QPSK/DQPSK) (Student Manual)	584891 (39865-00)
Quadrature Phase Shift Keying (QPSK/DQPSK) (Instructor Guide)	584893 (39865-10)
Quadrature Amplitude Modulation (QAM/DQAM) (Student Manual)	584895 (39866-00)
Quadrature Amplitude Modulation (QAM/DQAM) (Quick Start Guide)	584897 (39866-P0)
Quadrature Amplitude Modulation (QAM/DQAM) (Instructor Guide)	584898 (39866-10)
Asymmetric Digital Subscriber Line (ADSL) (Student Manual)	584900 (39867-00)
Asymmetric Digital Subscriber Line (ADSL) (Quick Start Guide)	584902 (39867-P0)
Asymmetric Digital Subscriber Line (ADSL) (Instructor Guide)	584903 (39867-10)

Table of Contents of the Manual(s)

Pulse Modulation and Sampling (PAM / PWM / PPM) (Student Manual) (584875 (39862-00))

- 1-1 Time Characteristics of Pulses
- 1-2 Frequency Characteristics of Pulses
- 1-3 Band-Limiting
- 2-1 PAM Signals
- 2-2 Spectral Characteristics of PAM Signals
- 2-3 Aliasing and the Nyquist Rate
- 2-4 Pre-filtering
- 3-1 PAM Signals Demodulation
- 3-2 Aliasing
- 4-1 PWM and PPM Signal Modulation
- 4-2 PWM and PPM Signal Demodulation
- 5-1 Troubleshooting Techniques
- 5-2 Troubleshooting the PAM Receiver
- 5-3 Troubleshooting a PAM Communication System
- 5-4 Troubleshooting the PWM / PPM Generator

- 5-5 Troubleshooting the PWM / PPM Receiver
- 5-6 Troubleshooting a PWM / PPM Communication System

Digital Modulation (PCM / DPCM / Delta) (Student Manual) (584883 (39863-00))
- 1-1 Binary and Hexadecimal Numbers and Analog-to-Digital Conversion
- 1-2 Digital-to-Analog Conversion
- 2-1 Distortion in PCM Systems
- 2-2 Characteristics of Quantization Noise
- 2-3 Quantization Noise Measurement
- 3-1 Information Transmission with a PCM System
- 3-2 Resistance of PCM to Noise and Distortion
- 3-3 Effect of Companding on the Performance of a PCM System
- 4-1 Principles of a DPCM System
- 4-2 Dynamic Operation of a DPCM System
- 5-1 A Linear Delta Modulation (LDM) System
- 5-2 An Adaptive Delta Modulation (ADM) System
- 6-1 Troubleshooting a PCM Communications System
- 6-2 Troubleshooting a DPCM Communications System
- 6-3 Troubleshooting a Delta/CVSD Communications System

Basic Modems and Data Transmission (ASK / FSK / BPSK) (Student Manual) (584887 (39864-00))
- 1-1 Pseudo-Random Binary Sequences
- 2-1 Generation and Reception of ASK Signals
- 3-1 FSK Principles
- 3-2 Bell 202 Modem (1200 baud)
- 4-1 Generation and Demodulation of BPSK Signals
- 5-1 Troubleshooting an ASK Communication System
- 5-2 Troubleshooting an FSK Modem
- 5-3 Troubleshooting a BPSK Communication System

Quadrature Phase Shift Keying (QPSK/DQPSK) (Student Manual) (584891 (39865-00))
- 1 QPSK Modulation
- 2 QPSK Demodulation
- 3 Differential QPSK (DQPSK)
- 4 Data Scrambling and Descrambling
- 5 Troubleshooting a QPSK/DQPSK Modem

Quadrature Amplitude Modulation (QAM/DQAM) (Student Manual) (584895 (39866-00))
- 1 QAM Modulation
- 2 QAM Demodulation
- 3 Differential QAM (DQAM)
- 4 Data Scrambling and Descrambling
- 5 Troubleshooting a QAM/DQAM Modem

Quadrature Amplitude Modulation (QAM/DQAM) (Quick Start Guide) (584897 (39866-P0))
- 1 Using the Binary Sequence Generator and the Instruments
- 2 QAM Modulator
- 3 QAM Demodulator

Asymmetric Digital Subscriber Line (ADSL) (Student Manual) (584900 (39867-00))

- 1 ADSL Signal Spectral Analysis
- 2 ADSL Signal Generation
- 3 ADSL Signal Demodulation
- 4 Framing, Synchronization, and Error Detection
- 5 Forward Error Correction Using Reed-Solomon Codes
- 6 Data Interleaving
- 7 Convolutional Coding in ATU Transmitters
- 8 Trellis-Coded Modulation in ATU Transmitters
- 9 Viterbi Decoding in ATU Receivers

Asymmetric Digital Subscriber Line (ADSL) (Quick Start Guide) (584902 (39867-P0))

- 1 Using the ADSL Application

System Specifications

Parameter	Value
Power Requirements	
Current	3.5 A
Service Installation	Standard single-phase ac outlet
Computer Requirements	A currently available personal computer with USB 2.0 ports, including a 3D graphics card (dual-monitor support is recommended) and a fast Ethernet (100 Mb/s) network interface adapter, running under one of the following operating systems: Windows® 7 or Windows® 8.
Physical Characteristics	
Intended Location	On a table able to support the weight of the equipment
Dimensions (H x W x D)	370 x 680 x 530 mm (14.6 x 26.7 x 20.8 in)
Net Weight	TBE

Communications Technologies Training System 5
582036 (8087-50)

The Communications Technologies Training System 5 includes the PAM/PWM/PPM applications, the PCM/DPCM/Delta Modulation applications, the ASK/FSK/BPSK Applications, the QPSK/QAM/ADSL applications, and the DSSS/FHSS/CDMA applications, as well as the corresponding courseware.

List of Equipment

Qty	Description	Model number
1	RTM Power Supply	593595 (9408-1X)
1	Reconfigurable Training Module (RTM)	587443 (9431-20)
1	LVCT Software	581621 (9432-00)
1	Data Acquisition Interface	581692 (9466-00)
1	Analog/Digital Output Interface	581693 (9467-00)
1	Vocoder	581694 (9468-00)
1	Cables and Accessories	581797 (9483-00)
1	Power Cord - Type B	789405 (95451-00)

List of Manuals

Description	Manual number
Pulse Modulation and Sampling (PAM / PWM / PPM) (Student Manual)	584875 (39862-00)
Communications Technologies Training System (User Guide)	584879 (39862-E0)
Pulse Modulation and Sampling (PAM / PWM / PPM) (Instructor Guide)	584881 (39862-10)
Digital Modulation (PCM / DPCM / Delta) (Student Manual)	584883 (39863-00)
Digital Modulation (PCM / DPCM / Delta) (Instructor Guide)	584885 (39863-10)
Basic Modems and Data Transmission (ASK / FSK / BPSK) (Student Manual)	584887 (39864-00)
Basic Modems and Data Transmission (ASK / FSK / BPSK) (Instructor Guide)	584889 (39864-10)
Quadrature Phase Shift Keying (QPSK/DQPSK) (Student Manual)	584891 (39865-00)
Quadrature Phase Shift Keying (QPSK/DQPSK) (Instructor Guide)	584893 (39865-10)
Quadrature Amplitude Modulation (QAM/DQAM) (Student Manual)	584895 (39866-00)
Quadrature Amplitude Modulation (QAM/DQAM) (Quick Start Guide)	584897 (39866-P0)
Quadrature Amplitude Modulation (QAM/DQAM) (Instructor Guide)	584898 (39866-10)
Asymmetric Digital Subscriber Line (ADSL) (Student Manual)	584900 (39867-00)
Asymmetric Digital Subscriber Line (ADSL) (Quick Start Guide)	584902 (39867-P0)
Asymmetric Digital Subscriber Line (ADSL) (Instructor Guide)	584903 (39867-10)
Spread Spectrum (DSSS/FHSS/CDMA) (Student Manual)	585064 (85031-00)
Spread Spectrum (DSSS/FHSS/CDMA) (Instructor Guide)	585066 (85031-10)

Table of Contents of the Manual(s)

Pulse Modulation and Sampling (PAM / PWM / PPM) (Student Manual) (584875 (39862-00))

Digital Modulation (PCM / DPCM / Delta) (Student Manual) (584883 (39863-00))

- 3-1 Information Transmission with a PCM System
- 3-2 Resistance of PCM to Noise and Distortion
- 3-3 Effect of Companding on the Performance of a PCM System
- 4-1 Principles of a DPCM System
- 4-2 Dynamic Operation of a DPCM System
- 5-1 A Linear Delta Modulation (LDM) System
- 5-2 An Adaptive Delta Modulation (ADM) System
- 6-1 Troubleshooting a PCM Communications System
- 6-2 Troubleshooting a DPCM Communications System
- 6-3 Troubleshooting a Delta/CVSD Communications System

Basic Modems and Data Transmission (ASK / FSK / BPSK) (Student Manual) (584887 (39864-00))
- 1-1 Pseudo-Random Binary Sequences
- 2-1 Generation and Reception of ASK Signals
- 3-1 FSK Principles
- 3-2 Bell 202 Modem (1200 baud)
- 4-1 Generation and Demodulation of BPSK Signals
- 5-1 Troubleshooting an ASK Communication System
- 5-2 Troubleshooting an FSK Modem
- 5-3 Troubleshooting a BPSK Communication System

Quadrature Phase Shift Keying (QPSK/DQPSK) (Student Manual) (584891 (39865-00))
- 1 QPSK Modulation
- 2 QPSK Demodulation
- 3 Differential QPSK (DQPSK)
- 4 Data Scrambling and Descrambling
- 5 Troubleshooting a QPSK/DQPSK Modem

Quadrature Amplitude Modulation (QAM/DQAM) (Student Manual) (584895 (39866-00))
- 1 QAM Modulation
- 2 QAM Demodulation
- 3 Differential QAM (DQAM)
- 4 Data Scrambling and Descrambling
- 5 Troubleshooting a QAM/DQAM Modem

Quadrature Amplitude Modulation (QAM/DQAM) (Quick Start Guide) (584897 (39866-P0))
- 1 Using the Binary Sequence Generator and the Instruments
- 2 QAM Modulator
- 3 QAM Demodulator

Asymmetric Digital Subscriber Line (ADSL) (Student Manual) (584900 (39867-00))
- 1 ADSL Signal Spectral Analysis
- 2 ADSL Signal Generation
- 3 ADSL Signal Demodulation
- 4 Framing, Synchronization, and Error Detection
- 5 Forward Error Correction Using Reed-Solomon Codes
- 6 Data Interleaving
- 7 Convolutional Coding in ATU Transmitters

- *8* Trellis-Coded Modulation in ATU Transmitters
- *9* Viterbi Decoding in ATU Receivers

Asymmetric Digital Subscriber Line (ADSL) (Quick Start Guide) (584902 (39867-P0))
- *1* Using the ADSL Application

Spread Spectrum (DSSS/FHSS/CDMA) (Student Manual) (585064 (85031-00))
- 1-1 DSSS Signal Generation and Demodulation
- 1-2 Principles of Code-Division Multiple Access (CDMA)
- 1-3 Process Gain and Interference Rejection in DSSS Wireless Communication Systems
- 1-4 Synchronization – Acquisition and Tracking
- 1-5 Voice Transmission in CDMA Wireless Communication Systems
- 2-1 FHSS Signal Generation
- 2-2 FHSS Signal Demodulation
- 2-3 Interference Rejection in FHSS Wireless Communication Systems
- 2-4 Synchronization – Acquisition and Tracking

System Specifications

Parameter	Value
Power Requirements	
Current	3.5 A
Service Installation	Standard single-phase ac outlet
Computer Requirements	A currently available personal computer with USB 2.0 ports, including a 3D graphics card (dual-monitor support is recommended) and a fast Ethernet (100 Mb/s) network interface adapter, running under one of the following operating systems: Windows® 7 or Windows® 8.
Physical Characteristics	
Intended Location	On a table able to support the weight of the equipment
Dimensions (H x W x D)	370 x 680 x 530 mm (14.6 x 26.7 x 20.8 in)
Net Weight	TBE

Equipment Description

RTM Power Supply
593595 (9408-1X)

The RTM Power Supply is the power source for the Reconfigurable Training Module (RTM) used in the communications and radar training systems. It has two multi-pin connector outputs, located on the back panel, that provide regulated dc voltages. Each output can supply power to one RTM. Auto-reset fuses protect the outputs of the RTM Power Supply against short-circuits.

Front view

Rear view

Additional Equipment Required to Perform the Exercises

Qty	Description	Model number
1	Power Cord - Type F _____	789182 (93992-05) [3]
1	Power Cord - Type B _____	789405 (95451-00) [4]
1	Power Cord - Type I _____	789406 (95451-0A) [5]

Specifications

Parameter	Value
Power Requirements	
Service Installation	Standard single-phase ac outlet
Voltage	100-240 V ac
Current	2.0-3.5 A
Frequency	50/60 Hz
Rating of DC Power Outputs (2)	
+5 V	8 A / output
+3.3 V	7 A / output

[3] The power cord line is not included with stand-alone RTM Power Supply. Please add the right power cord line for the region. Note that when ordering a system, all power cord lines are included.

[4] The power cord line is not included with stand-alone RTM Power Supply. Please add the right power cord line for the region. Note that when ordering a system, all power cord lines are included.

[5] The power cord line is not included with stand-alone RTM Power Supply. Please add the right power cord line for the region. Note that when ordering a system, all power cord lines are included.

Parameter	Value
+12 V - A	5 A / output
+12 V - B	3 A / output
-12 V	0.75 A (both outputs)
-5 V	0.5 A (both outputs)
Physical Characteristics	
Dimensions (H x W x D)	165 x 250 x 250 mm (6.5 x 9.8 x 9.8 in)
Net Weight	5.6 kg (12.2 lb)

Reconfigurable Training Module (RTM)
## 587443 (9431-20)

The Reconfigurable Training Module (RTM) consists mainly of a powerful digital signal processor (DSP), with three slots on the module front panel for installing interface modules. An Ethernet port (RJ-45) connector, located on the back panel, allows connection of the RTM to the host computer. The functionality of the training system is determined by downloading a program into the DSP memory using the host computer that runs the software. Electrical power is supplied to the RTM by the Power Supply, Model 9408, through a multipin cable that connects to the back panel.

Specifications

Parameter	Value
Interface Card Slots	
Analog/Digital	2
Digital	1
Analog Inputs (4)	
Voltage Range	±10 V
Impedance	600 Ω
Analog Outputs (4)	
Voltage Range	±10 V
Impedance	600 Ω
A and B Auxiliary Outputs	
Voltage Range	±10 V
Impedance	600 Ω
C and D Auxiliary Outputs	
Voltage Range	±3.0 V
Impedance	8 Ω
Data Link to Host Computer	10 Mb/s (Ethernet) or 100 Mb/s (Fast Ethernet), TCP/IP Protocol
Physical Characteristics	
Dimensions (H x W x D)	215 x 430 x 280 mm (8.5 x 16.9 x 11.0 in)
Net Weight	9.8 kg (21.6 lb)

LVCT Software
581621 (9432-00)
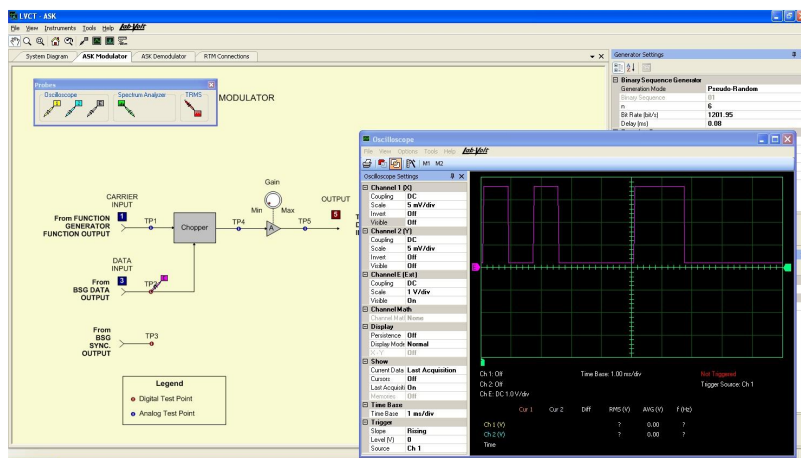
The Communications Technologies (LVCT) software provides a user interface for the system. Each different communications technology is presented as a separate application. On start-up, the user selects the desired application in the Application Selection dialog box. Then the LVCT software loads the signal processing routines used to implement that application in the RTM.

The main window of the software has a number of tabs each containing one diagram. Some diagrams show how the elements of the system are interconnected. The other diagrams show the functional blocks of the circuits that make up the application. Each circuit diagram includes a number of Test Points (TPs) and/or Test Busses (TBs) allowing the student to observe and measure the signals within the circuit using the virtual instruments included in the software. In some applications, Data Points (DPs) provide access to data in the form of editable or read-only tables.

The software includes the following virtual instruments (depending on the application):

- The Oscilloscope displays analog or digital signal waveforms.
- The Spectrum Analyzer displays the frequency spectrum of a signal.
- The True RMS Voltmeter measures the true RMS value of a signal.
- The Logic Analyzer records and displays the states of multiple digital signals.
- The ADSL application has two Constellation Viewers to display complex signal constellations.

The user interface includes tables of settings that allow changing various software parameters in order to control the system or to configure the virtual instruments and the generators (function generators and clock generators) provided in the applications. In addition, faults can be inserted into the circuits by the instructor for troubleshooting exercises. The Communications Technologies Training System User Guide, Model 39862-E0, is included with the LVCT Software.

Various application sets are available for the LVCT Software:

The following applications are enabled when the 9466 and 9467 RTM plug-ins are detected:

- PAM / PWM / PPM Applications
- PCM / DPCM / Delta Modulation Applications
- ASK / FSK / BPSK Applications
- QPSK / QAM / ADSL Applications

The following applications are enabled when the 9466, 9467 and 9468 RTM plug-ins are detected:

- DSSS / FHSS / CDMA Applications

* Please note that previous versions of the software used CD-ROMs to unlock the different applications. These CD-ROMs are not needed anymore as the applications are automatically enabled based on the detected RTM plug-ins.

Manual

Description	Manual number
Communications Technologies Training System (User Guide) _____	584879 (39862-E0)

Specifications

Parameter	Value
Virtual Oscilloscope	
Display Channels	3 (including External Trigger channel)
Channel Math	None, Ch 1 + Ch 2, Ch 1 – Ch 2
Memories	2
View modes	Single Refresh, Continuous Refresh
Display Mode	Normal, Dots
X-Y Mode	Yes
Persistence	Off, 2 Traces, 3 Traces, 4 Traces
Cursors	Off, Horizontal, Vertical, Both (Hor. Active), Both (Vert. Active)
Trigger Source	Ch 1, Ch 2, Ext
Scale Settings	5 mV/div to 5 V/div
Auto Scale	Yes
Time Base Settings	0.2 µs/div to 0.2 s/div
Virtual Spectrum Analyzer	
Memories	2
View modes	Single Refresh, Continuous Refresh
Averaging	Off, 2, 4, 8, 16
Cursors	Off, Horizontal, Vertical
Scale Type	Linear, Logarithmic
Maximum Input Settings	0.1 to 5 V Linear, -30 to 20 dBV Logarithmic
Scale Settings (Logarithmic)	1 to 10 dBV/div
Frequency Span Settings	2 to 20 kHz/div
Virtual True RMS Voltmeter	
Mode	Volts, dBm
View modes	Single Refresh, Continuous Refresh
Range Settings	10 mV to 10 V
Virtual Logic Analyzer	
Display Width	0.001 to 1000 ms
Data Channels	8
Symbol Channels	2
Record Buffer Length	256 clock cycles
Cursors	Off, On
Virtual Constellation Viewer (ADSL)	
Grid	None, Position, Limit
Axes	Off, On
Persistence	None, 5, 10, 15
Tone	0 to 31
Computer Requirements	The LVCT software requires a currently available personal computer with USB 2.0 ports, including a 3D graphics card (dual-monitor support is recommended) and a fast Ethernet (100 Mb/s) network interface adapter, running under one of the following operating systems: Windows® 7 or Windows® 8.

Data Acquisition Interface
581692 (9466-00)

The Data Acquisition Interface is a compact module designed to be installed into one of the slots of the Reconfigurable Training Module (RTM), Model 9431-1. This module provides input connectors for analog and digital signals so they can be processed by the RTM. It has two input BNC connectors for analog signals and four for digital signals. These inputs are protected from misconnections within the system. Test points on the module front panel facilitate the observation of these signals using a conventional oscilloscope. DC power is automatically supplied to the Data Acquisition Interface when it is installed in the RTM.

Specifications

Parameter	Value
Analog Inputs (2)	
Voltage Range	-1.5 to +1.5 V
Impedance	10 kΩ
Digital Inputs (4)	
Type	TTL
Test Points	
Quantity	6
Physical Characteristics	
Dimensions (H x W x D)	114 x 110 x 209 mm (4.5 x 4.3 x 8.2 in)
Net Weight	0.6 kg (1.4 lb)

Analog/Digital Output Interface
581693 (9467-00)

The Analog/Digital Output Interface is a compact module designed to be installed into one of the slots of the Reconfigurable Training Module (RTM), Model 9431-1. This module provides output connectors for analog and digital signals generated by the RTM. It has four output BNC connectors for analog signals and four for digital signals. These outputs are protected from misconnections within the system. Test points on the module front panel facilitate observing the signals using a conventional oscilloscope. DC power is automatically supplied to the Analog/Digital Output Interface when it is installed into the RTM.

Specifications

Parameter	Value
Analog Outputs (4)	

Parameter	Value
Voltage Range	-10 to +10 V
Impedance	600 Ω
Digital Outputs (4)	
Type	TTL
Test Points	
Quantity	8
Physical Characteristics	
Dimensions (H x W x D)	114 x 110 x 209 mm (4.5 x 4.3 x 8.2 in)
Net Weight	0.6 kg (1.4 lb)

Vocoder
581694 (9468-00)

The Vocoder is a compact module designed to be installed into one of the slots of the Reconfigurable Training Module (RTM), Model 9431-1. It allows the study of digitized voice transmission in a CDMA environment using reduced data rates, with or without forward error correction (FEC). This module uses two voice encoders to simultaneously encode two audio channels and uses one voice decoder to decode the selected channel. Each voice encoder has a 1/4-inch audio input jack, allowing two microphones (included) to be used as audio sources. The voice decoder has two 2.5 mm audio output jacks for headphones (included), allowing two people to hear the decoded voice signal. BNC connectors are also provided for data and clock outputs and inputs.

Specifications

Parameter	Value
Net bit rates (FEC off/FEC on)	2050/3600, 2400/3600, and 2750/3600 bits
Output bit rate (including zero padding)	4097.5 bits
Audio Inputs (2)	
Voltage range	±100 mV
Impedance	5 kΩ
Audio Outputs (2)	
Voltage range	±1.4 V
Impedance	32 kΩ
Digital Inputs (2)	
Type	TTL
Digital Outputs (4)	
Type	TTL
Physical Characteristics	
Dimensions (H x W x D)	114 x 110 x 209 mm (4.5 x 4.3 x 8.2 in)
Net Weight	0.6 kg (1.4 lb)

Cables and Accessories
581797 (9483-00)

The Cables and Accessories set contains BNC cables for making external connections to the interface modules in the Reconfigurable Training Module (RTM), a USB cable, an RJ-45 crossover connector cable, and an Ethernet adapter (network card) to be installed in the host computer.

Power Cord - Type B
789405 (95451-00)

Optional Equipment Description

Dual Trace Oscilloscope (Optional)
580849 (797-20)

The Dual Trace Oscilloscope is an economical and highly reliable solid-state instrument, ideal for general-purpose use in laboratory and training applications. Students can measure phase difference between waveforms using the X-Y operation mode, and video signals can be measured quickly with the special TV sync separation circuit. The Dual Trace Oscilloscope includes CH 1, CH 2, CHOP, and ALT display modes. An operating instruction manual, one fuse, one line cord, and two low-capacitance probes are provided with the oscilloscope.

Features & Benefits

- 15 cm (6 inch) width, high luminance CRT with internal graticule, 8 x 10 divisions
- Wide dynamic range even at high frequencies of −3 dB
- Fast rise time with low overshoot
- Flat frequency response up to half of −3 dB frequency
- Alternate and chopping display
- Polarity inversion and algebraic sum of CH1 and CH2

- Maximum sweep rates of 20 ns/div.
- Variable scale illumination
- Delayed sweep function with minimum delay time jitter of 1/20,000 or less
- Jitterless and superb trigger sensitivity
- TV sync separation and hold-off circuit useful for video signal observation
- Brightness modulation available with Z-axis input
- Low drift with compensation circuitry
- Signal delay with delay line useful for observation of signal leading edge
- X-Y phase difference measurement up to 50 kHz

Specifications

Parameter	Value
Power Requirements	
Current	0.4 A
Service Installation	Standard single-phase ac outlet
CRT Display	
Type	15.24 cm (6 in) rectangular, internal graticule, scale illumination
Effective Area	8 x 10 div (1 div = 1 cm)
Acceleration Potential	12 kV
Vertical Deflection	
Sensitivity	5 mV/div to 5 V/div in 10 calibrated steps ±3%
	1 mV/div to 1 V/div ±5% when using x5 magnifier
	Uncalibrated continuous control between steps 1:‹2.5
Bandwidth	DC to 40 MHz (-3 dB); dc to 7 MHz (-3 dB) when using x5 magnifier
Rise Time	Less than 8.8 ns
Maximum Input	300 V (dc + ac peak) or 500 V p-p ac at 1 kHz or less
Input Coupling	AC, GND, DC
Input Impedance	1 meg in parallel with 25 pF
Operating Modes	CH1, CH2 (INVERT), ADD, DUAL (CHOP: Time/div sw 0.2 s - 5 ms; ALT: Time/div sw 2 ms - 0.2μs)
X-Y Operation	CH1: X-axis, CH2: Y-axis
Horizontal Deflection	
Display	A, A int B, B, B triggered, X-Y
Time Base A	0.2 μs/div to 0.2 s/div in 19 calibrated steps ±3% uncalibrated continuous control between steps at least 1:‹2.5
Time Base B	0.2 μs/div to 20 μs/div in 7 calibrated steps ±3%
Trigger	
Modes	Auto, Norm, TV-V, TV-H
Coupling	AC
Sources	CH 1, CH 2, LINE, EXT
Sensitivity (Internal Source)	0.5 div (20 Hz to 2 MHz), 1.5 div (2 MHz to 40 MHz)
Sensitivity (External Source)	200 mV (20 Hz to 2 MHz), 800 mV (2 MHz to 20 MHz)
Slope	+ or -
TV Sync	Polarity: TV (-)
Calibrator	1 kHz, square wave, 0.5 ±3%, duty cycle: 50%
Accessories	Power cable, fuse, operation manual, 2 probes
Physical Characteristics	
Dimensions (H x W x D)	140 x 320 x 430 mm (5.5 x 12.6 x 16.9 in)
Net Weight	5.7 kg (12.57 lb)

Communications Technologies Host Computer (Optional) 587467 (9695-A0)

The Communications Technologies Host Computer is a Pentium-type personal computer running under a Windows® operating system with the LVCT software preinstalled. A dual-output display adapter (video card) and two color monitors are included. This Host Computer is linked to the Reconfigurable Training Module (RTM) through a high-speed data link (Ethernet link with TCP/IP protocol).

Communications Technologies Training System (Manuals on CD-ROM) (Optional)
584877 (39862-A0)

List of Manuals

Description	Manual number
Pulse Modulation and Sampling (PAM / PWM / PPM) (Student Manual)	591398 (39862-00)
Pulse Modulation and Sampling (PAM / PWM / PPM) (Instructor Guide)	591400 (39862-10)
Communications Technologies Training System (User Guide)	591402 (39862-E0)
Digital Modulation (PCM / DPCM / Delta) (Student Manual)	591404 (39863-00)
Digital Modulation (PCM / DPCM / Delta) (Instructor Guide)	591406 (39863-10)
Basic Modems and Data Transmission (ASK / FSK / BPSK) (Student Manual)	591408 (39864-00)
Basic Modems and Data Transmission (ASK / FSK / BPSK) (Instructor Guide)	591410 (39864-10)
Quadrature Phase Shift Keying (QPSK/DQPSK) (Student Manual)	591412 (39865-00)
Quadrature Phase Shift Keying (QPSK/DQPSK) (Instructor Guide)	591414 (39865-10)
Quadrature Amplitude Modulation (QAM/DQAM) (Student Manual)	591416 (39866-00)
Quadrature Amplitude Modulation (QAM/DQAM) (Instructor Guide)	591418 (39866-10)
(Quick Start Guide)	591420 (39866-P0)
Asymmetric Digital Subscriber Line (ADSL) (Student Manual)	591421 (39867-00)
Asymmetric Digital Subscriber Line (ADSL) (Instructor Guide)	591423 (39867-10)
Asymmetric Digital Subscriber Line (ADSL) (Quick Start Guide)	591425 (39867-P0)
Spread Spectrum (DSSS/FHSS/CDMA) (Student Manual)	591615 (85031-00)
Spread Spectrum (DSSS/FHSS/CDMA) (Instructor Guide)	591617 (85031-10)

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