



KL-910

Advanced Communication System



KL-910 is a modular trainer with various advanced communication experiments including digital encoding/decoding, modulation/demodulation and related multiplexing techniques. It's developed for bridging the gap between the theory and the practice of the modern communication system.

● Features

1. Essential theories and techniques in modern communication system including digital encoding/decoding techniques, various digital serial ports, DTMF signal system, ASK/FSK/QPSK/TDM/PAM/FDM modulation/demodulation and filters...etc.
2. KL-910 offers users not only the comprehensive experiments of advanced communication system but also various peripherals including analog/digital function generator, frequency meter, and V-F converter...etc. All of the experiments are carried out appropriately with the help of oscilloscope, spectrum analyzer and logic analyzer.

● Specifications

KL-96001 Main Unit

1. Dual Function Generators

- (1) Output waveform : sine, triangle, square and TTL level signal
- (2) Output voltage
 - a. 1Hz~50KHz : 0~20Vpp, continuously adjustable
 - b. 50KHz~200KHz : 0~16Vpp, continuously adjustable
 - c. 200KHz~500KHz : 0~10Vpp, continuously adjustable
- (3) Output frequency : 6 range, selectable
 - a. 1Hz~10Hz, continuously adjustable
 - b. 10Hz~100Hz, continuously adjustable
 - c. 100Hz~1KHz, continuously adjustable
 - d. 1KHz~10KHz, continuously adjustable
 - e. 10KHz~100KHz, continuously adjustable
 - f. 100KHz~500KHz, continuously adjustable

All above ranges are adjusted by a 10-turn fine tuning knob

- (4) AM modulation signal
 - a. Input amplitude : 0~5Vpp
 - b. Input frequency range : 1Hz~100KHz
 - c. Percentage modulation : 80%
 - d. Output : AM amplitude continuously adjustable
- (5) FM modulation signal
 - a. Input amplitude : 0~5Vpp
 - b. Input Impedance : 10K Ω
 - c. Maximum modulation ratio : 50:1
- (6) FSK modulation signal
 - a. Input impedance : 10K Ω
 - b. Input $\leq 0.7V$ for low level, adjustable output frequency
Input $\geq 3V$ for high level, fixed output frequency

2. V/F Converter

- (1) Input voltage : 0~20V
- (2) Output frequency : 0~20KHz
- (3) Conversion ratio : 1V=1KHz

3. Adjustable DC Power Supply

- (1) Output voltage : 0~20V, continuously adjustable
- (2) Max. output current : 100mA with overload protection

4. Fixed DC Power Supply

- (1) Output voltage : +5V, -5V (rated current 500mA)
- (2) Output voltage : +12V, -12V (rated current 500mA)

5. Universal Frequency/Period Counter

- (1) Function : logic probe, frequency, period, pulse width
- (2) Input frequency range (F) : 1Hz~99.999999MHz
10Hz~100.000000MHz
- (3) Input period range (TH&TL) : 0.01 μ s~999999.99 μ s
1 μ s~99999999 μ s
- (4) Input level : TTL, analog signal ($V_{in} \geq 2.2V_{pp}$)
- (5) Sampling time : 1sec & 0.1sec
- (6) Display : 8-digit, 7-segment display

6. Power Input

- 90V ~ 230V AC, 50Hz/60Hz



KL-96002 Clock/Data & Noise Generator

1. Clock Generator
 - (1) Standard clock generator : 1MHz, 100KHz, 20KHz, 10KHz, 2KHz, 1KHz
 - (2) Adjustable OSC. : 10Hz ~ 100KHz
 - (3) Manual pulse generator
2. Data Synchronous Clock Generator
3. Sequential Data Generator
 - (1) Sequence length : 64, 256, 1024, 2048
 - (2) 16 bits parallel data output is displayed by LEDs.
 - (3) 1- bit serial data output is available per input clock, TTL compatible, MSB first.
 - (4) 2-bits (even bit+odd bit) serial data output is available per two input clocks.
4. Random Data Generator
 - (1) Use 3-bit DIP switch to select a 16-bit random seed
 - (2) 1- bit random data output is available per input clock, TTL level.
 - (3) 8-bit parallel random data output is available per input clock, TTL level.
 - (4) R-2R DAC & buffer for noise generator
5. 3-bit Unipolar to Bipolar
 - (1) Input : UNI-A, UNI-B, UNI-C, TTL level
 - (2) Output : HI = +3.3V, LO = -3.3V

KL-96003 Line-Code Encoder & Decoder

1. Line-Code Encoder
 - (1) Data bit clock generator : $F_{max} \leq 1\text{MHz}$
Standard clock generator : 1MHz, 100KHz, 20KHz, 10KHz, 2KHz, 1KHz
 - (2) Data bit generator
 - (3) Data & clock is reset by external pulse or pushbutton.
 - (4) Signal level unipolar : 0, +3V
Bipolar : -3V, +3V
3-level : -3V, 0, +3V
 - (5) Standard TTL data is encoded using following line-code schemes :
 - a. NRZ-L(BIP) b. NRZ-M(BIP) c. UNI-RZ(UNI)
 - d. BIP-RZ(3L) e. RZ-AMI(3L) f. BI Φ -L(Manchester 3L)
 - g. DICODE-NRZ(3L)
2. Line-Code Decoder
 - (1) Line decoder clock
 - (2) Line decoder data input
 - a. NRZ-L(BIP) b. NRZ-M(BIP) c. UNI-RZ(UNI)
 - d. BIP-RZ(3L) e. RZ-AMI(3L) f. BI Φ -L(Manchester 3L)
 - g. DICODE-NRZ(3L)
 - (3) Line decoder data : independently output, TTL level
 - a. NRZ-L b. NRZ-M c. UNI-RZ
 - d. BIP-RZ e. RZ-AMI f. BI Φ -L
 - g. DICODE-NRZ

KL-96004 Delta/Sigma/Adaptive Modulation&Demodulation

1. Delta Modulation
 - (1) Sample clock selected by DIP switch
 - (2) Data sample control output
 - (3) 4-bit DAC(R-2R buffer) for adaptive delta modulation
 - (4) Unipolar to bipolar level shift
Input : 0 ~ +3V ; Output : -3V ~ +3V
 - (5) Integrator
 - a. Input : bipolar signal
 - b. Frequency range : 400Hz ~ 10KHz

- (6) Hard limiter
 - a. Zero crossing detector with threshold voltage of 0V
 - b. Frequency range : 100Hz ~ 100KHz
- (7) SUM. & SUB.
- (8) Multiplier : for adaptive delta voltage control amplitude(VCA)

2. Delta Demodulation

- (1) Data sample control output
- (2) 4-bit DAB(R-2R buffer) for adaptive delta modulation
- (3) Unipolar to bipolar level shift Input : 0 ~ +3V,
Output : -3V ~ +3V
- (4) Integrator
 - a. Input : bipolar signal
 - b. Frequency range : 400Hz ~ 10KHz
- (5) RC LPF
Adjustable cut-off frequency : 2KHz ~ 20KHz

KL-96005 QPSK Modulation&QPSK Demodulation

1. QPSK-8PSK-8QAM Modulation

- (1) Data modulation source
16 bits parallel DIP switch data input
- (2) Modulation function 8PSK, 8QAM, QPSK
- (3) Unipolar to bipolar level shift
- (4) Amplitude modulation
- (5) I modulation multiplier
- (6) Q modulation multiplier
- (7) Linear adder QPSK (shift $\pi/4$)
- (8) Mode selector QPSK (No shift)
- (9) 8PSK modulation
- (10) 8QAM modulation

2. QPSK Demodulation

- (1) Signal squarer
- (2) Hard limiter
Zero crossing detector with threshold voltage of 0V
- (3) Phase locked loop (PLL)
- (4) Frequency divider
- (5) IQ-splitter
- (6) I- level discrimination
- (7) Q- level discrimination
- (8) Serial to parallel converter

KL-96006 DTMF Generator & Decoder/Controller

1. DTMF Generator

- (1) Scan keypad & display:
 - a. Input : 4x4 keypad
 - b. Scan display : 8-digit 7-segment display & LCDM 20 x 2
- (2) DTMF generator
- (3) 100 sets phone number storage

2. DTMF Decoder

- (1) Ring detector
- (2) DTMF decoder
 - a. DTMF decoder number display : LCDM 20 x 2
 - b. DTMF code compare with 2 LED output
- (3) DTMF code controller

Remark: 1. DTMF generator and DTMF decoder share the same LCDM.

2. To carry out more experiment computer is essential but extra.

KL-96007 Multi-Function Process Module (A)

1. Quadrature Audio Generator
Frequency range : 300Hz ~ 10KHz
2. Quadrature Phase Splitter
Input frequency range : 200Hz ~ 10KHz



3. Phase Shifter

- (1) Frequency range : high approx. 100KHz, low approx. 2KHz for 0 ~ 360 degrees of phase shift.
- (2) Coarse adjustment 0 ~ 180 degrees shift
- (3) Fine adjustment approx. 20 degrees shift

4. Tunable LPF & 2 Sets of Counter

- (1) Filter corner-frequency display :
2 range setting & 4-digit 7-segment display
Normal : 0.1Hz ~ 2.5KHz
Wide : 10Hz ~ 25KHz
- (2) LPF cut-off frequency attenuation > 60 dB
- (3) Width band VCO
- (4) External frequency counter range
High range : 1KHz ~ 9999KHz
Low range : 0.1KHz ~ 999.9KHz

5. 4-Channel Analog Multiplexer

- (1) Each channel DC offset : +6V, +2V, -2V, -6V
- (2) Input channel : 4 channels
- (3) Bandwidth : DC ~ 2MHz
- (4) Synchronous frequency
ALT : 1KHz ~ 500KHz
CHOP : 10Hz ~ 1KHz

KL-96008 Multi-Function Process Module (B)

1. Triple Analog Switch & Switch Sequencer Counter & TDM Modulation

- (1) Analog input bandwidth : DC ~ 300KHz
- (2) Control input level : TTL level

2. Dual Multiplier

- (1) Input gain : 1 ~ 5 adjustable
- (2) Bandwidth approx. DC ~ 1MHz
- (3) Offset Z : 0 ~ ±5V adjustable

3. TTL to Bipolar & Subtractor/Adder

- (1) Three sets of TTL to bipolar :
input TTL level, output -3V ~ +3V
- (2) Bandwidth approx. DC ~ 1MHz

4. Power Amplifiers & DIF. ENC./DEC.

- (1) Amplifier bandwidth : DC to approx. 1MHz
- (2) 8-bit DIP switch data for differential encoder & decoder

5. Dual RC LPF

- Corner frequency(-3dB) :
- LB : 100Hz ~ 1KHz
- HB : 1KHz ~ 10KHz continuously adjustable

6. Dual Voltage Level Comparator

- (1) Input analog level : 0 ~ ± 3V
- (2) Level adjustment : 2 level variable
Vcph : +5V ~ -4V, Vcpl : -5V ~ +4V
- (3) TTL level inverter

KL-93006 TDM & PAM-TDM Multiplexer / Demultiplexer

1. TDM Multiplexer

- (1) Audio signal generator
 - a. Triangle generator : 100Hz ~ 15KHz, 6Vpp
 - b. Square generator : 100Hz ~ 15KHz, 6Vpp
 - c. Sine generator : 800Hz ~ 65KHz, 6Vpp

(2) Analog Switch Multiplexer

- a. TDM channel : channel A, B, C 3 port
- b. TDM switch frequency : 1MHz, 50KHz, 5KHz, 1KHz
- c. TDM frame generator :
 - I . FSYNO : TDM frame synchronously transmit pulse, TTL level
 - II . FCLKX : TDM transmit data clock, TTL level
 - III . FSX : TDM data frame transmit synchronous pulse, TTL level
- d. TDM frame auto start level for synchronization, TTL Level

2. High Speed Analog PAM-TDM Multiplexer

Audio signal PAM-TDM simultaneous multiplexer

3. Multichannel TDM Simultaneous Demultiplexer

- (1) Analog switch demultiplexer
 - a. TDM mixed signal level : 6Vpp
 - b. Switch voltage level : 6Vpp
 - c. TDM switch frequency : 1MHz, 50KHz, 5KHz, 1KHz
 - d. FSYNI : TDM start frame (input TTL level)
 - e. Auto start frame detector : TTL level
- (2) TDM demultiplexer output : channel A, B, C 3 port
- (3) TDM frame receiver counter : F0 ~ F7 (8-bit LED)

KL-93007 FDM Multiplexer / Demultiplexer

1. FDM Multiplexer

- (1) FDM multiplexer channel : channel A, B, C 3 port
- (2) Wien bridge audio signal generator
 - a. Variable sine generator : 2KHz ~ 50KHz, 0 ~ 6Vpp
 - b. Fixed sine generator : 3.3KHz, ± 10%, 0 ~ 6Vpp
 - c. Fixed sine generator : 1KHz, ± 10%, 0 ~ 6Vpp
- (3) Hartley carrier signal generator
 - a. Adjustable carrier generator : 450KHz ~ 550KHz, 0 ~ 6Vpp
 - b. Adjustable carrier generator : 270KHz ~ 330KHz, 0 ~ 6Vpp
 - c. Fixed carrier generator : 100KHz, ± 5%, 0 ~ 6Vpp
- (4) AM modulator
 - a. Carrier signal : 100KHz ~ 500KHz
 - b. Audio signal : 1KHz ~ 20KHz
 - c. Modulation rate & level : 10% ~ 100%
 - d. FDM high bandwidth SUM : 1Hz ~ 1MHz

2. FDM Demultiplexer

- (1) FDM demultiplexer channel : channel A, B, C 3 port
- (2) AM band tune
Carrier bandpass filter BPF : 3 channel input (3Vpp)
Channel A : 500KHz Adj. ± 20%, BW : 100KHz, ± 10%
Channel B : 300KHz Adj. ± 20%, BW : 100KHz, ± 10%
Channel C : 100KHz Adj. ± 20%, BW : 100KHz, ± 10%
- (3) AM demodulator
 - a. AM rectifier
 - b. Adjusting LPF
LPFA : Min. : 1KHz Adj. ± 20%, Max. : 30KHz Adj. ± 20%
LPFB : Min. : 1KHz Adj. ± 20%, Max. : 30KHz Adj. ± 20%
LPFC : Min. : 250Hz Adj. ± 20%, Max. : 2.5KHz Adj. ± 20%
- c. FDM demultiplexer audio signal output :
Channel A : Sine (3KHz ~ 20KHz, ± 10%)
Channel B : Sine (3KHz, ± 10%)
Channel C : Sine (1KHz, ± 10%)



KL-93008 Signal Converter/Recovery/Regeneration

1. Quadrature Audio Generator
 - (1) Frequency range : 300Hz ~ 10KHz
 - (2) Analog output level : 7Vpp
 - (3) Analog output : $\sin(\omega t)$, $\cos(\omega t)$
 - (4) Analog distortion : $< 0.1\%$
 - (5) Digital output : TTL, TTL with 90° phase shift
2. Up/Down Frequency Converter
 - (1) Multiplier
 - a. Frequency A input : 10KHz ~ 1MHz
 - b. Frequency B input : 10KHz ~ 1MHz
 - (2) Second order LPF down converter : 1KHz ~ 120KHz
 - (3) Second order HPF up converter : 330KHz ~ 1MHz
 - (4) External input LPF & HPF for other up / down converter
3. Carrier Signal Recovery
 - (1) Up converter for double carrier input : $V_{in}(\text{Min.}) : 0.5V_{pp}$
 - (2) PLL & PLL/2
 - (3) Adjustable second order LPF : remove harmonic for carrier (sine) signal recovery
 - (4) Adjust phase shift : $0 \sim 150$ degrees phase shift
4. Synchronous Clock Recovery
 - (1) Manchester encoder enclosed synchronous signal
 - (2) Clock XOR and clock delay for clock periodic detector
 - (3) PLL for synchronous clock recovery output

List of Modules



KL-96001



KL-96002



KL-96003



KL-96004



KL-96005



KL-96006



KL-96007



KL-96008



KL-93006



KL-93007



KL-93008

List of Experiments

1. Main Unit (KL-96001)
 - (1) Signal measurement and experiment
 - (2) Signal modulating experiment
 - (3) Voltage to frequency converter
 - (4) Frequency and period measuring experiment
2. Clock / Data & Noise Generator (KL-96002)
 - (1) Measurement of clock generator
 - (2) Measurement experiment for synchronous data clock
 - (3) Detection of the data sequence output
 - (4) Measurement experiment of single-to-dual parallel output
 - (5) Measurement experiment for digital random number generator and analog noise generator
 - (6) Experiment of 3-bit unipolar to bipolar conversion
3. Line-Code Encoder & Decoder (KL-96003)
 - (1) Experiment with serial data sequence
 - (2) NRZ-L/BIP (None return to zero) encoding
 - (3) NRZ-M/BIP (None return to zero mark) encoding
 - (4) UNI-RZ/UNI (Unipolar return to zero) encoding
 - (5) BIP-RZ/3L (3 Level) encoding
 - (6) RZ-AMI/3L encoding
 - (7) Bi Φ -L/3L (Manchester) encoding
 - (8) DICODE-NRZ (3L) encoding
 - (9) NRZ-L/BIP decoding
 - (10) NRZ-M/BIP decoding
 - (11) UNI-RZ/UNI decoding
 - (12) BIP-RZ/3L decoding
 - (13) RZ-AMI/3L decoding
 - (14) Bi Φ -L/3L(Manchester) decoding
 - (15) DICODE-NRZ (3L) decoding
4. Delta/Sigma/Adaptive Modulation & Demodulation(KL-96004)
 - (1) Experiment of delta modulation
 - (2) Experiment on the LPF of delta modulator
 - (3) Experiment of delta demodulation
 - (4) Adaptive-delta modulation & demodulation circuits
 - (5) Experiment on controlling voltage amplitude of integrator of adaptive-delta modulator/demodulator
 - (6) Experiment on controlling voltage amplitude of integrator of VGA adaptive-delta modulator/demodulator
 - (7) Experiment on delta-sigma modulation circuit
5. QPSK Modulation & QPSK Demodulation(KL-96005)
 - (1) Experiment on nPSK modulation sinusoidal signal source & synchronization data source
 - (2) Experiment on sinusoidal signal measurement with phase shift circuit
 - (3) Experiment on quadrature phase splitter
 - (4) Experiment on BPSK analog signal modulation
 - (5) Experiment on BPSK demodulation



- (6) Experiment on synchronization of BPSK demodulation signal with SIN TTL and carrier signal restoring
 - (7) Experiment on QPSK modulation
 - (8) Experiment on 8PSK modulation
 - (9) Experiment on 8QAM modulation
 - (10) Experiment on QPSK demodulation with signal sampling identification
6. DTMF Generator & Decoder/Controller (KL-96006)
- (1) Keypad scanning & dialing experiments of DTMF
 - (2) Storage and dialing of phone number on DTMF system
 - (3) Demodulation experiment using internal DTMF signal
 - (4) Password setting & decoding experiment using internal DTMF
 - (5) Password setting & decoding experiment using external phone-line DTMF
 - (6) DTMF control experiment using UART
7. Multi-Function Process Module(A) (KL-96007)
Multi-Function Process Module(B) (KL-96008)
- (1) Experiment with VCO and LPF
 - (2) Experiment on LPF frequency response
 - (3) Experiment of transforming Square waveform into sinusoidal waveform using LPF
 - (4) Experiment on triple-state analog multiplexer and TDM
 - (5) Experiment on four-channel analog multiplexer with level shift configuration
 - (6) Experiment on AM and double-side-band modulation
 - (7) Experiment on SSB (Single-side-band) AM modulation
 - (8) Experiment on AM Demodulation
 - (9) The generation of accurate 45-degree phase shift
 - (10) Experiment on BPSK and QPSK modulations
 - (11) Experiment on BPSK demodulation
 - (12) Level comparator
 - (13) Experiment on Power amplifier
 - (14) Experiment on ASK modulation
 - (15) Experiment on ASK demodulation
 - (16) Experiment on FSK modulation
 - (17) Experiment on FSK modulation using VCO
 - (18) Experiment on the Built-in FSK modulation function of function generator
 - (19) Experiment on FSK modulation using digital VCO
 - (20) Experiment on the conversion from FSK to ASK
 - (21) Experiment on FSK demodulation by Multiplying by f1 or f2
 - (22) Experiment on FM modulation
 - (23) Experiment on FM demodulation
 - (24) Experiment on digital difference encoding
 - (25) Experiment on digital difference decoding
 - (26) Experiment on DBPSK modulation
 - (27) Experiment on DQPSK modulation

8. Time-Division Multiplexing(TDM)/Pulse-Amplitude Modulation(PAM)(KL-93006)
 - (1) Analog-multiplexer modulating experiment
 - (2) Analog-multiplexer demodulating experiment
 - (3) Analog-multiplexing TDM modulating experiment
 - (4) Analog-multiplexing TDM demodulating experiment
9. Frequency Division Multiplexing (KL-93007)
 - (1) FDM multiplexer experiment
 - (2) BPF characteristics of FDM demultiplexer
 - (3) 3-channel FDM demultiplexer experiment
10. Frequency Converter, Carrier Frequency Recovery and Manchester Clock Regeneration (KL-93008)
 - (1) Frequency-up and frequency-down experiments
 - (2) Carrier frequency recovery experiment
 - (3) Manchester encoder / decoder and clock regeneration experiment

● Accessories(KL-98005)

1. Connection Leads and Plugs x 1 set
2. Storage Cabinet x 2 sets (KL-99001)
3. Experiment Manual x 1 pce

Optional Accessories

1. Rack Frame (KL-89003)
2. Digital Storage Oscilloscope with FFT
3. 1GHz Logic Analyzer (16Channel, 200MHz, PC-based)