



## KL-910

### Advanced Communication System



\* Notebook, Oscilloscope and Logic analyzer are excluded.

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

#### ► Features

- Various essential theories and techniques in modern communication system includes digital encoding/decoding techniques, various digital serial ports, DTMF signal system, ASK/FSK/QPSK/TDM/PAM/FDM modulation/demodulation and filters...etc.
- 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. 1 Hz~50 KHz : 0~20 Vpp continuously adjustable
  - b. 50 KHz~200 KHz : 0~16 Vpp continuously adjustable
  - c. 200 KHz~500 KHz : 0~10 Vpp continuously adjustable
- (3) Output frequency : 6 Range, selectable
  - a. 1 Hz~10 Hz continuously adjustable
  - b. 10 Hz~100 Hz continuously adjustable
  - c. 100 Hz~1 KHz continuously adjustable
  - d. 1 KHz~10 KHz continuously adjustable
  - e. 10 KHz~100 KHz continuously adjustable
  - f. 100 KHz~500 KHz continuously adjustable

All above ranges are adjusted by a 10-turn fine tuning knob
- (4) AM modulation input
  - a. Input amplitude : 0~5 Vpp
  - b. Input frequency range : 1 Hz~100 KHz
  - c. Percentage modulation : 80%
  - d. Output : AM amplitude continuously adjustable

###### (5) FM modulation input

- a. Input amplitude : 0~5 Vpp
- b. Input Impedance : 10 K $\Omega$
- c. Maximum modulation ratio : 50:1

###### (6) FSK modulation input

- a. Input impedance : 10 K $\Omega$
- 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 : 0~20 V
- (2) Output frequency : 0~20 KHz
- (3) Conversion ratio : 1 V=1 KHz

###### 3. Adjustable DC power supply

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

###### 4. Fixed DC power supply

- (1) Output voltage : +5 V, -5V (rated current 500 mA)
- (2) Output voltage : +12V, -12V (rated current 300 mA)

###### 5. Universal frequency/period counter

- (1) Function : Logic Probe/Frequency/Period/Pulse Width
- (2) Input frequency range (F) : 1 Hz~99.999999 MHz  
10 Hz~100.000000 MHz
- (3) Input period range (TH&TL) : 0.01  $\mu$ s~999999.99  $\mu$ s  
1  $\mu$ s~99999999  $\mu$ s
- (4) Input level : TTL, Analog signal ( $V_{in} \geq 2.2V_{pp}$ )
- (5) Sampling time : 1 sec & 0.1 sec
- (6) Display : 8-digit, 7-Segment display

###### 6. Power input

##### KL-96002 Clock/Data & Noise Generator

###### 1. Clock generator

- (1) Standard clock generator : 1 MHz, 100 KHz, 20 KHz,  
10 KHz, 2 KHz, 1 KHz
- (2) Adjustable OSC. : 10 Hz~100 KHz
- (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 : 0V, +3V  
Bipolar : -3V, +3V  
3-level : -3V, 0V, +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 $\Phi$ -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 $\Phi$ -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 $\Phi$ -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 : 0V ~ +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: 0V ~ +3V,  
Output: -3V ~ +3V
- (4) Integrator  
a. Input : bipolar signal  
b. Frequency range : 400Hz ~ 10KHz
- (5) RC LPF  
Cut-off frequency is adjustable in : 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

### KL-96006 DTMF Generator & Decoder/Controller

#### 1. DTMF generator

- (1) Scan keypad & display:  
a. Input : 4x4 keypad  
b. Scan display : 8-digit seven segment display & LCDM 20 \*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 \*2  
b. DTMF code compare with 2 LED output
- (3) DTMF code controller  
(Note : DTMF generator and DTMF decoder share a same LCDM)

### 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 : Hi approx. 100KHz, Lo approx. 2KHz for 0 to 360 degrees of phase shift.
- (2) Coarse adjust 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  
Hi range : 1KHz ~ 9999KHz  
Lo 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 : 0V~±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 : 0V~±3V
- (2) Level adjustment : 2 level variable  
V<sub>cph</sub> : +5V~-4V, V<sub>cpl</sub> : -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%  
LPC : 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 : Vin(min) : 0.5Vpp
- (2) PLL & PLL/2
- (3) Adjustable second order LPF : Remove harmonic for carrier (sine) signal recovery
- (4) Adjust phase shift : 0~150 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)

- 1-1 Signal measurement and experiment
- 1-2 Signal modulating experiment
- 1-3 Voltage to frequency converter
- 1-4 Frequency and period measuring experiment
- 1-5 DC power supply experiment

### 2. Clock / Data & Noise Generator (KL-96002)

- 2-1 The measurement of clock generator
- 2-2 Measurement experiment for synchronous data clock
- 2-3 The detection of the data sequence output
- 2-4 The measurement experiment of single-to-dual parallel output
- 2-5 The measurement experiment for digital random number generator and analog noise generator
- 2-6 The experiment of 3-bit unipolar to bipolar conversion

### 3. Line-Code Encoder & Decoder (KL-96003)

- 3-1 Test and experiment with serial data sequence
- 3-2 NRZ-L/BIP (Non-return-to-zero) encoding experiment
- 3-3 NRZ-M/BIP (Non-return-to-zero mark) encoding experiment
- 3-4 UNI-RZ/UNI (Unipolar-return-to-zero) encoding experiment
- 3-5 BIP-RZ/3L (3 Level) encoding experiment
- 3-6 RZ-AMI/3L (return-to-zero alternate mark inversion) encoding experiment
- 3-7 Bi $\Phi$ -L/3L bipolar manchester encoding experiment
- 3-8 DICODE-NRZ(3L) (di-code non-return-to-zero) encoding Experiment
- 3-9 NRZ-L/BIP (Non-return-to-zero) decoding experiment
- 3-10 NRZ-M/BIP (Non-return-to-zero mark) decoding experiment
- 3-11 UNI-RZ/UNI (Unipolar-return-to-zero) decoding experiment
- 3-12 BIP-RZ/3L (3 Level) decoding experiment
- 3-13 RZ-AMI/3L (return-to-zero alternate mark inversion) decoding experiment
- 3-14 Bi $\Phi$ -L/3L bipolar manchester decoding experiment
- 3-15 DICODE-NRZ(3L) (di-code non-return-to-zero) decoding experiment

### 4. Delta/Sigma/Adaptive Modulation & Demodulation (KL-96004)

- 4-1 The experiments with delta modulator
- 4-2 The experiments of the low-pass filter circuit utilizing delta demodulator
- 4-3 The demodulating experiment with delta modulator
- 4-4 The Adaptive-delta modulating and demodulating circuits with controllable integral time and amplitude
- 4-5 Test and experiment of VGA circuit using controllable integral voltage
- 4-6 The VGA adaptive-delta modulating and demodulating circuits with controllable integral voltage
- 4-7 The experiment with delta-sigma modulator

### 5. QPSK Modulation & QPSK Demodulation (KL-96005)

- 5-1 PSK sinusoidal modulation source and synchronization experiment
- 5-2 The experiment on sinusoidal signal measurement with phase-shift circuit
- 5-3 The experiment with four quadrant splitter circuit
- 5-4 The experiment on BPSK analog modulation
- 5-5 The experiment on BPSK demodulation



- 5-6 The experiment on the synchronous SIN TTL of BPSK demodulation signal and carrier signal restoration
- 5-7 The experiment on QPSK signal modulation
- 5-8 The experiment on 8PSK signal modulation
- 5-9 The experiment on 8QAM signal modulation
- 5-10 The experiment on precise QPSK demodulation using signal sampling identification

## 6. DTMF Generator & Decoder/Controller (KL-96006)

- 6-1 Keypad scanning & dialing experiments of DTMF
- 6-2 Storage and dialing of phone number on DTMF system
- 6-3 Demodulation experiment using internal DTMF signal
- 6-4 Password setting & decoding experiment using internal DTMF
- 6-5 Password setting & decoding experiment using external phone-line DTMF
- 6-6 Asynchronous serial transmission USB (UART)

## 7. Multi-Function Process Module(A) (KL-96007) Multi-Function Process Module(B) (KL-96008)

- 7-1 Frequency control using VCO of LPF
- 7-2 Frequency response of LPF
- 7-3 Square to sinusoid transformation using LPF
- 7-4 The experiment on tri-state analog multiplexer and TDM
- 7-5 The experiment on four-channel analog multiplexer with level allocation
- 7-6 AM and double-side band modulation
- 7-7 AM with single-side band modulation
- 7-8 The demodulation of AM
- 7-9 Generation of the signal with precise 45-degree phase shift
- 7-10 Modulation of BPSK and QPSK
- 7-11 Demodulation of BPSK
- 7-12 The window-type signal level identifier
- 7-13 The experiment on power amplifier
- 7-14 Modulation of ASK signal
- 7-15 Demodulation of ASK signal
- 7-16 FSK modulation signal using dual-frequency multiplexer
- 7-17 FSK modulation signal using the VCO of function generator
- 7-18 FSK modulation signal using the built-in function of function generator
- 7-19 FSK modulation based on the square wave generated by digital-controlled VCO
- 7-20 FSK-to-ASK demodulation
- 7-21 Demodulation of the product of FSK and  $f_1$  or  $f_2$
- 7-22 FM modulation
- 7-23 FM demodulation
- 7-24 Digital difference encoding
- 7-25 Digital difference decoding
- 7-26 DBPSK modulation
- 7-27 DQPSK modulation

## 8. Time-Division Multiplexing(TDM)/Pulse-Amplitude Modulation(PAM)(KL-93006)

- 8-1 Analog-multiplexer modulating experiment
- 8-2 Analog-multiplexer demodulating experiment
- 8-3 Analog-multiplexing TDM modulating experiment
- 8-4 Analog-multiplexing TDM demodulating experiment

## 9. Frequency Division Multiplexing (KL-93007)

- 9-1 FDM multiplexer experiment
- 9-2 BPF characteristics of FDM demultiplexer
- 9-3 3-channel FDM demultiplexer experiment

## 10. Frequency Converter, Carrier Frequency Recovery and Manchester Clock Regeneration (KL-93008)

- 10-1 Frequency-up and frequency-down experiments
- 10-2 Carrier frequency recovery experiment
- 10-3 Manchester encoder / decoder and clock regeneration experiment

## ► Accessories (KL-98005)

- 1. Connection leads and plugs : 1 set
- 2. Storage cabinet : 2 sets (KL-99001)
- 3. Experiment manual : 1 pce

## Optional Accessories

- 1. Rack frame (KL-89003)
- 2. Digital storage oscilloscope with FFT