



KL-920

Advanced Digital Communication System



KL-920 is implemented with high speed MCU, DSP and high flexible FPGA devices, giving students more opportunities to setup and observe digital data signals at each transmission stage.

Learning topics include ASK / FSK transmission in wireless ISM band, FEC codec technique (block code and convolution code), digital data formatting (Preamble, ID, FEC and CRC), Manchester coding, SONET transportation frame (STS-1 and STM-1), TDMA, PCM, TDM, DSSS, CDMA, Digital filter, etc...

► Features

- Complete digital transmitting data format including start bit, preamble, identifier, data with FEC coding, CRC coding, and stop bit
- All digital transmitting data are encoded with Manchester code before transmitting via ASK or FSK modulator.
- Programmable data, data rate, preamble, identifier, and noise from DIP switches
- FEC encoding, CRC mechanism, and Manchester coding can be included or ignored before wireless ISM transmission.
- Transmit and receive 3 sets of audio signals in TDMA channel via STS-1 and STM-1 frame
- Dual channel TDM transmission with audio signal modulated by PCM or A-Law/ μ -Law compander

► 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 Ω
- c. Maximum modulation ratio : 50:1

(6) FSK modulation input

- a. Input impedance : 10 K 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 : 0~20 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 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 : 1 sec & 0.1 sec
- (6) Display : 8-digit, 7-Segment display

6. Power input : AC 90~230V, 50/60Hz



KL-96021 ISM ASK/FSK Transceiver & Digital Data Encoder

1. RF carrier
 - (1) Transceiver carrier frequency : 434.92MHz
 - (2) Transmitter carrier power : 10dBm
 - (3) Receiver carrier sensitivity : about -100dBm at 2.4Kbps
 - (4) Modulation : ASK/FSK selectable
 - (5) IF signal : ASK(250KHz), FSK(150KHz)
 - (6) Bandwidth of modulation : 100Hz~16KHz
2. Data rate
 - (1) 100/62.5Hz
 - (2) 160/100Hz
 - (3) 1.6K/1KHz
 - (4) 16K/10KHz
3. Data transmission format
 - (1) Start bit
 - (2) 64-bit encoded data : 8-bit data encoded by 8-bit spread spectrum setting
 - (3) Stop bit
4. Data transmission
 - (1) Direct modulation
 - (2) Manchester encoding
5. Data setting and display :
8-bit data set by High and Low key switches and LED display
6. Code division encoding and setting : 8-bit DIP switch

KL-96022 ISM ASK/FSK Transceiver & Digital Data Decoder

1. RF carrier
 - (1) Transceiver carrier frequency : 434.92MHz
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2. Data rate
 - (1) 100/62.5Hz
 - (2) 160/100Hz
 - (3) 1.6K/1KHz
 - (4) 16K/10KHz
3. Decoder sampling frequency : 16X transmitted signal frequency
4. Received data decoding format
 - (1) Start bit check
 - (2) 8-bit spread spectrum code check
 - (3) Stop bit
5. Data received
 - (1) Direct demodulation
 - (2) Manchester decoding
6. Received code division data display :
16 LEDs used for 64 bits data display, 16 bits x 4, selected by 2 DIP switches
7. Decoded data display : 8 LEDs
8. Code division decoding set : 8-bit DIP switch

KL-96023 ID Code/CRC/FEC (Block Code)/Manchester Data Encoder

1. Data rate
 - (1) 100/62.5Hz
 - (2) 160/100Hz
 - (3) 1.6K/1KHz
 - (4) 16K/10KHz
2. Data setting and display :
8-bit data set by High and Low key switches and LED display
3. 8-bit data Forward Error Correction (FEC) mode :
Two 16-bit Hamming codes
 - (1) 4-bit data + 3-bit error-correcting code, two sets
 - (2) 7-bit data + 4-bit error-correcting code, one set

4. 16-bit Hamming code display : 16 LEDs
5. 8-bit ID code setting : 8-bit DIP switch
6. CRC code : CRC-16
7. Data format : 58-bit data
 - (1) Start bit
 - (2) 16-bit preamble code
 - (3) 8-bit ID
 - (4) 16-bit FEC Hamming code
 - (5) CRC-16 code
 - (6) Stop bit
8. Data transmission
 - (1) Direct modulation
 - (2) Manchester encoding
9. Error code setting : 6-bit DIP switch
10. Data transmission via ISM FSK/ASK transceiver for RF remote data transfer

KL-96024 ID Code/CRC/FEC (Block Code)/Manchester Data Decoder

1. Data rate
 - (1) 100/62.5Hz
 - (2) 160/100Hz
 - (3) 1.6K/1KHz
 - (4) 16K/10KHz
2. 8-bit data Forward Error Correction (FEC) mode :
Two 16-bit Hamming codes
 - (1) 4-bit data + 3-bit error-correcting code, two sets
 - (2) 7-bit data + 4-bit error-correcting code, one set
3. FEC data display :
8 LEDs for displaying 8-bit or 7-bit correct data received
4. 8-bit ID code setting : 8-bit DIP switch
5. CRC code : CRC-16
6. Data format : 58-bit data
 - (1) Start bit detecting
 - (2) 16-bit preamble code : detecting signal strength and synchronization
 - (3) 8-bit ID code check
 - (4) 8/7-bit data decoded from 16-bit Hamming code
 - (5) CRC-16 code check
 - (6) Stop bit
7. Data received
 - (1) Direct demodulation
 - (2) Manchester decoding
8. Received data display :
16 LEDs for displaying 64-bit receive data (including CRC code)
9. Decoder output display : 8 LEDs
10. Decoding check
 - (1) Flags for ID and CRC checks
 - (2) Hamming code error bits detecting : 6 LEDs
11. Data transmission via ISM FSK/ASK transceiver for RF remote data transfer

KL-96025 ID Code/CRC/FEC (Convolution)/Manchester Data Encoder

1. Data format
 - (1) Start bit
 - (2) 32-bit data or 32-bit data interleave :
16-bit data setting via FEC convolution encoding (1/2 data rate)
 - (3) 8-bit ID code
 - (4) 64-bit data transmission :
40-bit data plus CRC-16 code plus 8-bit ID
2. Error code setting and transmitted data monitor
 - (1) Combining 2-bit error byte address with 8-bit error setting for selecting error bits
 - (2) 16 LEDs used for monitoring the transmitted data



3. Transmitted data can select Manchester encoding.
4. Data transmission via ISM FSK/ASK transceiver for RF remote data transfer

KL-96026 ID Code/CRC/FEC (Viterbi)/Manchester Data Decoder

1. Data received
 - (1) Start bit detecting
 - (2) 8-bit ID code check
 - (3) 64-bit data: CRC-16 code calculation and detection
 - (4) 32-bit data interleave setting
 - (5) Viterbi algorithm for decoding correct 16-bit data
2. Manchester decoding
3. Data decoding and receiving LED display
4. Data receiving via ISM FSK/ASK transceiver for RF remote data transfer

KL-96027 ISM FSK/Manchester/ID Code/FEC/CRC/Transceiver

1. RF carrier
 - (1) Transceiver carrier frequency : 433.2MHz
 - (2) Transmitter carrier power : 15dBm
 - (3) Receiver carrier sensitivity : about -105dBm at 100Kbps
 - (4) Modulation : FSK
 - (5) IF signal : 200KHz at 100Kbps
 - (6) Bandwidth of modulation : 1KHz~100KHz
2. Data transmission format
 - (1) Programmable preamble : 2 or 4 bytes
 - (2) Programmable Identifier : 2 or 4 bytes
 - (3) Programmable data : 1 to 64 bytes
 - (4) FEC Hamming encoding :
FEC 4-bit data + 3-bit error-correcting code
 - (5) CRC-16
 - (6) Manchester encoding and decoding
3. Transmission interface : SPI interface
4. Communicating with PC via SCI interface

Remark* 1. Experiment module : 2 pcs
2. Computer is optional to carry out more experiment.

KL-96028 SONET TDMA-STS1 Multiplexer/Demultiplexer

1. TDMA modulation and transmission
 - (1) Speech ADC sampling rate : about 8KHz
 - (2) Speech ADC output : 7 bits
 - (3) Transmission channels : 5
2. Data input : 5 sets set by five 8-bit DIP switches, 00-7FH (MSB=0), 2 of the five sets can be from DIP switch or ADC
3. Preamble code : AAAA55H
4. TDMA transmission bits : 64 bits
5. TDMA transmission rate : about 512.8KHz
6. TDMA output signals :
STS1 data, Frame Sync Transmit (FSX) and bit sync clock (SYNCLK)
7. TDMA reception and demodulation
 - (1) From transmitter output STS1 data
 - (2) Bit clock regeneration
 - (3) Preamble code detect
8. TDMA demultiplexer outputs :
3 channels (24 bits, 8 bits each) indicated by LEDs, 2 of the 3 channels can select LED indications or DAC output
9. TDMA transmission rate : about 512.8KHz

KL-96029 SONET TDMA-STM1 Data Encoder

1. Speech ADC sampling frequency : about 8KHz
2. Speech ADC output : 7 bits
3. Transmission channel : 3 sets of STS1 multiplexing transmission
4. Input data: 7 sets set by seven 8-bit DIP switches, 00-7FH (MSB=0)
5. Preamble code : AAAA55AA55H
6. TDMA transmission bits : 160 bits
7. TDMA transmission rate : about 2.105MHz
8. Two STS1 data outputs
9. STM1 data : multiplexed output of three STS1 data inputs

KL-96030 SONET TDMA-STM1 Data Decoder

1. Received STM1 data
 - (1) Bit clock regeneration
 - (2) Preamble code detect : AAAA55AA55H
 - (3) Demultiplexer STS1 data : 3 sets
2. Demultiplexer output display : 7 x 8 LEDs
3. TDMA transmission rate : about 2.105MHz

KL-96031 TDM/CODEC; PCM/PWM; DSP-FIR Module

1. TDM-SADC-SDAC-CODEC
 - (1) Codec module : TI TLV320AIC23 chip
 - (2) Stereo TDM (Time Division Multiplexing) signal
 - (3) TDM signal sources
 - a. Internal signal generator : Left-sine wave, Right-triangle wave
 - b. External line and microphone inputs
2. ADC-PCM-SDAC-PWM
 - (1) ADC module
 - a. Resolution : 12 bits
 - b. Maximum sampling rate : 2MHz
 - (2) PCM (Pulse Code Modulation)
 - a. PCM transmission : SPI bus
 - b. Switch-selected 4-channel inputs
 - (3) PCM-SDAC : PCM data to analog signal via SDAC
 - (4) PWM (Pulse Width Modulation)
PWM resolution : 12 bits
 - (5) ADC Parallel Output and Scanned Display
 - a. Inputs : 4-channel inputs from ADC outputs
 - b. Outputs: 12-bit parallel TTL-level output, LED indications
 - c. ADC output data display : 4-digit 7-segment LED scanned display

KL-96032 DSSS/CDMA Encoder & Decoder

1. CDMA Encoder
 - (1) CDMA encoder channels : 3 channels
 - (2) Data input of each channel : 8-bit DIP switch setting
 - (3) PN code input of each channel : 8-bit DIP switch setting
 - (4) CDMA encoded sum sequence : 4 bits
2. DSSS Generator
 - (1) Sine, nSine and square wave generator
Frequency range : 300Hz~10KHz adjustable, $\pm 20\%$
 - (2) 3-channel DSSS encoder
3 CDMA spread-spectrum signals for BPSK modulation
 - (3) Multi-channel DSSS carrier generator
BPSK sum QAM output signal with adjustable gain (Gain value : 1~2)



3. CDMA Decoder

- (1) PN code : 8-bit DIP switch setting
- (2) CDMA multiplier output : 5 bits
- (4) CDMA accumulator output
- (5) CDMA accumulator sign detecting
- (6) CDMA decoded data-word output



KL-96001



KL-96021

4. DSSS Decoder

- (1) Multiplying BPSK sum by PN sequence in DSSS multiplier decoder
- (2) BPSK sync clock delay adjustment
- (3) BAPSK (Binary Amplitude Phase Shift Keying) outputs
- (4) CDMA BAPSK demodulator
- (5) 5-bit DSSS add-accumulate processing and sign detecting
- (6) DSSS decoded data-word output



KL-96022



KL-96023

KL-96033 PCM-TDM-Compander Modulation/Demodulation

1. PCM-TDM-Compander (A-/μ-Law) Modulation

- (1) 8-bit ADC Module
 - a. Strobe signal : 8KHz
 - b. 4Vpp positive and negative signal levels adjustment
 - c. Input audio frequency : 100Hz~2KHz
 - d. PCM output : 8-bit parallel data PCM to serial TDM output
- (2) 14-bit μ-Law and 13-bit A-Law audio compression to TDM output
 - a. Switch-selected 14-bit μ-Law or 13-bit A-Law compression
 - b. Converting A-/μ-Law input data set by 14-bit DIP switch to 8-bit compressed data
 - c. A-/μ-Law compressed 8-bit output indication : 8 LEDs
 - d. A-/μ-Law compression rate : at least 1MHz
- (3) TDM transmitter system
 - a. Operating frequency : 20MHz
 - b. Multiplexer bits: preamble (55AAH) plus 32-bit data
 - c. Bit clock: 434KHz or higher
 - d. Frame Sync Transmit (FSX) frequency : at least 46KHz
 - e. Master/slave setting
 - f. TDM output: TTL-level Q and open-collector NQ
 - g. Connecting two sets of 16-bit data for TDM master/slave multiplexing transmission



KL-96024



KL-96025



KL-96026



KL-96027



KL-96028



KL-96029

2. PCM-TDM-Compander (A-/μ-Law) Demodulation

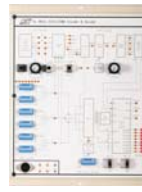
- (1) 8-bit DAC module
 - a. Signal analog output : R-2R buffer and level shifter
 - b. Audio output frequency : 100Hz~2KHz
- (2) 14-bit μ-Law and 13-bit A-Law expanding
 - a. Switch-selected 14-bit μ-Law or 13-bit A-Law audio expanding
 - b. 14/13-bit expanded output indicated by LEDs
- (3) TDM receiver system
 - a. Operating frequency : 20MHz
 - b. Demultiplexer bits : preamble (55AAH) plus 32-bit data
 - c. Bit clock : 434KHz produced by clock regeneration
 - d. Master/slave demultiplexing setting



KL-96030



KL-96031



KL-96032



KL-96033



► List of Experiments

KL-96021

- (1) Data Spread-Spectrum Modulation
- (2) Serial Data Manchester Encoding

KL-96022

- (1) Serial Data Manchester Decoding
- (2) Serial Data Identification
- (3) Serial Data Spread-Spectrum Decoding
- (4) ISM Band ASK Transceiver
- (5) ISM Band FSK Transceiver

KL-96023

- (1) Hamming Error Code Setting
 - a. 4-bit data + 3-bit error-correcting code
 - b. 7-bit data + 4-bit error-correcting code
- (2) CRC Code
- (3) Digital Serial Data Encoding
- (4) Digital Serial Data (including Manchester) Encoding

KL-96024

- (1) ID Code Verification
- (2) CRC Code and Detecting
- (3) Digital Serial Data FEC Demodulation / Error Correction
- (4) Digital Serial Data (including Manchester) FEC Demodulation / Error Correction
- (5) Digital Serial Data (Manchester Code) ASK/FSK Modulation / Demodulation

KL-96025

- (1) Digital Serial Data Interleave
- (2) Digital Serial Data Convolution Encoding
- (3) CRC Code
- (4) Digital Serial Data Encoding
- (5) Digital Serial Data (including Manchester) Encoding

KL-96026

- (1) ID Code Verification
- (2) CRC Code and Detecting
- (3) Digital Serial Data (Manchester Code) FEC Viterbi Demodulation / Error Correction
- (4) Digital Serial Data (Manchester Code) ASK/FSK Modulation / Demodulation

KL-96027

- (1) ISM Band FSK Transceiver
- (2) 1-Byte Data Transmitting / Receiving Test
- (3) ID Code Verification
- (4) Analog Signal Transmitting / Receiving Test
- (5) 64-Byte Data (PC Setting) Transmitting / Receiving Test
- (6) 64-Byte Data (PC Setting) FEC Error Correction

KL-96028

- (1) Digitized Speech Communication Network TDMA Modulation
 - a. Digital Data
 - b. Analog Signal + Digital Data
- (2) Digitized Speech Communication Network TDMA Demodulation
 - a. Digital Data
 - b. Analog Signal + Digital Data

KL-96029 & KL-96030

- (1) SONET-STM1 System Encoding
- (2) SONET-STM1 System Decoding

KL-96031

- (1) High-Resolution and High-Sampling-Rate CODEC serial ADC/DAC
- (2) DSP-Based FIR Filters
- (3) High-Speed ADC Operation
- (4) PCM and SDAC Conversion
- (5) PWM Modulation

KL-96032

- (1) CDMA Modulation
- (2) CDMA Orthogonal Code Modulation and Demodulation
- (3) DSSS Modulation
- (4) DSSS Modulation and Demodulation

KL-96033

- (1) Digital Signal μ -Law (14-Bit) Companding
- (2) Digital Signal A-Law (13-Bit) Companding
- (3) Digital Serial Data TDM (Master/Slave) Compressing
- (4) Analog Signal TDM (Master/Slave) Compressing
- (5) Digital Serial Data TDM (Master/Slave) Expanding
- (6) Analog Signal TDM (Master/Slave) Expanding

► Accessories (KL-98006)

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
3. Logic analyzer (16Channel, 100M bits/s, 128K bits or better)