DL 3155M62: Transmission of digital signals

This Training Software analyzes the principles of the transmission of digital signal:

PRACTICAL GUIDE
Units:

- Base band transmission
- Transmission with ASK coding
- Transmission with FSK coding
- Transmission with PSK coding

Unit N. 1: Base band transmission

Objectives:

- **familiarize the student with the architecture of the transmission education system and with the several stages composing it**
- **familiarize the student with the NRZ, RZ, Biphase and Manchester line co for base band transmission systems**
- **study the partial response operation with duo-binary coding**
- **study the limits of right operation of the base band and partial response system in presence of attenuation, distortion and random noise**

Requisites:

- **theoretical knowledge of the digital transmission**
- **reading of the theoretical guide DL 3155M62**

Instruments:

- **DL 3155AL2 base or stabilized supply sources**
- **auxiliary module**
- **double trace 20MHz oscilloscope**
- **connection cables**

Line codes - coding

Topographical diagram

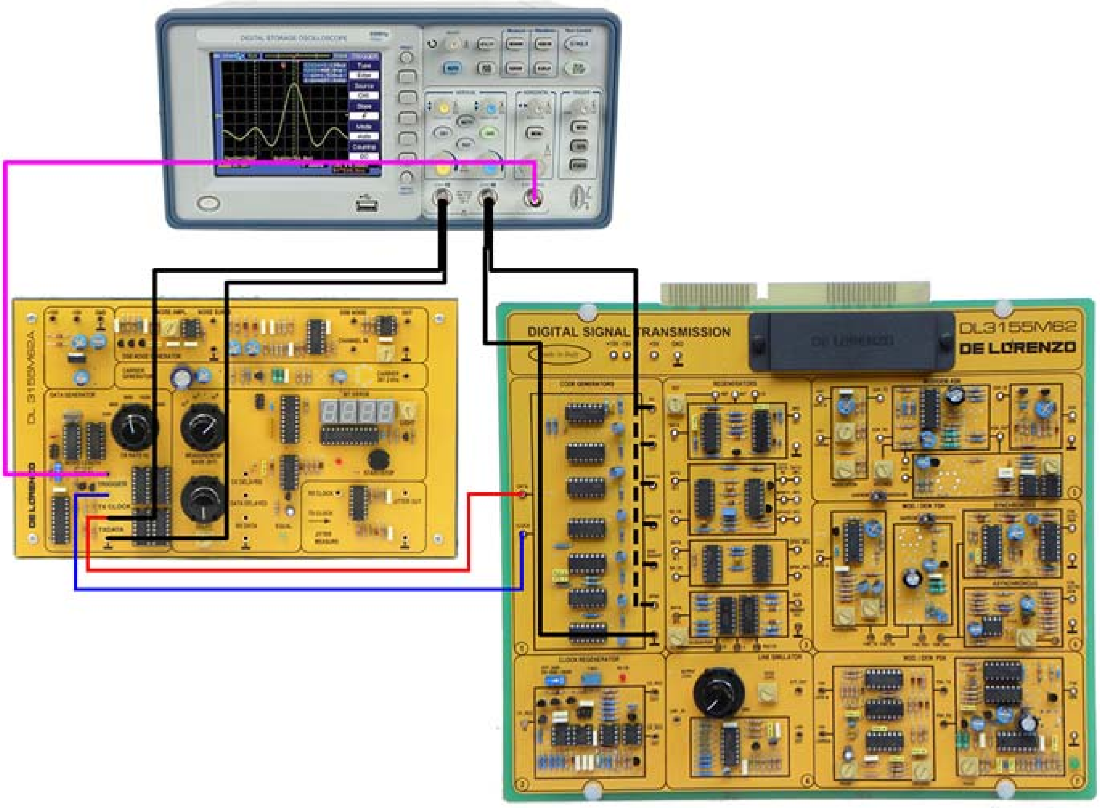


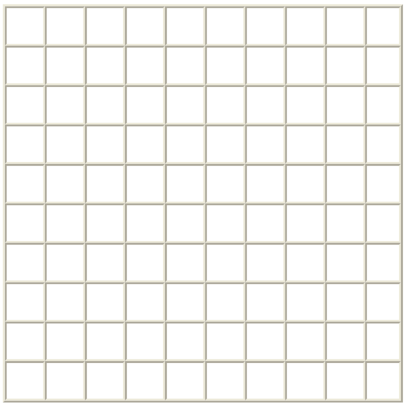
Fig. 1.1

EXPERIMENT

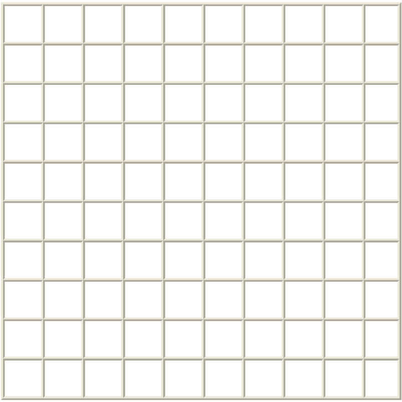
1) Connect (see fig. 1.1) the test point TXDATA of Data Generator block (Auxiliary Module) with the test point DATA of Code Generators block and the point TX CLOCK (DATA GENERATOR) with the pont CLOCK (CODE GENERATORS).
2) Set the oscilloscope to external trigger (TRIGGER point of DATA GENERATOR), with CH1 in the TXDATA signal (Auxiliary Module).
3) Select test Word Length to 16 BIT and the transmission speed to 2400 Hz.
4) Later set CH2 to each one of the outputs of the Code Generators (NRZ, RZ, Manchester, BIPHASE, Duo-Binary, DPSK) section. Measure and write down the observed waveforms, by setting them in relationship with the sequence we can observe on CH1. Justify the observations in agreement with figure 2 and with the following aspects:
   - *NRZ code* : the DATA sequence, generator test data (Auxiliary Module), is at TTL levels and in NRZ code, i.e an unipolar code **NRZ** or **NRZL**. The signal at output NRZ has in return a POLAR NRZ code characterized by levels of (about) +2.35 V and -2.35 V for the logic states "1" and "0".
   - *RZ code* exists in different forms. In the form adopted for the board, for each bit in 1 the signal goes to a low level with the falling edge pulse of the transmission clock.
   - *Manchester code* in correspondence to each falling edge of the transmission clock the signal switches from Low to High, if the bit we have to transmit is "0", and from High to Low it is "1".

- *Biphase code* — if the bit we have to transmit is "0", after the initial switching the signal remains at constant level during all the clock period. If the bit we have to transmit is "1", after the initial switching the signal switches to the complementary value with the falling edge of the clock signal.
- *Duo-binary code* — the line signal can assume the zero, high (H), low (L) values. In each bit interval the signal is:
  H if the bit we have to transmit is 1 and the previous bit was 1
  L if bit is 0 and the previous bit was 0
  0 if bit is 0 and the previous bit was 1
  0 if bit is 1 and the previous bit was 0

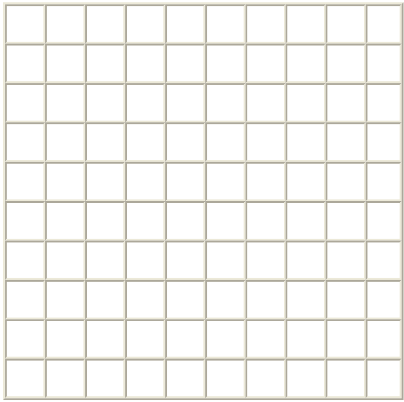
Obtained results



DATA signal



Clock signal (Auxiliary Module)



CK_REG signal (clock regenerator)

Line codes - decoding

Topographical diagram

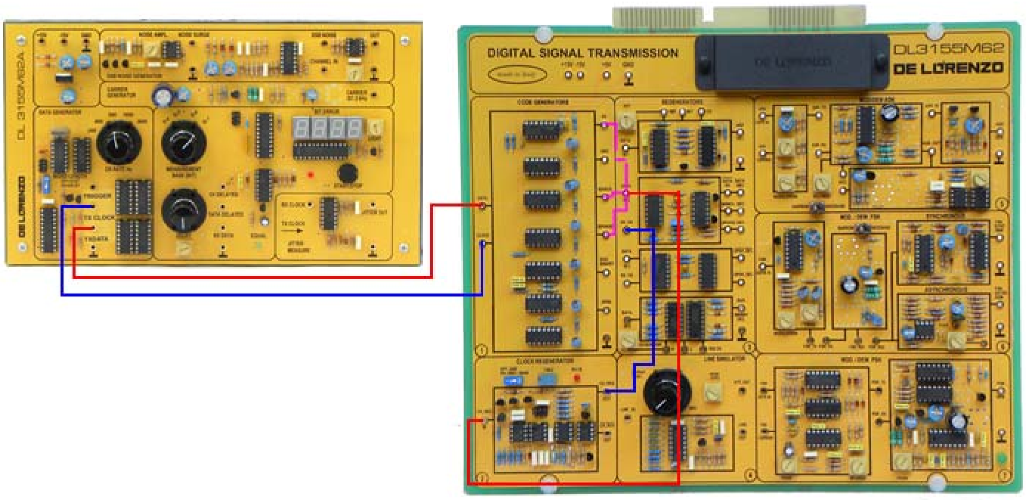


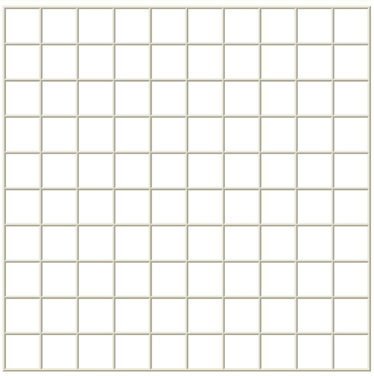
Fig. 1.2

EXPERIMENT

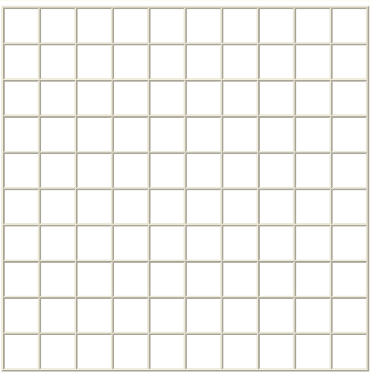
In this part of the experiment we study the decoding of RZ, Manchester and Biphase signals. The NRZ and duo-binary decoding will be studied in the following experiments.

1) Connects (see fig 1.2) DATA and CLOCK as the previous exercise. Connect the output ,that it's using , with the CK_REG IN in the CLOCK REGENERATOR block and the CK_REG OUT with the appropriate RX_CK. Verify that the oscilloscope is set to external trigger, with CH1 to display the transmitted data (TXDATA), clock rate set to 2400 Hz and word length to 16 BIT.
2) In the Regenerators section of the board, connect alternatively (dotted lines) the RZ, Manchester and Biphase coded output to the receiving input (DATA IN). With the CH2 of the oscilloscope examine the waveforms decoded respectively at the RZ, Manchester and Biphase terminals; compare the sequences decoded with the original signal in CH1.
3) Prepare the Clock Regenerator by connecting the DATA IN terminal.
4) Connect CH2 of the oscilloscope at the denied clock (CK_REG) output. Adjust the f ADJ if necessary, the hook of the PLL signal.
5) Set CH2 alternatively to the decoded outputs (RZ, Manchester and Biphase).In the oscilloscope diagram the CH1 trace shows the transmitted sequence and CH2 the decoded signal.
6) Measure the phase delays (transmission clock period fractions) with which the decoded signals appear as to the transmitted ones.
7) Repeat by using for the decoding the denied $\overline{\text{CK\_REG}}$ OUT signal. In some cases the decoding could not be performed in the right way. Highlight these cases.

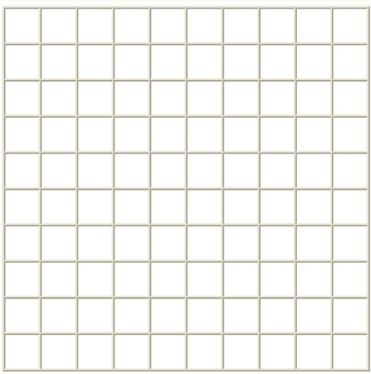
Obtained results



RZ signal



Manchester signal



Biphase signal

NRZ "INTEGRATE AND DUMP" decoder

Topographical diagram

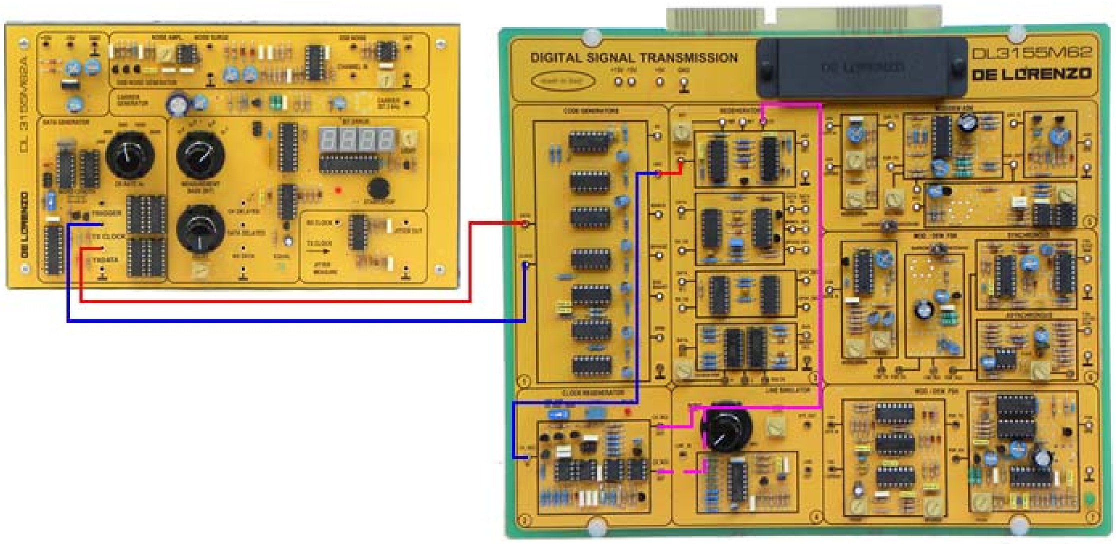
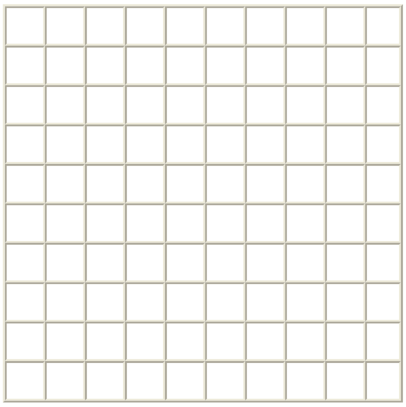


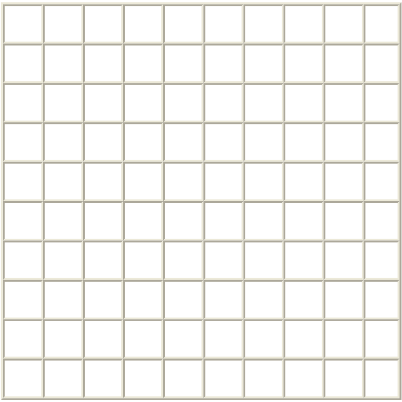
Fig. 1.3

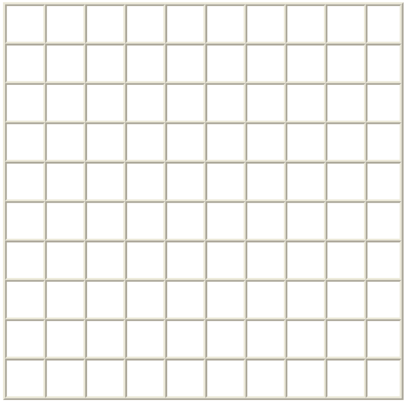
EXPERIMENT

1) Connects (see fig. 1.3) DATA and CLOCK as the first exercise. Connect the output NRZ ,in the CODE GENERATORS block with the CK_REG IN in the CLOCK REGENERATOR block and the CK_REG OUT with CK of NZR REGENERATORS block. Connect the output NRZ with the DATA IN 1 of the REGENERATORS block.
2) Set the oscilloscope to external trigger. Select CK RATE to 2400Hz and Word Length to 16 BIT.
3) Display the DATA sequence in the oscilloscope CH1.
4) Turn the regulator f ADJ of the clock regenerator,if necessary, so that it hooks the received signal
5) Display the received signal (encoded NRZ) on the oscilloscope CH1 and on CH2 the **REF** signal. Adjust by means of the potentiometer **REF**ERENCE so that the limit level is at an intermediate value between the maximum level and the minimum one of the received signal.
6) Set CH2 to the output (NRZ DEC). Adjust REF limit and eventually the fADJ to obtain in this way the regenerated output of decoded NRZ, the most approximated one as to the transmitted one (DATA).
7) Measure the phase shift between the transmitted signals and the decoded signal. Represent the delay in cycle fractions of the transmission Clock.
8) Measure and justify the waveform at the integrator output (INT).
9) Verify the time coincidence between the regenerated clock edges, used for the decoding, and the output waveform (NRZ DECODED).
10) Repeat the experiment by using the denied $\overline{\text{CK\_REG}}$ OUT instead of the CK_REG OUT.

Obtained results







NRZ DATA OUT signal INT signal NRZ DECODED signal

Partial response base band system

Topographical diagram

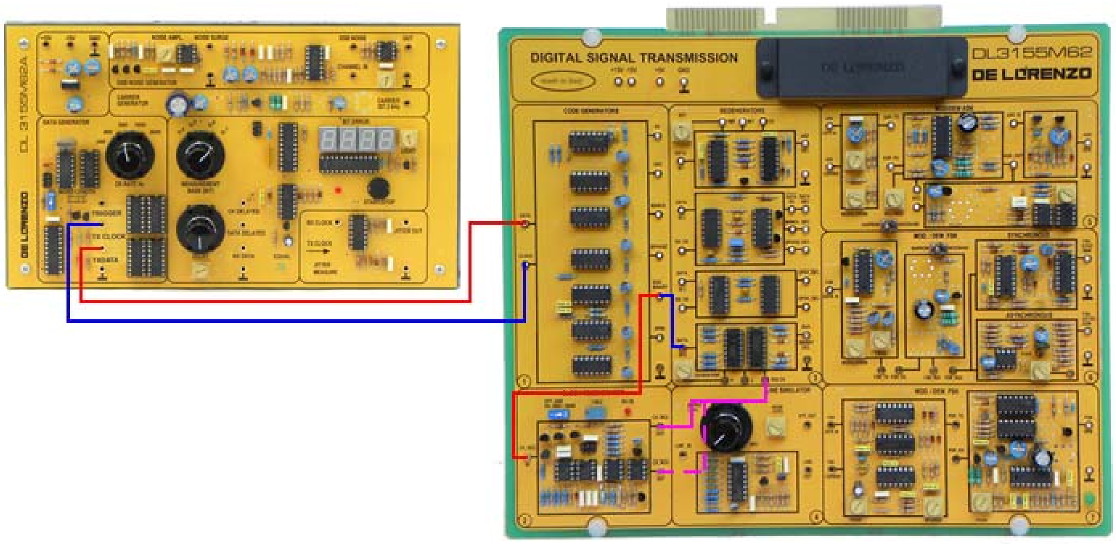
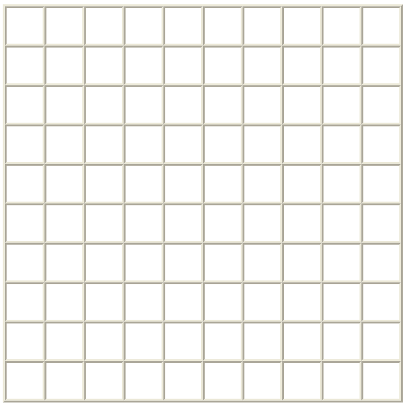


Fig. 1.4

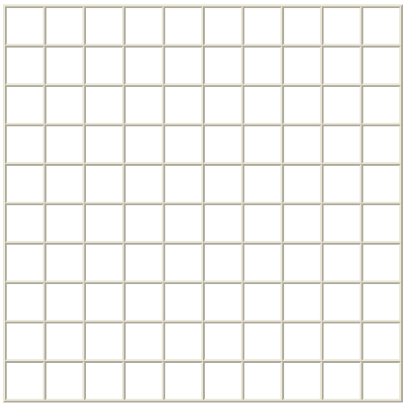
EXPERIMENT

1) Connects DATA and CLOCK as the first exercise. Connect the output DUO BINARY ,in the CODE GENERATORS block with the CK_REG IN in the CLOCK REGENERATOR block and the CK_REG OUT with RX2 CK of DUO BINARY in the REGENERATORS block. Connect the output DUO BINARY with the DATA IN 4 of the REGENERATORS block.
2) Set the Ck Rate to 2400 Hz and the Word Length to 16 BIT.
3) Connect the oscilloscope to the trigger, CH1 to DATA, CH2 to the output of the duo-binary encoder. Examine examined the waveform and explain each aspect.
4) Set CH1 to terminal (**H**), by leaving CH2 to terminal DATA OUT of the Duo-Binary. Adjust DECISION POINT to have a limit voltage H to an intermediate value between the maximum and minimum value of the signal.
5) Set CH1 to terminal (**L**). Verify that also the limit voltage L is set to an intermediate value.
6) Set CH1 to the decoder output (DUO-BINARY DEC), by leaving CH2 at the input.
7) Adjust f ADJ, if necessary, its at limits **H** and **L** to allow in this way the appearance of the decoded signal.
8) Set CH2 to DATA and compare the phases (generated and decoded signal) which appear on the screen.
9) Measure the phase delay passing between the two signals.
10) Repeat the observations for higher clock rates.
11) Repeat the observations by using for the decoding the denied $\overline{\text{CK\_REG}}$ OUT instead of the CK_REG OUT.

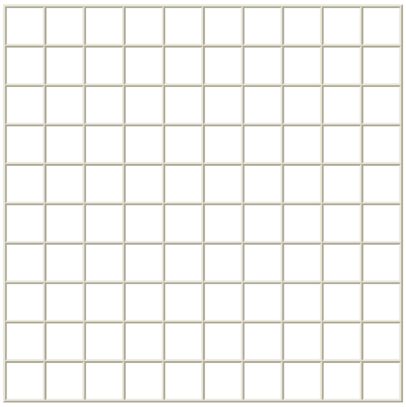
Obtained results



H and L signal



DATA OUT signal of the DUO BINARY



DECODED DUO-BINARY signal

NRZ base band system in presence of transmission perturbations

Topographical diagram

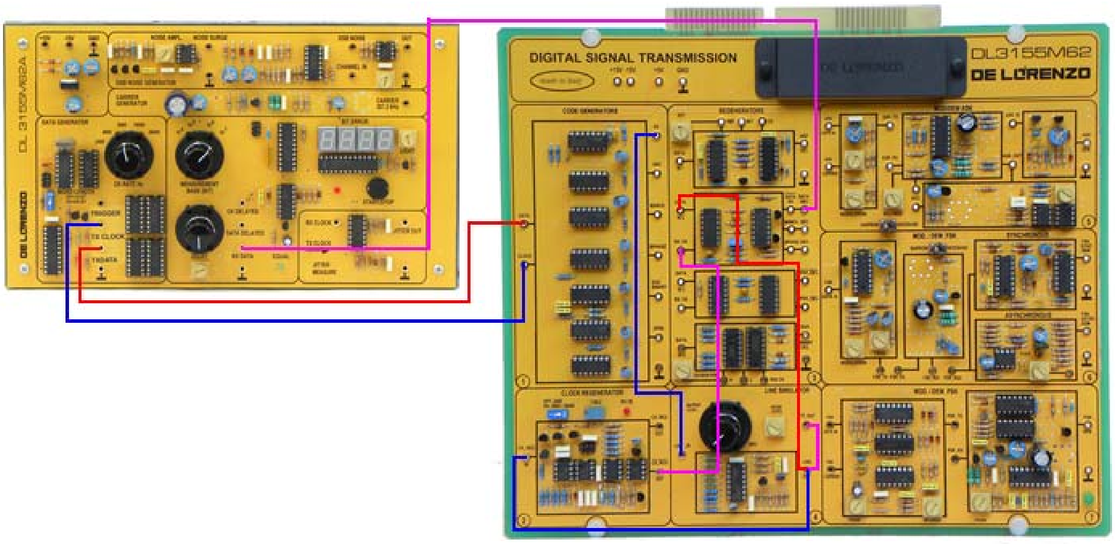


Fig. 1.5

EXPERIMENT

1) Make the follows connections :
TXDATA in DATA GENERATOR block (Auxiliary Module) with DATA in CODE GENERATORS block
TX CLOCK in DATA GENERATOR block (Auxiliary Module) with CLOCK in CODE GENERATORS block
RZ output in CODE GENERATORS block with LINE IN in LINE SIMLATOR block
ATT_OUT in LINE SIMLATOR block with LINE OUT in LINE SIMLATOR block
LINE OUT in LINE SIMLATOR block with CK_REG IN in CLOCK REGENERATOR block
LINE OUT in LINE SIMLATOR block with DATA IN 2 in REGENERATORS block
dennied CK_REG OUT in CLOCK REGENERATOR block with RX_CK in REGENERATORS block
DATA RZ DEC in REGENERATORS block with RX DATA in BER block (Auxiliary Module)
2) Set CK RATE to 2400 Hz and Word Length to 16 BIT.
3) Set CH1 of the oscilloscope to the Noise Generator output (LINE OUT). Adjust the Noise level to about 0% (all clockwise). Adjust the OUTPUT level to about 100% (all counterclockwise)
4) Set CH1 on the receiving terminal. Set the oscilloscope in external trigger with the clock generator . Display the eye pattern. Study the form variations of the clock rate until increasing it up to 38.400 Hz at different additional noise levels.
5) Set the Noise Generator level to a minimum level again, the output level to 100% e il clock rate a 2400 Hz. Act on the controls of the clock regenerator as we have already seen, and hook the received signal. Adjust the controls again so to obtain a decoded signal (DATA DEC.) as near as possible to the transmitted original signal (DATA).
6) Act on the DELAY control of the DIGITAL DELAY EQUALIZER of the Auxiliary Module so that the EQUAL indicator Led switches on. Verify through the double trace oscilloscope that the (DATA DELAYED) and (RX DATA) signals coincide. (turn all counterclockwise the potentiometer delay and the commutator Delay then adjust the potentiometer and if need the commutator)

7) Set the MEASUREMENT BASE selector to 10^5 and select Word Length to 16 BIT.

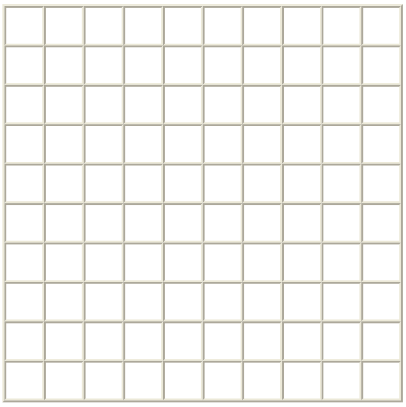
8) Push START/STOP. Wait that LED GO, showing the measurement cycle finishing, switches off. Record the display readings, showing the number of bits we have found wrong in 10^5.

9) Settle a measurement program in relationship to the available time, by measuring the BIT ERROR RATE for different transmission speeds (clock rates) and for different positions of the potentiometers Noise Level and Output Level.

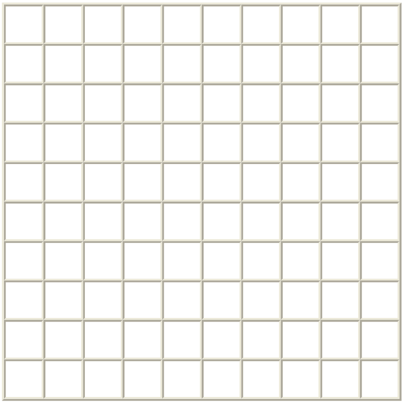
10) Represent the results on graphs showing the BER as a function of the different positions of the noise level regulation potentiometer at the same output level (for example 5%).

11) If we have an Effective Value voltmeter (RMS) available, measure the noise voltage in the chosen measurement points, calculate the S/N ratio and set this indication on the horizontal axis of the graph itself collecting the results of the measurements.

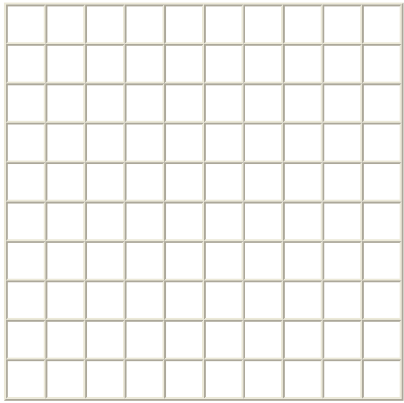
Obtained results



S+N signal



CK_REG Clock Regenerator signal



Rx DATA signal (Auxiliary Module)

Partial response base band system in presence of transmission perturbations

Topographical diagram

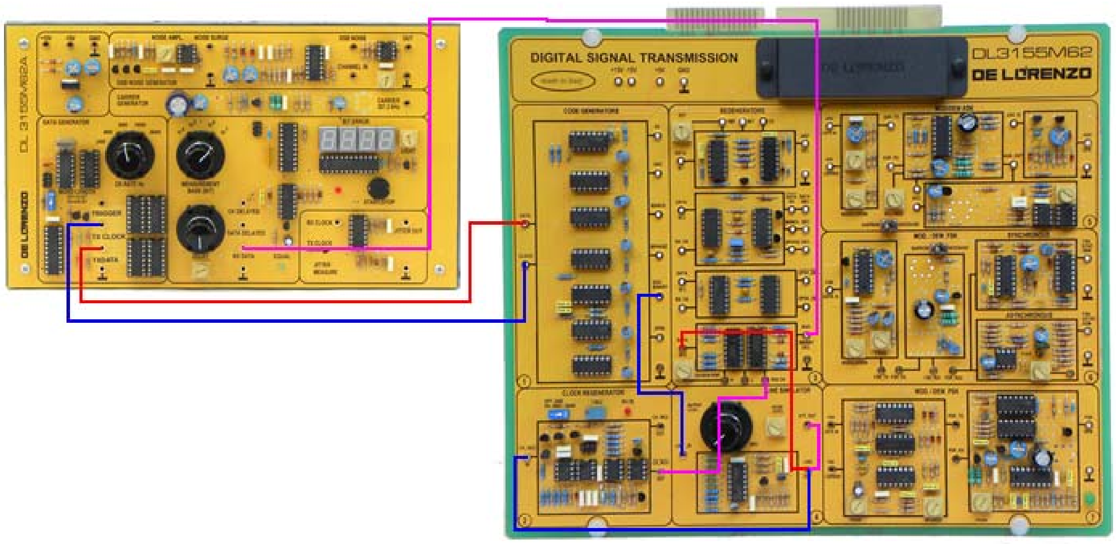


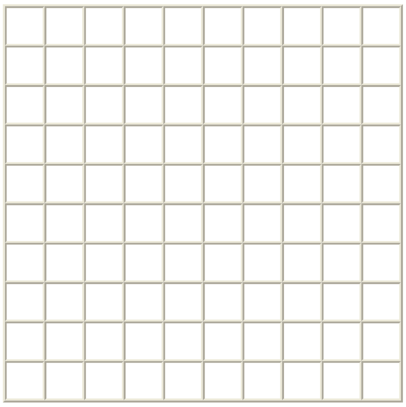
Fig. 1.6

EXPERIEMENTS

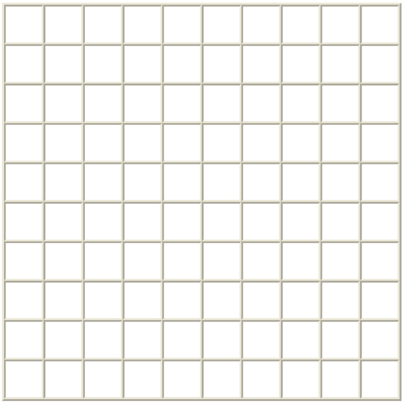
The experiment is similar to the previous case. The general procedure, therefore, won't be described but only the main aspects and the differences as to this exercise will be mentioned.

1) Make the follows connections :
TXDATA in DATA GENERATOR block (Auxiliary Module) with DATA in CODE GENERATORS block
TX CLOCK in DATA GENERATOR block (Auxiliary Module) with CLOCK in CODE GENERATORS block
DUO BINARY output in CODE GENERATORS block with LINE IN in LINE SIMLATOR block
ATT_OUT in LINE SIMLATOR block with LINE OUT in LINE SIMLATOR block
LINE OUT in LINE SIMLATOR block with CK_REG IN in CLOCK REGENERATOR block
LINE OUT in LINE SIMLATOR block with DATA IN 4 in REGENERATORS block
dennied CK_REG OUT in CLOCK REGENERATOR block with RX_CK in REGENERATORS block
DATA DUO BINAY DEC in REGENERATORS block with RX DATA in BER block (Auxiliary Module)
We will use the Noise Generator as a simulator of the transmission medium. The potentiometer generates two interdependent ("tracking") levels, a positive one and a negative one, of the same amplitude. These levels which can be measured at terminals **H** and **L** are used a decision limit to distinguish in the received signal the high levels (H) of the ZERO and the ZERO of the low levels. Each time that we modify the position of the potentiometer OUTPUT LEVEL (i.e., each time the attenuation of the transmission medium changes) we will have to readjust the position of the decision limits, to have an excellent operation.
2) Observe the eye pattern of the received signal. The difference is that now we appreciate also the symmetric zero line in the eye pattern.
3) Set a measurement program for the error probability again, starting from low clock rates and minimum noise, by increasing both of them according to the program.
4) Collect the results in graphic form.

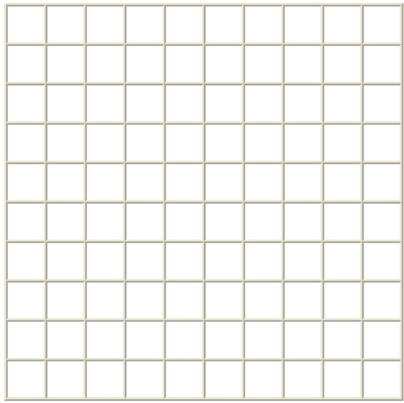
Obtained results



S+N signal



H and L signal level



Rx DATA signal (Auxiliary Module)

Questions

A Mention some types of digital modulation:

1. linear and base band AM, FM, PCM modulation.
2. ASK, PSK, FSK modulation
3. PCM and TDM modulated with carrier

B To reconstruct the data signal with a good accuracy we need:

1. to do a distortion free sampling at the Nyquist rate.
2. reach the Nyquist rate and compare it with the clock one.
3. synchronize the data sampling times with the clock ones.

C To remove the type of intersymbolic interference we recommend that:

1. the pulses to be transmitted are intervals of T_0.
2. the minimum rate of the filter is $f_c/2$.
3. the maximum of the rate to be transmitted is 2B.

D In a partial response general system:

1. the intersymbolic interference requires no control.
2. the transmission speed is the double of the Nyquist one.
3. the signal can have one of the three values -V, 0, +V.

E The Nyquist rate is, and contributes to:

1. it's twice the higher rate to be transmitted and it allows to build the signal with a greater accuracy.
2. it's the half of the elementary pulse rate and it considerably improves the signal transmission.
3. it's the highest rate synchronizing the data signal and it removes a part of the intersymbolic interference.

F The eye pattern provides the information relative to:

1. the interference in the data signal.
2. the distortion in a transmission system.
3. the distortion generated by the digital coding.

G For the base band transmission we require the equalization:

1. because the characteristics are variable owing to the switching.
2. because the transmitter and the receiver have different characteristics.
3. because the receiving filters require it for the fact of being variable.

H Timing is fundamental because:

1. the signal phase has to be equal for the best operation of the local oscillator.
2. the receiver requires this synchrony for a right reconstruction.
3. the resonant circuits of the clock regenerator adapt the phase.

I In the numeric modulation:

1. the carrier encodes the modulating signal.
2. the electric signal encodes in not defined values.
3. the modulating signal modifies the carrier.

L The jitter is:

1. phase modulation causing error at high transmission speed.
2. degradation of the modulated signal with reduced bandwidth.
3. the error index due to the presence of external interference.