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Telecommunication Education Environment and its Optimal Usage

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Telecommunication Education Environment and its Optimal Usage

INSTRUCTION:

Acquaint yourself with the Telecommunication Instructional Modelling System (TIMS). It is a laboratory teaching environment for students in wireless, telecommunications & signal processing courses. It models mathematical equations representing electrical signals or block diagrams representing telecommunications systems. An Australian firm, EMONA Instruments, produces this system in hardware and software versions and in the Biskit version. Compare the individual versions and point out their advantages and disadvantages. Optimize the usage of the TIMS system for laboratory teaching of communication subjects such that the manuals do not only mechanically describe the points of procedure; pay attention to the theoretical analysis, which should allow students to grasp the principles of experiments during the solution process. Design minimally three new advanced laboratory tasks and prepare optimized manuals, which will develop students' creativity. In addition, make model protocols and detailed manuals describing the tasks complexly. Design a future application of the TIMS system.

REFERENCE:

[1] FRENZEL,L.,E. Principles of Electronic Communication Systems. McGrawHill, New York 2003
[2] HAYKIN, S. Communication Systems. John Wiley, New York 2001
[3] DUNCAN, B. EMONA TIMS-301 User Manual. Sydney 2008

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V Brně dne …………………

(podpis autora)

Abstract: Students in introductory communication theory classes can benefit from a well-planned laboratory component, Such that TIMS lap equipments which can handle a wide variety of experiments ranging from analog baseband to pass-band digital communications. These papers describe three advanced laboratory tasks with their optimized manuals designed by Al Salman Ahmed at Brno University of technology. Two are based on the simulation software TutorTIMS to implement Eye patterns, and Signal Constellations. The third is based on the Biskit hardware to implement Quadrature phase shift keying (QPSK), both of them TIMS instruments.

Anotace: V kursech úvodní komunikační teorie mohou studenti profitovat z dobře vytvořené laboratorní podpory. Vhodné je zařízení TIMS, které umožňuje široký výběr experimentů od analogového základního pásma po širokopásmovou digitální komunikaci. Práce popisuje tři pokročilé laboratorní úkoly včetně optimalizovaných manuálů navržené Al Salman Ahmedem z Vysokého učení technického v Brně Dvě úlohy jsou založeny na simulačním software TutorTIMS a implementují zákonitosti oka a zpracování signálů třetí je založena na hardware Biskit k implementaci kvadraturního fázového klíčování (QPSK).

Table of contents

Abstract ....

1. Introduction 1

2. TIMS Telecoms Signals and Systems Lab Equipment 3

2.1 The Hardware Equipments 3

2.1.1 TIMS-301 Hands-on lab hardware 3

2.1.2 Emona Telecoms-Trainer 101 (Biskit) 4

2.2 The Software Simulation 4

3. Quadrature phase shift keying (student edition) 6

3.1 Requirement 7

3.2 Preparation 7

3.3 Theoretical introduction 7

3.4 Experiment 9

4. Quadrature phase shift keying (Administrator edition) 14

4.1 Requirement 15

4.2 Equipment 15

4.3 Experiment 15

5. Signal Constellations (student edition) 20

5.1 Requirement 21

5.2 Preparation 21

5.3 Terminology 21

5.4 Theoretical Introduction 21

5.5. Experiment 23

6. Signal Constellations (Administrator edition) 28

6.1 Requirements 29

6.2 Preparation 29

6.3 Terminology 29

6.4 Experiment 29

7. Eye patterns (student edition) 38

7.1 Requirement 39

7.2 Preparation 39

7.3 Theoretical Introduction 39

7.4 Experiment......40
8. Eye patterns (Administrator edition) 43
8.1 Requirement......44
8.2 Preparation......44
8.3 Experiment......44
10. Conclusion......49
References 50

1. Introduction

The telecommunication laboratory helps the students to understand the basic principles of telecommunication systems by both practical module systems and computerized simulation. TIMS, Telecommunications Instructional Modeling System, is laboratory teaching equipment for EE and EET students in wireless, telecommunications and signal processing courses. TIMS has the distinction of being the only telecommunications lab equipment that can implement practically any form of modulation or coding – keeping pace with the rapid development of telecommunications theory. It is hardware and software based and includes numerous modules that students can use to study signals in a variety of contexts .while students may create equivalent circuits by bread boarding components building these devices is very time consuming and fraught with the vagaries of such quick , in –laboratory construction .times hardware is analogues to a cockpit simulator.

TIMS lab equipments give students hands-on experience with the theories and concepts involved in the specific area of "transmission theory". "Transmission" involves an original message being carried from one point to another, using either analog or digital modulation. It will allow the students to learn about the concepts of the many sub-sections of a major telecommunications system: eg sampling and reconstruction; coding and decoding; modulation and demodulation; etc. After a student has learnt and grasped these fundamental concepts, it is much easier for them to take this knowledge and apply it to HF electronics, microwaves, telephone lines, computer local area networks, and so on.

Experiments are made by patching together TIMS modules. Each module represents a fundamental telecommunications system building block. The block diagram of the text book can be quickly realized by patching together TIMS modules in accordance with the block diagram.

TIMS is used to implement block diagrams, which are used to model mathematical equations, or the hardware realizations of telecommunications systems or signal processing schemes. The BASIC modules include the simplest, fundamental, general purpose electronic building-blocks, e.g. signal adder; signal multiplier; filters; oscillators; phase shifters; etc. The ADVANCED modules include more specialized or more specific electronic building-block functions, e.g. PCM waveform encoders and decoders; bit error rate and signal to noise measuring functions; Delta modulation building-blocks; etc. Because TIMS models mathematical systems using functional building-blocks, the number and type="text" of experiments is only limited by the modules (building-blocks) available and the user's imagination (and understanding of the subject). From this it follows that TIMS has an unlimited capability for telecommunications and signal processing experiments.

These papers discuss several hardware and software instruments -based options for providing students with effective laboratory experiences. We designed a three advanced laboratory tasks with their manuals in such a way allow students to grasp the principles of experiments during the implementation process and will develop them creatively. And also we made detailed manuals describing the tasks complexly to help the laboratory teacher understanding the whole procedures step by step during the students' implementation for the experiments. We have also examined the three individual versions of the TIMS instruments to point out their advantages and disadvantages.

2. TIMS Telecoms Signals and Systems Lab Equipment

2.1 The Hardware Equipments

TIMS by Emona Instruments consists of a base system unit that accommodates a wide variety of specialized plug-in modules. Examples of basic modules include adders, audio oscillators, multipliers, and phase shifters. The standard system provides experiments in AM, FM, PM, and numerous digital modulation schemes. Advanced modules Support single sideband, spread spectrum, bit-error measurement, and others.

2.1.1 TIMS-301 Hands-on lab hardware

The TIMS-301 System is a true real-time hardware mathematical modeling system. It is similar in concept to traditional "analog computer' with a high degree of specialization to easily implement almost any analog or digital modulation, coding or signal processing scheme. The system provides students the opportunity to connect the modules and measure the signals with actual test equipment. This enables students to focus on learning and experiencing the mathematical and theoretical concepts which are often difficult to comprehend without actual hands-on experience through manipulation of real-world signals.

The System is made up of different plug-in and fixed modules. The fixed modules are the most commonly used and are built into the system unit. The plug-in modules slide into the system unit's rack (the top half of the system) and are selected according to the experiment which will be implement.

An advantage of the TIMS-301 system is a wide range of communications systems that can be implemented by simply buying additional modules, another advantage that it has a unique capacity to be continuously and inexpensively expanded to implement the very latest developments in telecommunications and signal theory. The only disadvantage of that system to be considered that some of the modules slides contain on jumper switch placed inside the chip, which should be placed in the control panel front of the slide to be visible, and no need to plug the slide out the system unit's rack when want to switch it up-down [1].

2.1.2 Emona Telecoms-Trainer 101 (Biskit)

The Emona Telecoms-Trainer 101 is a single board trainer that makes teaching telecommunications much easier for teachers at technical college and technical high school level. It is unrivalled in the wide range of over 29 modern communications topics that can be studied with one compact trainer. The key to the ETT101's versatility is its unique block diagram approach for building experiments. By working at the block diagram level, we are able to achieve many experiments in one system. This dynamic visual approach helps younger students to see the relationship between modern telecoms methods and the math.

An advantage of that system that The 'hands-on' approach builds student confidence and makes the experiment satisfying as the students are free to explore and learn by making mistakes. When they explore more, they learn more. The Disadvantages that students view the modules as "black boxes" whose inner workings remain opaque. Thus, from a teaching viewpoint, they may not be significantly better than pure software simulations. The second disadvantage of the system that it has a limited number of slides, which is not enough for some experiments to be implemented with one single board, for example it is not possible Generate and regenerate the Quadrature Shift Keying (QPSK) signal by using one single board, its only one arm of that experiment could be implemented. And also the system is Non-scalable, which means it won't be keeping pace with the rapid development of telecommunications theory at the future [2].

2.2 The Software Simulation

TutorTIMS – Simulation Software

TutorTIMS is a TIMS telecommunications experiments simulator which looks just like the TIMS lab equipment. All front panel controls mimic the TIMS lab hardware system, with true point and click technology. No programming or syntax entry is required. So students can start patching telecommunications experiments in minutes. And also it's possible to keep a copy of the experiment implementation by saving it as a file in the pc to get it back at anytime. TutorTIMS is ideal for helping students prepare at home before attending hands-on labs at college.

The Simulation Software makes it feasible to model even the most complex communication systems via user-friendly graphical interfaces. The biggest drawback to this approach is that students never have the feeling they are working on a real system. Systems are "wired" together by dragging parts onto the screen and connecting them with mouse clicks. A common characteristic is that, for ease of use, the software hides as many details of the simulation as possible. This may be a disadvantage to students who need exposure to details so they can understand how the system works.

3. Quadrature phase shift keying (QPSK)

Student edition

Emona Telecoms-Trainer 101

3.1 Requirement

Acquaint yourself with the Emona Telecoms–Trainer 101 to understand how to generate QPSK signal (modulation) and how to pick up one of the QPSK signal' BPSK (QPSK demodulation).

3.2 Preparation

- Emona Telecoms-Trainer 101 (pulse power-pack).
- Dual channel 20MHZ Oscilloscope.
- Three Emona Telecoms-Trainer 101 oscilloscope leads.
- Assorted Emona Telecoms-Trainer 101 patch leads.

3.3 Theoretical introduction

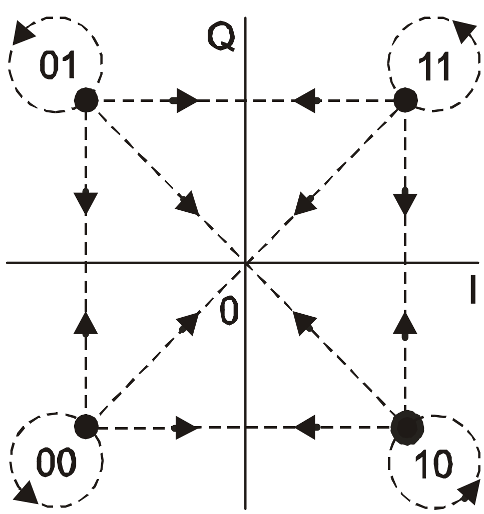

Figure3.1: Diagram QPSK Constellation

Quadrature phase shift keying (QPSK) is a method for transmitting digital information across an analog channel. Data bits are grouped into pairs, and each pair is represented by a particular waveform, called a symbol, be sent across the channel after modulating the carrier. This requires having a unique symbol for each possible combination of data bits in a pair. Because there are four possible combinations of data bits in a pair (Figure3.1), QPSK creates four different symbols one for each pair, by changing the I gain and Q gain for the cosine and sine modulators [3].

QPSK Modulation

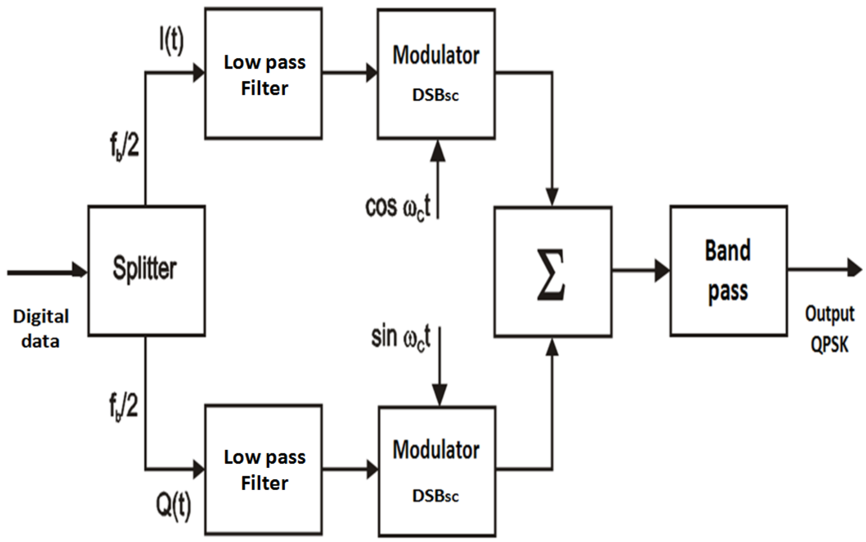

Figure 3.2: Block diagram of QPSK modulation

At the input to the modulator (figure3.2) , the digital data even bits (I) and odd bits (Q) are stripped each one separately from the data stream by a "bit-splitter" and are multiplied with a carrier (DSB-SC modulation) to generate two BPSK signals(called PSKI & PSKQ*),. These two signals are then simply added together for transmission and, as they have the same carrier frequency, they occupy the same portion of the radio-frequency spectrum. The required 90° of phase separation between the carriers allows the sidebands to be separated by the receiver using phase discrimination.

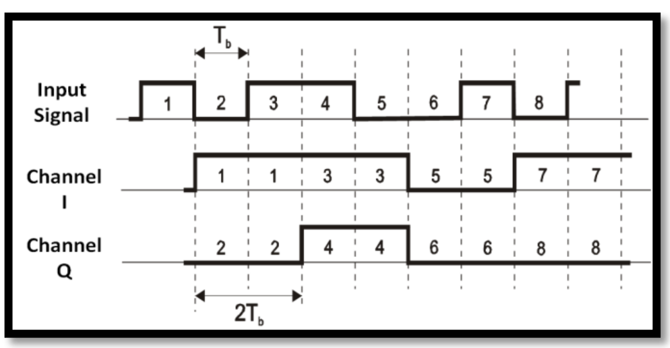

Figure 3.3

* The PSKQ signal's carrier is phase –shifted by 90° before being modulated.

QPSK Demodulation

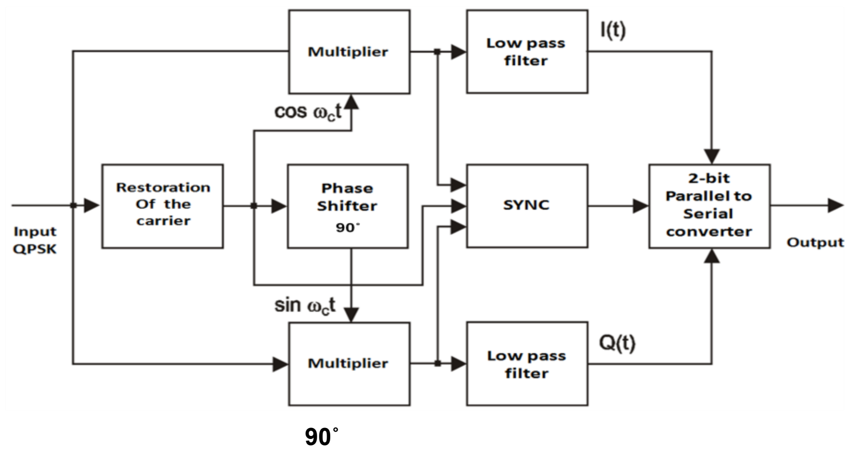

Figure 3.4: Block diagram of QPSK demodulation

To understand how each detector picks out only one of the BPSK signals and not both of them, recall that the product detection. That is recovery of the message is optimal if the transmitted and local carriers are in phase with each another. But the recovered message is attenuated if the two carriers are not exactly in phase, so if the phase error is 90˚ the amplitude of the recovered message is Zero and it's completely rejected.

3.4 Experiment

A- Use the Emona Telecoms- Trainer 101 to generate a QPSK signal, and then examine the QPSK signals using the scope.

Procedure

1. Set the scope's Trigger Type to Edge.
2. Set the scope's Trigger Source control to the EXT/5 position.
3. Set the scope's Trigger source coupling to the HF REJ position.
4. Set the scope's Timebase control to the 25ms/div position.
5. Set the Vertical Attenuation control for channel 1 to the 2V/div position.

6. Connect the set-up shown in figure 3.5 below:

Note: Insert the black plugs of the oscilloscope leads into a ground (GND) socket.

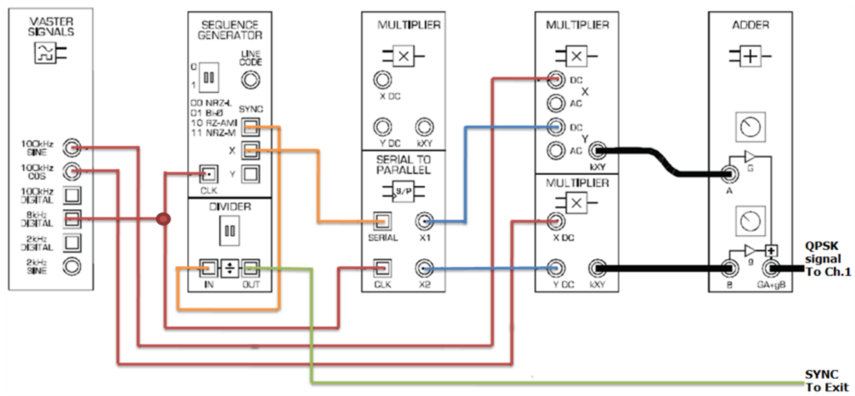

Figure 3.5

The set-up in Figure 3.5 can be represented by the block diagram in figure 3.6 below. The Sequence Generator module is used to model digital data. The 2-bit Serial to Parallel Converter module is used to split the data bits up into stream of even bit and odd bits, connected to independent Multiplier modules. The other input to the Multiplier modules is a 100 KHz sin wave and, the signals are out of phase with each other by 90˚ which is a requirement of QPSK. The adder module is used to add the PSKI and PSKQ signals [4].

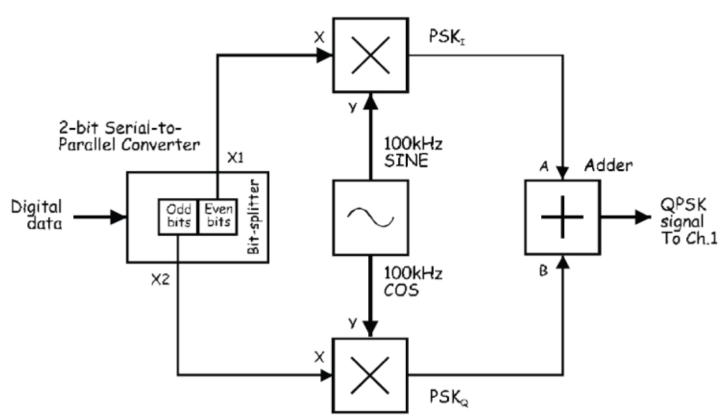

Figure 3.6: block diagram of the mathematical implementation of QPSK

*The Sequence Generator module's SYNC output must be halved for it to be used as the triggering signal for the scope.

7. Locate the Divider module and set it up to divide by 2 by pushing the left-side switch up and the right-side switch down.
8. Turn the Adder module's G control fully anti-clockwise. And g control fully clockwise.
   Note: this removes the BPSKI signal from the signal on the Adder module's output.
9. Adjust the Adder's g control to obtain a 4vp-p output.
10. Disconnect the patch lead to the Adder module's B input.
    Note: This removes the BPSKQ signal from the signal on the Adder module's output.
11. Adjust the Adder's G control to obtain a 4Vp-p output.
12. Reconnect the patch lead to the Adder's B input.
13. The result will be shown as QPSK signal.

Exercise 1. Compare each of the following by using the Oscilloscope:

A. The Even bits with the Odd bits.
B. The Even bits with the PSKI.
C. The Odd bits with the PSKQ.

B- How to pick up one of the QPSK signal's BPSK by using phase discrimination (QPSK demodulation)?

Procedure

1. Set the scope's Timebase control to the 1ms/div position.
2. Set the Vertical Attenuation control for channel 1 to the 20V/div position.
3. Modify the set up as shown in Figure 3.7 below:

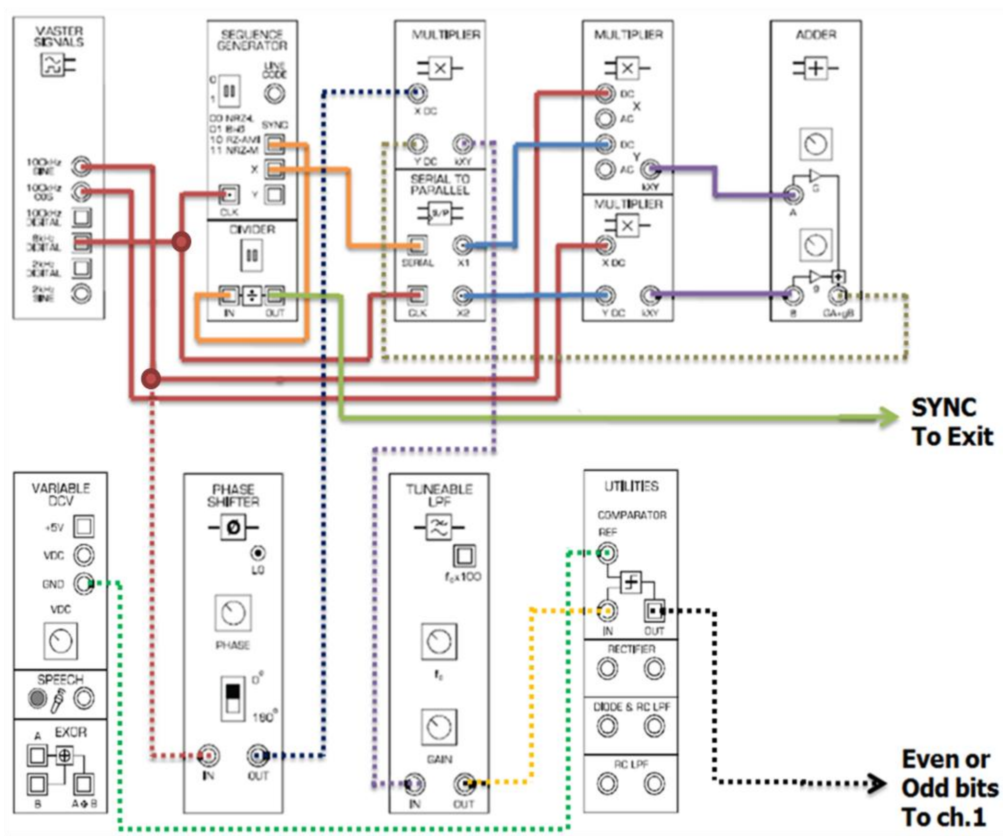

Figure 3.7

The set-up in Figure 3.7 can be represented by the block diagram in figure 3.8 below. The product detectors share the carrier but one of them is phase shifted 90˚.once the phase of the local carrier for one of the product detectors matches the phase of the transmission carrier for one of the BPSK signals, there automatically a 90˚ phase error between that detector's local carrier and the transmission carrier of the other BPSK signal. So, the detector recovers the data on the BPSK signal that it's matched to, and rejects the other BPSK signal [4].

Note: Lines show leads already in place. Dotted lines show new leads

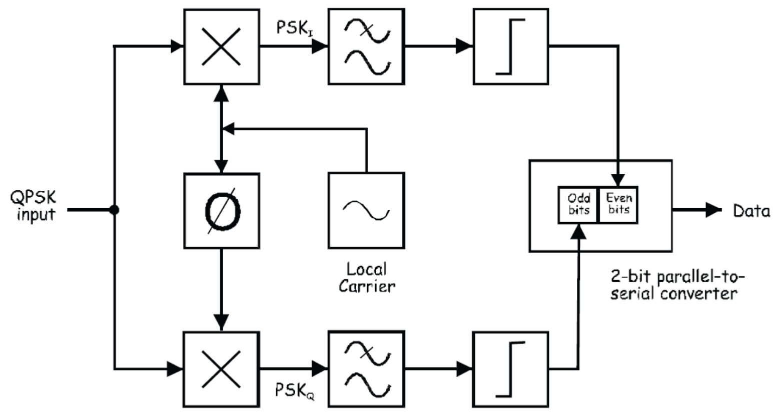

Figure 3.8: Block diagram of the mathematical implementation of QPSK demodulation

*Notice it's not possible to implement both a QPSK modulator and demodulator with one Emona Telecoms- trainer 101. However, it's possible to demonstrate how phase discrimination is used by a QPSK demodulator to pick-out one or other of the two BPSK signals that make up the QPSK signal. In this case we will implement one arm of a QPSK demodulator as in Figure 3.9.

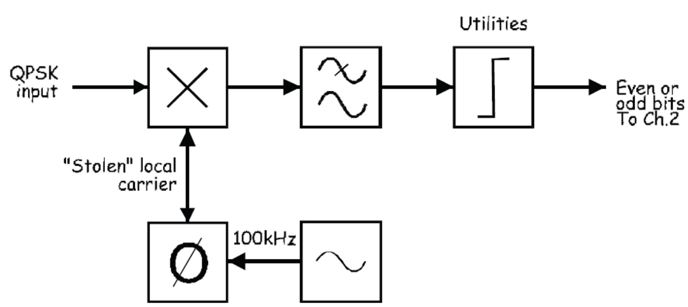

Figure 3.9: one arm of QPSK demodulator

4. Locate the Tuneable LPF module and turn its Cut-off Frequency Adjust control fully clockwise.
5. Set the Tuneable LPF module's Gain control to about the middle of its travel.
6. Vary the Phase Shifter module's Phase Adjust control left and right and observe the effect on the demodulated signal. You will be aiming to recover a signal like the original X1 or X2 signals from the Serial-to-Parallel Converter module.

Exercise 2. Compare between all of the:

A. The even data bits (X1 output) with the recovered data.
B. The odd data bits (X2 outputs) with the recovered data.

4. Quadrature phase shift keying (QPSK)

Administrator Lab edition

4.1 Requirement

Generate QPSK signal and pick up one of the QPSK signal' BPSK (QPSK demodulation).

4.2 Equipment

- Emona Telecoms-Trainer 101 (plus power-pack).
- Dual channel 20MHZ Oscilloscope.
- Three Emona Telecoms-Trainer 101 oscilloscope leads.
- Assorted Emona Telecoms-Trainer 101 patch leads.

4.3 Experiment

A- Generating a QPSK signal

Procedure

1. Set the scope's Trigger Type to Edge.
2. Set the scope's Trigger Source control to the EXT/5 position.
3. Set the scope's Trigger source coupling to the HF REJ position.
4. Set the scope's Timebase control to the 25ms/div position.
5. Set the Vertical Attenuation control for channel 1 to the 2V/div position.
6. Connect the set-up shown in figure 4.1 below:

Note: Insert the black plugs of the oscilloscope leads into a ground (GND) socket.

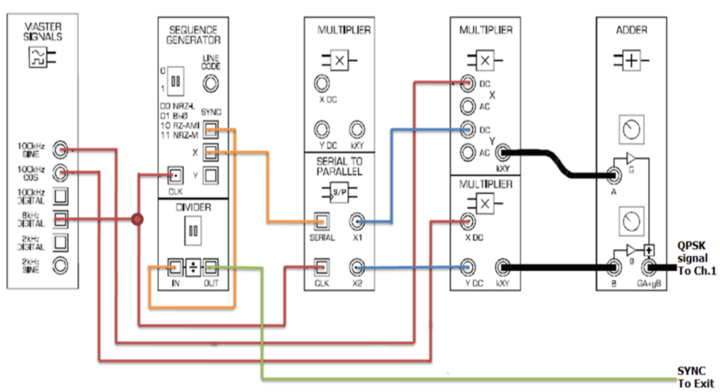

Figure 4.1

7. Locate the Divider module and set it up to divide by 2 by pushing the left-side switch up and the right-side switch down.
8. Turn the Adder module's G control fully anti-clockwise. And g control fully clockwise.
   Note: this removes the BPSKI signal from the signal on the Adder module's output.
9. Adjust the Adder's g control to obtain a 4vp-p output.

10. Disconnect the patch lead to the Adder module's B input.

    Note: This removes the BPSKQ signal from the signal on the Adder module's output.

11. Adjust the Adder's G control to obtain a 4Vp-p output.
12. Reconnect the patch lead to the Adder's B input.
13. The result will be as shown in figure 4.2 below:

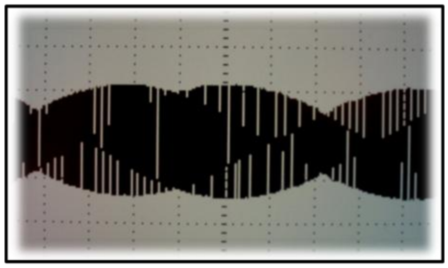

Figure 4.2

Exercise 1. Compare each of the following by using the Oscilloscope:

A. The Even bits with the Odd bits.

B. The Even bits with the PSKI.

C. The Odd bits with the PSKQ.

Solution 1. To compare each of them follow these next steps:

A- The Even bits with the Odd bits:

1. Set the scope's Timebase control to the 1ms/div position.
2. Set the Vertical Attenuation control for both channels to 20V/div position.
3. Set the Vertical position for channel 1 to about 28V.
4. Set the Vertical position for channel 2 to about -28V.
5. Plug the scope's Channel 1 input to the Serial to Parallel Converter module's X1 output (Even bits).
6. Plug the scope's Channel 2 input to the Serial to Parallel Converter module's X2 output (Odd bits).
7. The result will be as shown in figure 4.3 below:

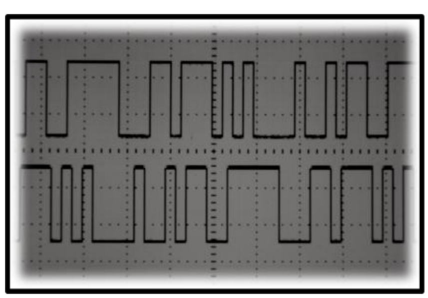

Figure 4.3

B- The Even bits with the PSKI:

1. Set the scope's Timebase control to the 0.01ms/div position.
2. Plug the scope's Channel 1 input to the Serial to Parallel Converter module's X1 output (Even bits).
3. Plug the scope's Channel 2 input to the Multiplier module's Output (PSKI).
4. Set the Vertical Attenuation control for channel 1 to 20V/div position.
5. Set the Vertical Attenuation control for channel 2 to 50V/div position
6. Use the scope's Horizontal Position control to locate a transition in the data sequence.
7. The result will be as shown in figure 4.4 below:

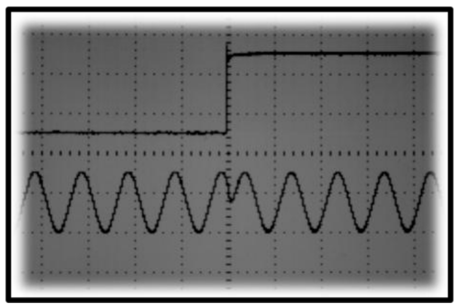

Figure 4.4

C- The Odd bits with the PSKQ:

1. Plug the scope's Channel 1 input to the Serial to Parallel Converter module's X2 output (Odd bits).
2. Plug the scope's Channel 2 input to the Multiplier module's Output (PSKQ).
3. Use the scope's Horizontal Position control to locate a transition in the data sequence.
4. The result will be as shown in figure 4.5 below:

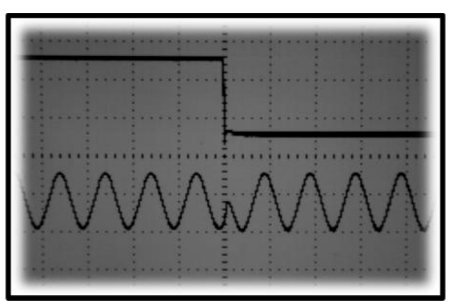

Figure 4.5

B- Using phase discrimination to pick-out one of the QPSK signal’s BPSK signals.

Procedure

1. Set the scope's Timebase control to the 1ms/div position.
2. Set the Vertical Attenuation control for channel 1 to the 20V/div position.
3. Modify the set up as shown in Figure 4.6 below:

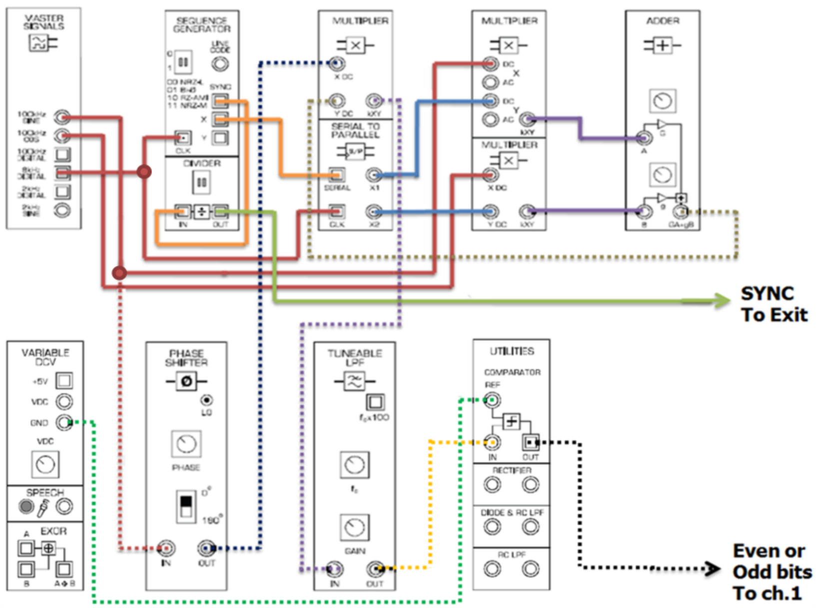

Figure 4.6

4. Locate the Tuneable LPF module and turn its Cut-off Frequency Adjust control fully clockwise.
5. Set the Tuneable LPF module’s Gain control to about the middle of its travel
6. Vary the Phase Shifter module’s Phase Adjust control left and right and observe the effect on the demodulated signal as shown in figure 4.7. You will be aiming to recover a signal like the original X1 or X2 signals from the Serial-to-Parallel Converter module.

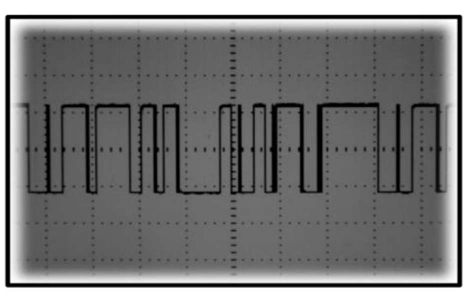

Figure 4.7

Note: Lines show leads already in place. Dotted lines show new leads.

Exercise 2. Compare between all of the:

A. The even data bits (X1 output) with the recovered data.

B. The odd data bits (X2 outputs) with the recovered data.

Solution 2. To compare each of them follow these next steps:

A. The even data bits (X1 output) with the recovered data:

1. Set the Vertical Attenuation control for both channels to the 20V/div position.
2. Plug the scope's Channel 1 input to the Serial to Parallel Converter module's X1 output.
3. Plug the scope's Channel 2 input to the Comparator's output.
4. Set the Phase shifter module's Phase change control to the 0 position.
5. Adjust the Phase Shifter module's Phase Adjust control until you have recovered the even data bits (ignoring any phase shift).
6. The result will be as shown in figure 4.8 below:

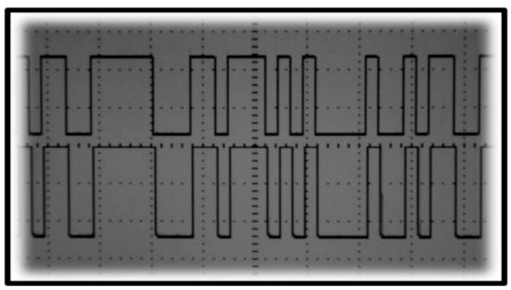

Figure 4.8

B. The Odd data bits (X2 output) with the recovered data:

1 Plug the scope's Channel 1 input to the Serial to Parallel Converter module's X2 output.

2. Set the Phase shifter module's Phase change control to the 180 position.
3. Adjust the Phase Shifter module's Phase Adjust control until you have recovered the Odd data bits (ignoring any phase shift).
4. The result will be as shown in figure 4.9 below:

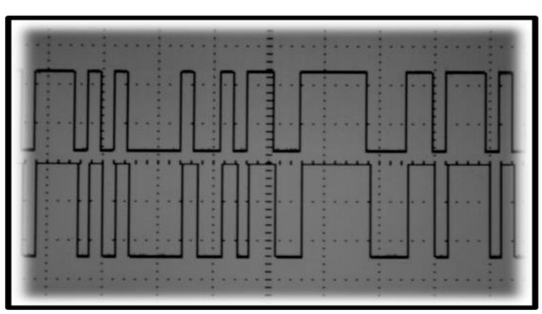

Figure 4.9

5. Signal Constellations

Student edition

5.1 Requirement

Acquaint yourself with the TutorTims –Simulation Software to generate and regenerate the m-QAM and m-PSK (Signal Constellations) by using M-LEVEL ENCODER and M-LEVEL DECODER.

5.2 Preparation

Advanced modules:

- M-LEVEL ENCODER.
- M-LEVEL DECODER.
- 2 TUNEABLE LPF.
- SEQUENCE GENERATORS.

5.3 Terminology

The two outputs from the M-LEVEL ENCODER are referred to as the I and Q signals. Here the 'I' and the 'Q' refer to In phase and Quadrature. Which describe the phase of the carriers of the DSBSC modulators to which they are connected.

The upper case 'M' in the module names (M-LEVEL ENCODER OR DECODER) is intended to imply that the I and Q output signals are 'Multi-level'. In the lower case 'm' of the abbreviations m-PSK and m-QAM it refers specifically to the number of points in the constellation diagram, and is derived from the number of bits 'L' [5].

5.4 Theoretical Introduction

Quadrature amplitude modulation (QAM) is both an analog and a digital modulation scheme. It conveys two analog message signals, or two digital bit streams, by changing the amplitudes of two carrier waves, using the amplitude-shift keying (ASK) digital modulation scheme. These two waves, usually sinusoids, are out of phase with each other by 90° and are thus called Quadrature carriers. The modulated waves are summed, and the resulting waveform is a combination of both phase-shift keying (PSK) and amplitude-shift keying.

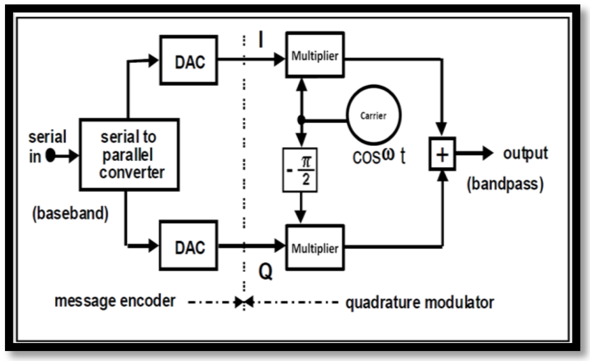

Figure 5.1: A Quadrature modulator

- **Encoding**

To generate the two multi-level analog signals the input serial binary data stream is segmented into frames of L bits each in a serial-to-parallel converter. For a particular choice of L there will be m=2L unique words. From each of these words is generated a unique pair of analog voltages, one of which goes to the I-path, and other to the Q-path, of the Quadrature modulator.

- **Demodulation**

The input signal is a pair of DSBSC, added in phase Quadrature. It is the purpose of the demodulator to recover their individual messages, which are presented to the two inputs of the decoder. If the DSBSC phasing at the transmitter is ideally in Quadrature, then the single phase adjustment to separate the messages of the two signals.

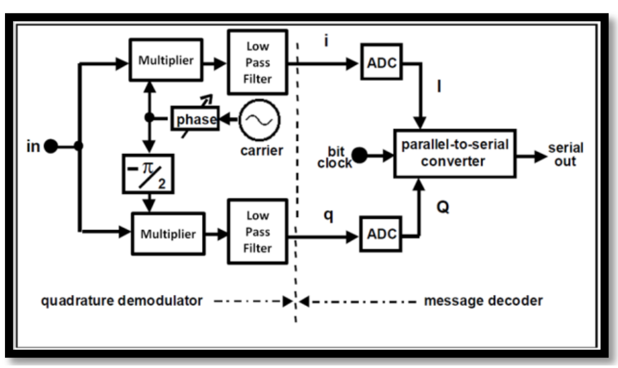

Figure 5.2: An m-QAM demodulator

- **Decoding**

Each arm of the decoder is presented with a band limited analog waveform. The decoder has a bit clock input knows beforehand the number of bit periods (L) in a frame. Each waveform is sampled once per frame, and decision made as to which of the possible levels it represents. This will give a unique pair of levels, which represents a binary word of L bits. This decoded word is output as a serial binary data stream [5].

- **Constellations**

A constellation diagram is a representation of a signal modulated by a digital modulation scheme such as Quadrature amplitude modulation (QAM) or phase-shift keying (PSK). It displays the signal as a two-dimensional scatter diagram in the complex plane at symbol sampling instants. These signals can come from the encoder output, or from the decoder input. The first of these shows the constellation under ideal conditions. The second shows the constellation after the signal has passed through the channel. In the second case the display can be used to reveal much about the impairments suffered by the signal [6].

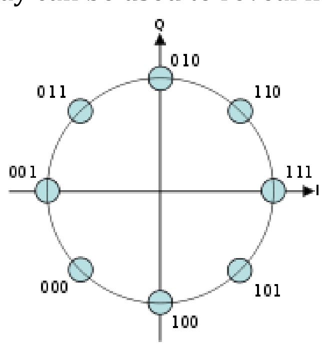

Figure 5.3: A constellation diagram for 8-PSK

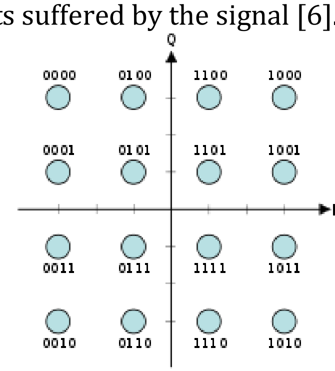

Figure 5.4: A constellation diagram for 16-QAM

Why are constellation maps or diagrams useful?

They help you design a transmission system that is less prone to errors and can possibly recover from transmission problems without relying on higher level protocols. They also help you visually understand how a particular modulation mechanism works. If you make a chart of all the possible values (symbols) that a modulation system can create during transmission, you end up with what is called a constellation map. When a communications device transmits, it modulates a pattern into the signal being transmitted. That pattern represents information and is called a symbol. Symbols are used to represent sets of zeroes and ones--binary data [7].

5.5. Experiment

Part A- Use M-Level Encoder module to generate 4-QAM, 4-PSK signals, and then examine each of them by using Constellation diagram on the scope.

Procedure

1. Set the Input Coupling control for both channels to the AC position.
2. Set the scope in X-Y mode.
3. Set the scope's Timebase control to the 5ms/div position.
4. Set the Vertical Attenuation control for both channels to the 400 mV/div position.
5. Set the Vertical position for channel A to about 7 steps of its travel.
6. Set the Vertical position for channel B to about 4 steps of its travel.
7. Connect the set-up shown in Figure 5.5 below :

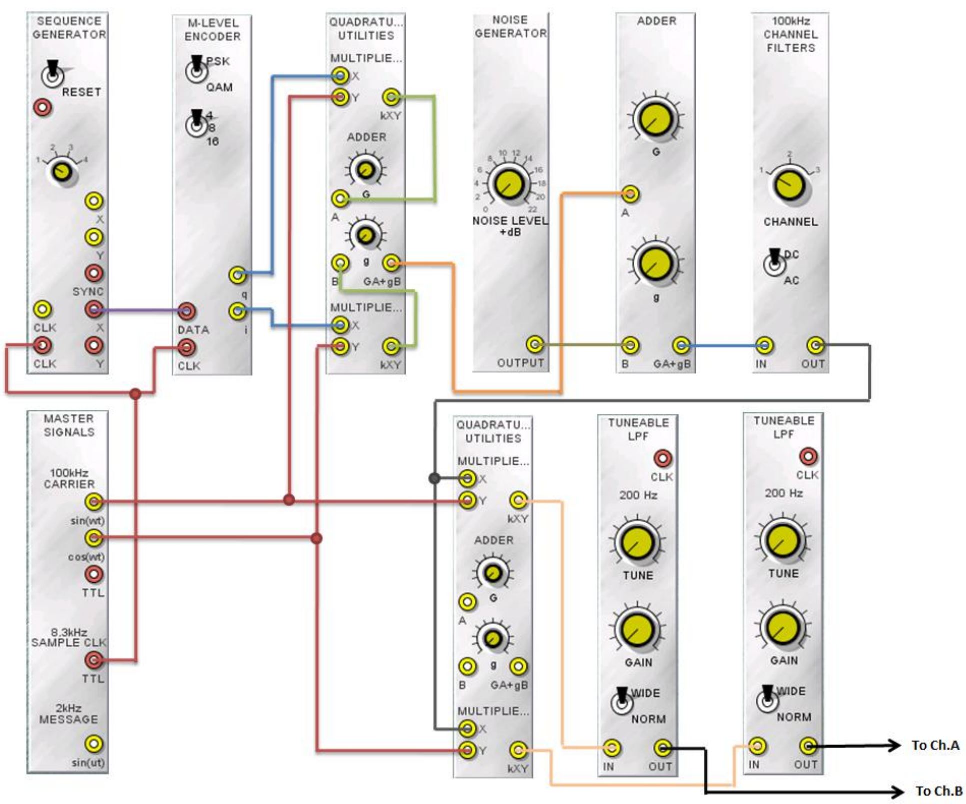

Figure 5.5

The Sequence Generator module is used for the serial data stream, clocked by 8.33 KHz signal from MASTER SIGNAL as a bit clock. M-LEVEL ENCODER is used to generate a m-

QAM and m-PSK signals (Constellation signals).which obtain two multi-level analog signals are Q signal and I signal connected to independent Multiplier modules. The other input to the Multiplier modules is a 100 KHz sine wave and 100 KHz cosine wave, the signals are out of phase with each other by 90°. The adder module is used to add the PSKI and PSKQ signals as required to pass them though a noisy band limited channel, to be transmitted. The second Adder serves to introduce the noise [5].

8. Set the TLL Level reset of the Sequence generator to 4 Levels.
9. Select the 8-PSK from the M-LEVEL ENCODER.
10. Turn the first Adder module both G and g controls half anti-clockwise.
11. Set the Noise Generator Level to 22dB.
12. Turn the second Adder module G control half anti-clockwise, and g control to fully anti-clockwise.
13. Switch the channel select of the 100 KHz channel filters to the 3th channel.
14. Adjust the both Tuneables LPF Tune's control to 4117 Hz.
15. Set the both Tuneables LPF module's Gain control to about the middle of its travel.
16. The result will be shown as a constellation of 8-PSK signal.

Exercise 1. Examine the constellations of the other signals available from the M- LEVEL ENCODER.

Part B- Use the M-level Decoder to regenerate and clean multi-level data streams from the received analog waveforms (Demodulation).

Procedure

1. Set up the scope as on the pervious experiment.
2. Modify the set up as shown in Figure 5.6 below:

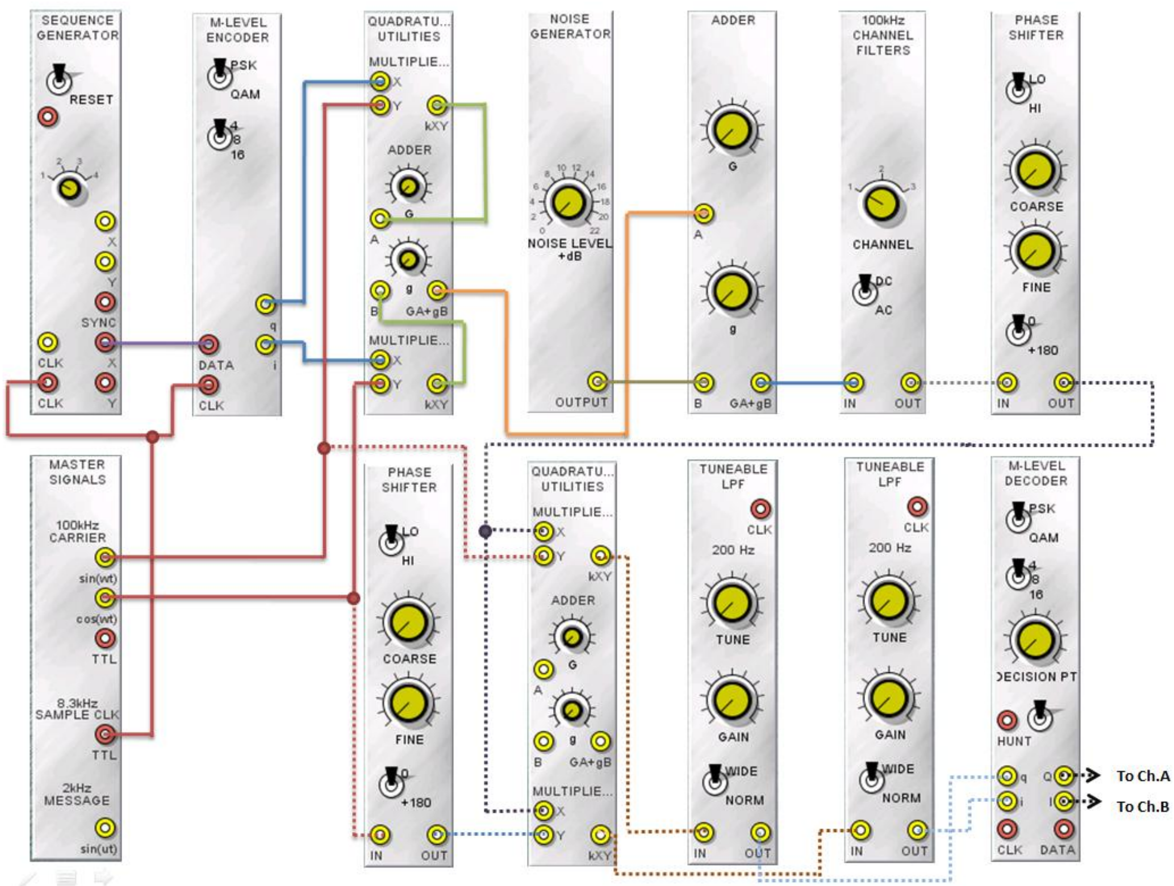

Figure 5.6

The decoder would normally be provided with the in phase and Quadrature outputs from a Quadrature amplitude demodulator. These would be noisy, band limited baseband signals. Each must be 'cleaned up' and their absolute Levels adjusted so as to be suitable for analog-to-digital decoding. The 'cleaning up' and decoding is performed by the M-level decoder module. The decoder has in-built circuitry (decision makers) to regenerate clean multi-level data streams from the received analog waveforms.

Note: Lines show leads already in place. Dotted lines show new leads.

3. Select the 8-PSK from both the M-LEVEL ENCODER, DECODER.
4. Turn the second Adder module G, g controls half anti-clockwise.
5. Switch the channel select of the 100 KHz channel filters to the 2th channel.
6. Adjust the phase Shifter module's Coarse and fine phase controls fully.
7. Adjust the both Tuneables LPF Tune's control to 11150 Hz.
8. Set the both Tuneables LPF module's Gain control to about the middle of its travel.
9. Increase the M-LEVEL DECODER Decision point until you get the right shape of the constellation signal.
10. The result will be shown as a Demodulation for the signal.

Exercise 2. Confirm if there is agreement between all of these:

A- The I and Q outputs from the encoder and the I and Q outputs from the decoder.

B- the serial data input to the M-LEVEL ENCODER and the corresponding output from the M-LEVEL DECODER.

6. Signal Constellations

Administrator Lab edition

6.1 Requirements

Generating and Regenerating the (m-QAM, m-PSK) by using M-LEVEL ENCODER, M-LEVEL DECODER, and examining them by using Constellation diagram.

6.2 Preparation

Advanced modules:

- M-LEVEL ENCODER
- M-LEVEL DECODER
- 2 TUNEABLE LPF
- SEQUENCE GENERATORS

6.3 Terminology

The two outputs from the M-LEVEL ENCODER are referred to as the I and Q signals. Here the 'I' and the 'Q' refer to in phase and Quadrature, Which describe the phase of the carriers of the DSBSC modulators to which they are connected.

The upper case 'M' in the module names (M-LEVEL ENCODER OR DECODER) is intended to imply that the I and Q output signals are 'Multi-level'. In the lower case 'm' of the abbreviations m-PSK and m-QAM it refers specifically to the number of points in the constellation diagram, and is derived from the number of bits 'L'.

6.4 Experiment

Part A- Use M-Level Encoder module to generate 4-QAM and 4-PSK signals and then examine each of them by using Constellation diagram on the scope.

Procedure

1. Set the Input Coupling control for both channels to the AC position.
2. Set the scope in X-Y mode.
3. Set the scope's Timebase control to the 5ms/div position.
4. Set the Vertical Attenuation control for both channels to the 400 mV/div position.
5. Set the Vertical position for channel A to about 7 steps of its travel.
6. Set the Vertical position for channel B to about 4 steps of its travel.
7. Connect the set-up shown in Figure 6.1 below :

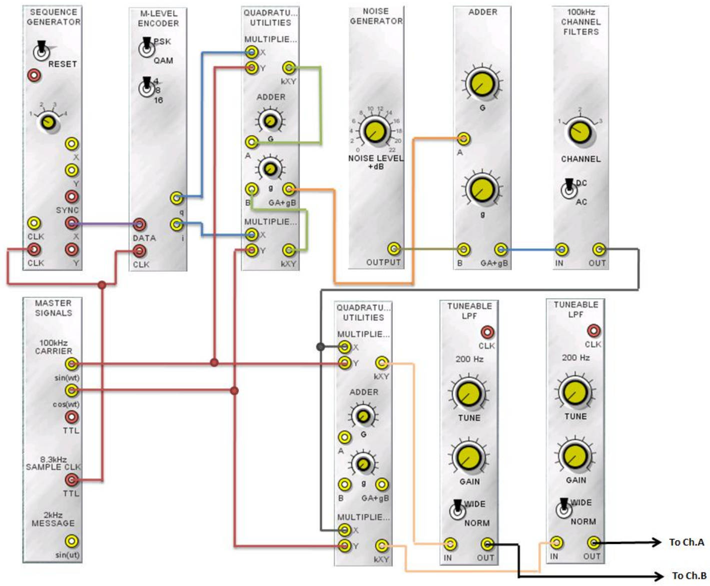

Figure 6.1

8. Set the TLL Level reset of the Sequence generator to 4 Levels.
9. Select the 8-PSK from the M-LEVEL ENCODER.
10. Turn the first Adder module both G and g controls half anti-clockwise.
11. Set the Noise Generator Level to 22dB.
12. Turn the second Adder module G control 5 steps to anti-clockwise, and g control to fully anti-clockwise.
13. Switch the channel select of the 100 KHz channel filters to the 3th channel.
14. Adjust the both Tuneables LPF Tune's control to 4117 Hz.
15. Set the both Tuneables LPF module's Gain control to about the middle of its travel.
16. The result will be as shown in Figure 6.2 below:

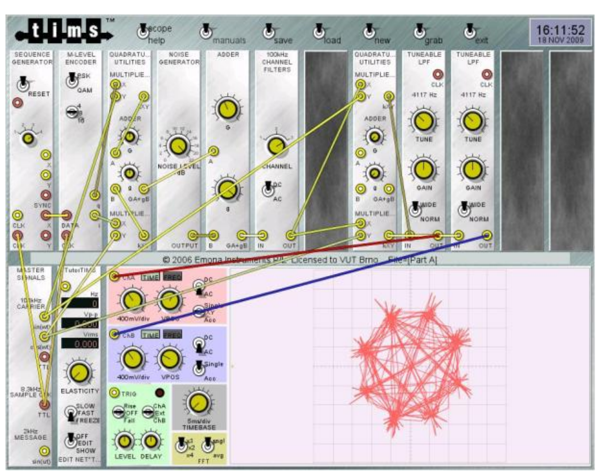

Figure 6.2

Exercise 1. Examine the constellations of the other signals available from the M- LEVEL ENCODER.

Solution 1. To examine the constellations follow these steps:

A- Select the 4-PSK from the M-LEVEL ENCODER and the result with the setup will be as shown in Figure 6.3 below :

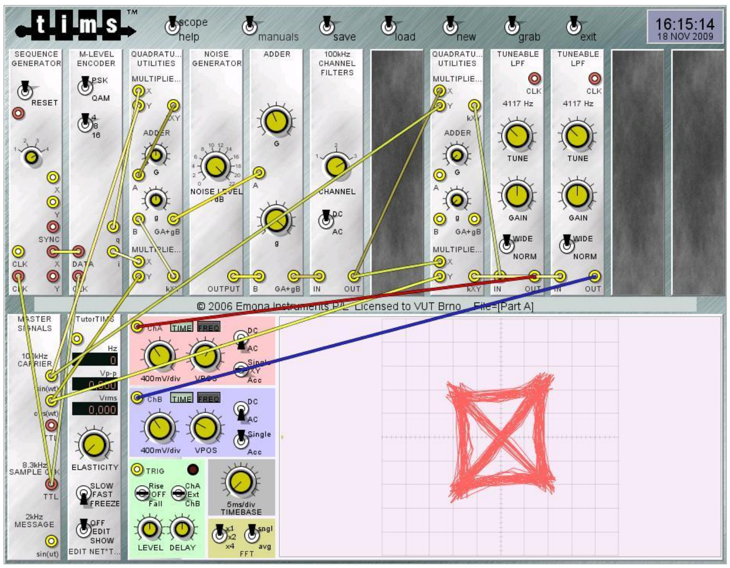

Figure 6.3

B- Select the 16-PSK from the M-LEVEL ENCODER and the result with the setup will be as shown in Figure 6.4 below :

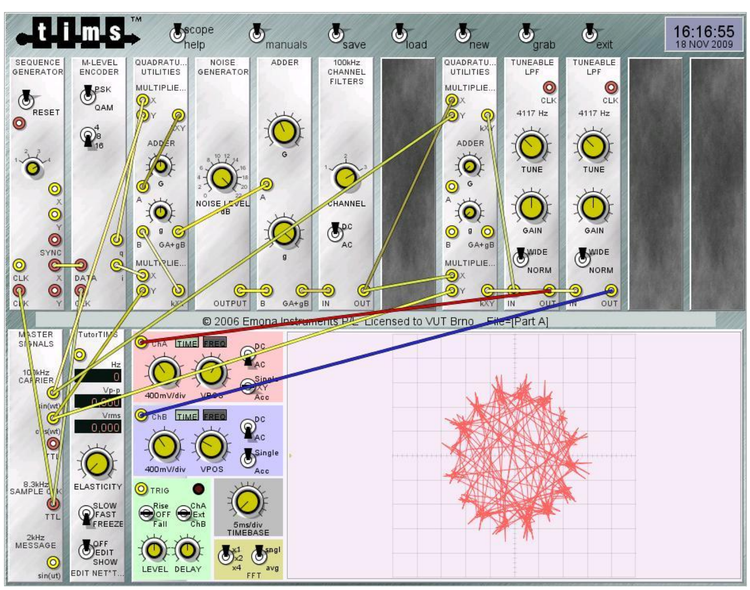

Figure 6.4

C- Select the 4-QAM from the M-LEVEL ENCODER and the result with the setup will be as shown in Figure 6.5 below :

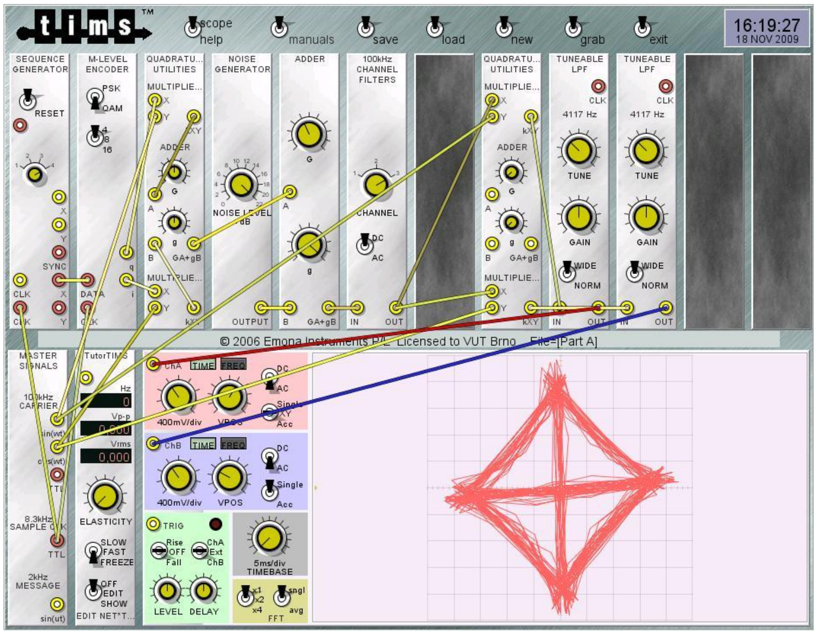

Figure 6.5

D- Select the 8-QAM from the M-LEVEL ENCODER and the result with the setup will be as shown in Figure 6.6 below :

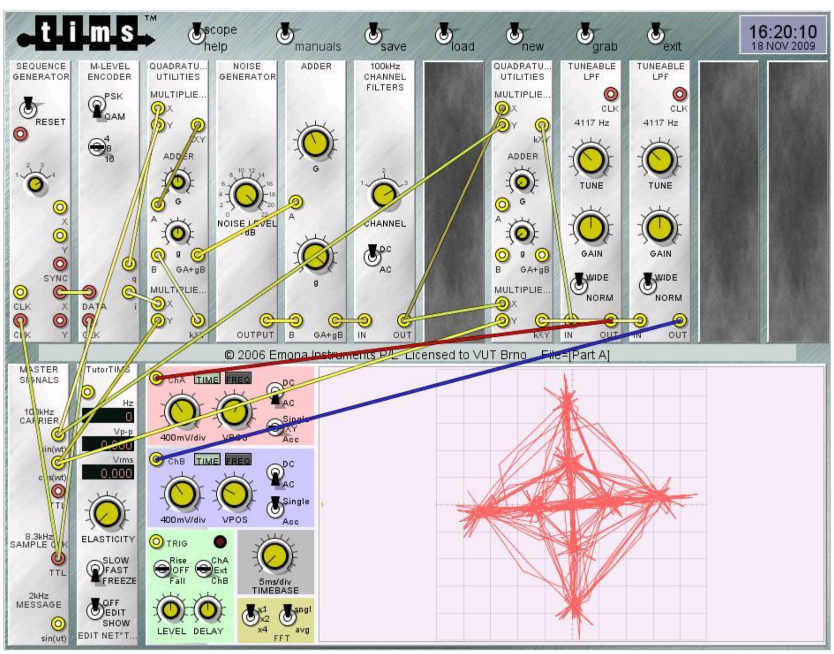

Figure 6.6

E- Select the 16-QAM from the M-LEVEL ENCODER and the result with the setup will be as shown in Figure 6.7 below :

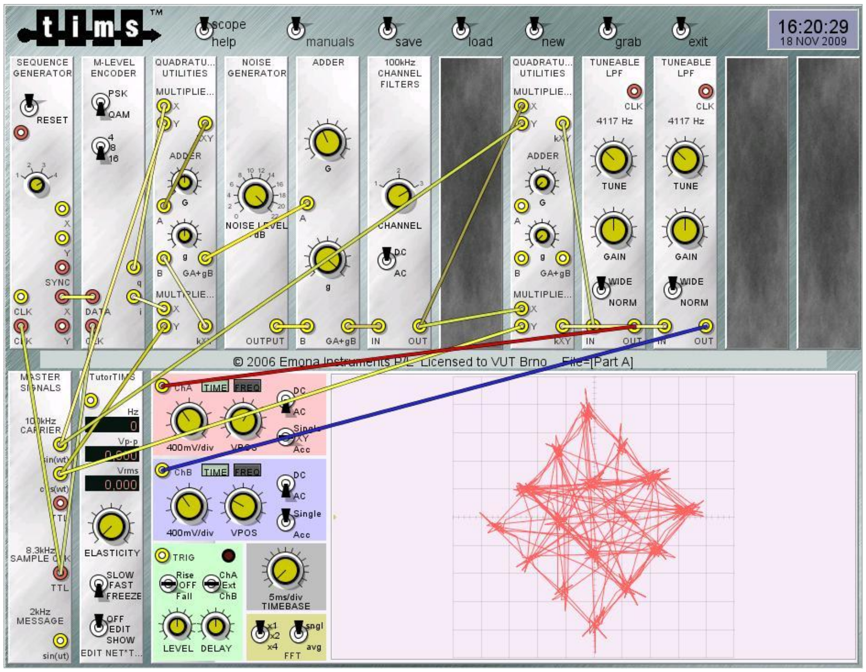

Figure 6.7

Part B- Use the M-level Decoder to regenerate and clean multi-level data streams from the received analog waveforms (Demodulation).

Procedure

1. Set up the scope as on the pervious experiment.
2. Modify the set up as shown in Figure 6.8 below:

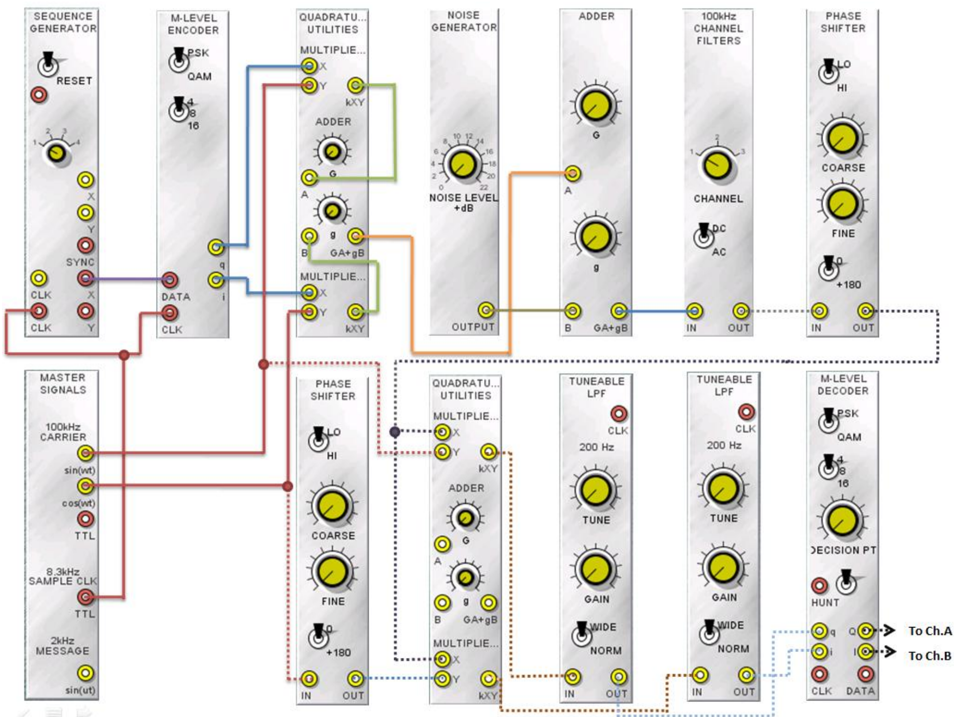

Figure 6.8

3. Select the 8-PSK from both the M-LEVEL ENCODER, DECODER.
4. Turn the second Adder module G control 5 steps to anti-clockwise, and g control to fully anti-clockwise.
5. Switch the channel select of the 100 KHz channel filters to the 2th channel.
6. Adjust the both phase Shifter modules Coarse and fine phase controls about the middle of their travel.
7. Adjust the both Tuneables LPF Tune's control to 11150 Hz.
8. Set the both Tuneables LPF module's Gain control to about the middle of its travel.

Note: Lines show leads already in place. Dotted lines show new leads.

9. Increase the M-LEVEL DECODER Decision point until you get the right shape of the constellation signal.

10. the result will be as shown in Figure 6.9 below:

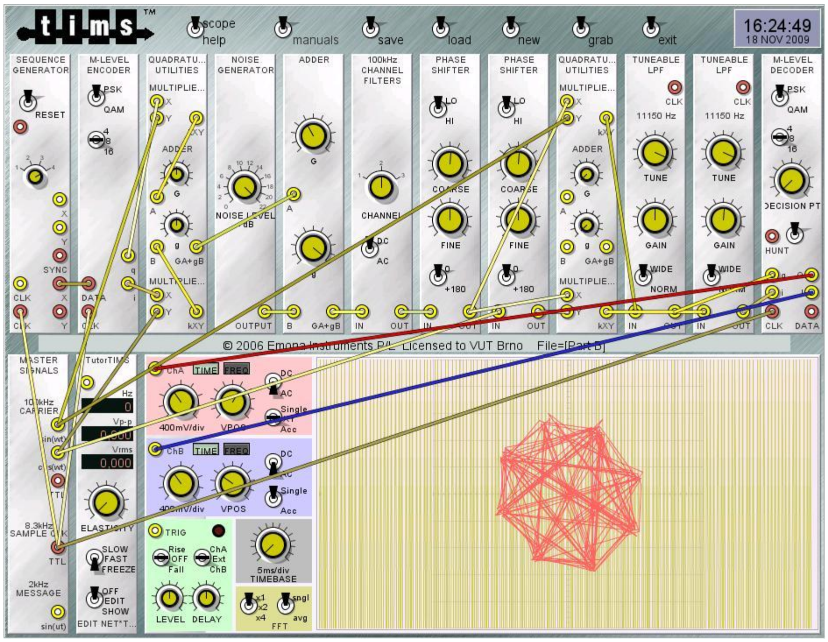

Figure 6.9

Exercise 2. Confirm if there is agreement between all of these:

A- The I and Q outputs from the encoder and the I and Q outputs from the decoder.

B- The serial data input to the M-LEVEL ENCODER and the corresponding output from the M-LEVEL DECODER.

Solution 2. To confirm if there are agreements between all of these (Exercise 2) follow these steps:

A- Between the i output from the encoder and the I output from the decoder:

1. Set the scope in Single mode.
2. Set the scope's Timebase control to the 1ms/div position.
3. Set the Vertical Attenuation control for both channels to the 2 V/div position.
4. Set the second Phase shifter module's Phase change control to the 180 position.
5. Connect the scope's Channel A to the M-LEVEL ENCODER module's i output.
6. Connect the scope's channel B to the M-LEVEL DECODER module's I output.
7. the result will be as shown in Figure 6.10 below:

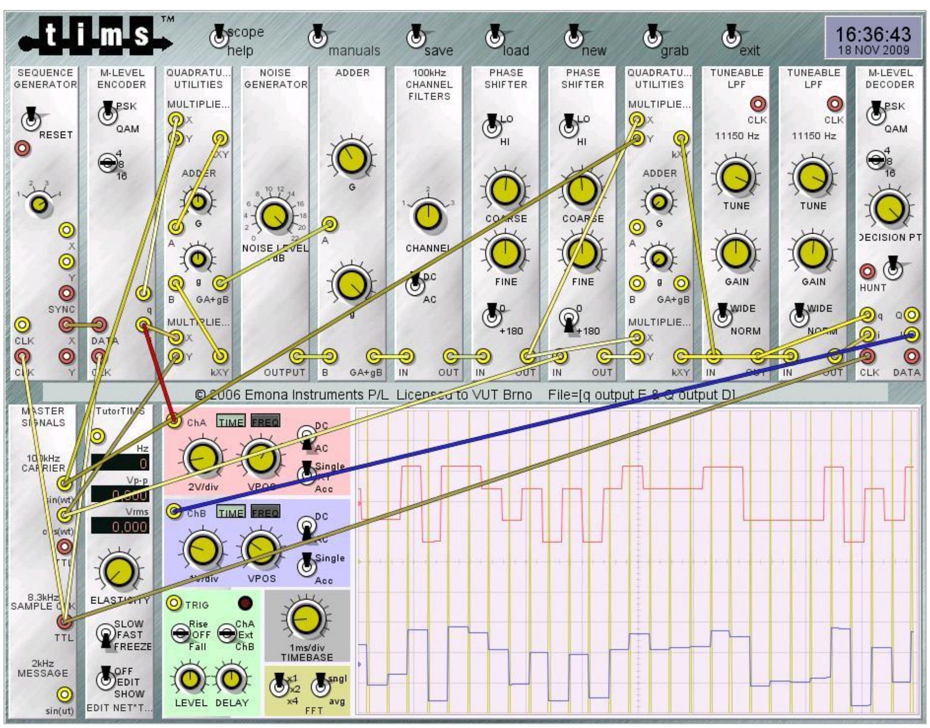

Figure 6.10

B- Between the q output from the encoder and the Q output from the decoder:

1. Set the first Phase shifter module's Phase change control to the 180 position.
2. Connect the scope's Channel A to the M-LEVEL ENCODER module's i output.
3. Connect the scope's channel B to the M-LEVEL DECODER module's I output.
4. the result will be as shown in Figure 6.11 below:

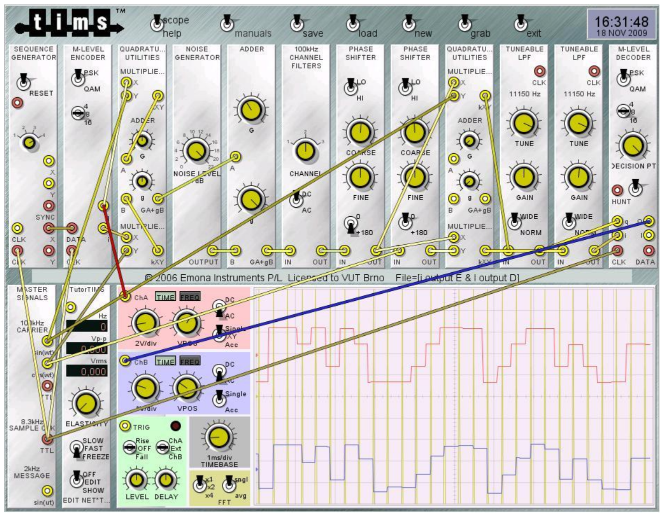

Figure 6.11

C- Between the serial data input to the M-LEVEL ENCODER and the corresponding output from the M-LEVEL DECODER:

1. Set the scope's Timebase control to the 2ms/div position.
2. Connect the scope's Channel A to the sequence generator module's X output.
3. Connect the scope's Channel B to the M-LEVEL DECODER module's data output.
4. the result will be as shown in Figure 6.12 below:

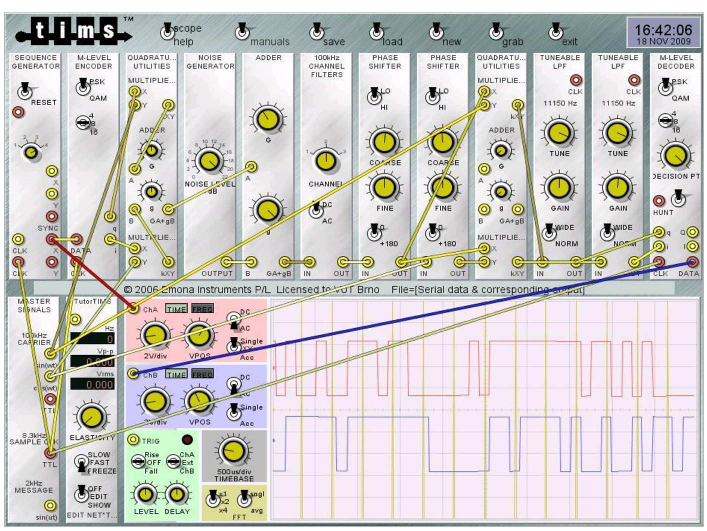

Figure 6.12

7. Eye patterns

Student edition

TutorTims –Simulation Software

7.1 Requirement

Acquaint yourself with the TutorTims –Simulation Software to display the eye pattern of a binary sequence which has been transmitted over a band limited channel. And make assessment of the maximum data rate.

7.2 Preparation

- SEQUENCE GENERATOR
- AUDIO OSCILATOR
- BASBAND CHANNEL FILTER

7.3 Theoretical Introduction

There are many reasons for looking at a data stream. Depending on one's requirements, and the sophistication of the viewing oscilloscope, there are many possible types of display. Connecting a 'standard' oscilloscope to data stream, and synchronizing the oscilloscope to the data stream itself, is generally unproductive, as you will see . But there is a useful variation to this theme, its eye pattern display [8].

Eye pattern, also known as an eye diagram is an oscilloscope display in which a digital data signal from a receiver is repetitively sampled and applied to the vertical input, while the data rate is used to trigger the horizontal sweep. It is so called because, for several types of coding, the pattern looks like a series of eyes between a pair of rails.

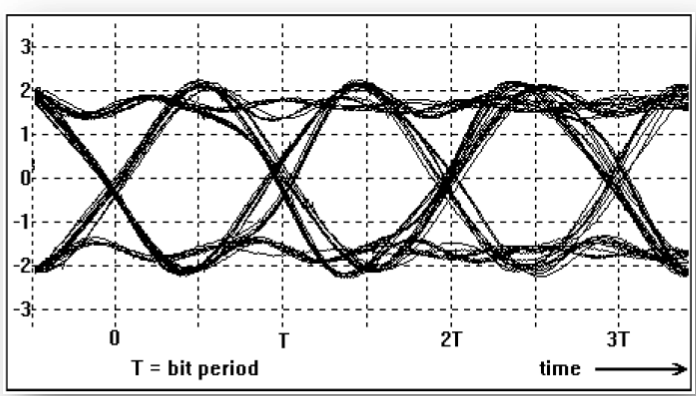

Figure 7.1: An eye pattern

Several system performance measures can be derived by analyzing the display. If the signals are too long, too short, poorly synchronized with the system clock, too high, too low, too noisy, and too slow to change, or have too much undershoot or overshoot, this can be observed from the eye diagram. An open eye pattern corresponds to minimal signal distortion. Distortion of the signal waveform due to inter symbol interference and noise appears as closure of the eye pattern [9].

7.4 Experiment

Use a simple demonstration of the technique which can be given using the arrangement of Figure 2 to observe the effect on the eye pattern when using short or long sequences.

Procedure

1. Set the scope's Trigger Source control to the EXT position.
2. Set the Input Coupling control for both channels to the DC position.
3. Set the scope in Acc mode.
4. Set the scope's Timebase control to the 200us/div position.
5. Set the Vertical Attenuation control for both channels to the 2V/div position.
6. Set the Vertical position for channel A to about 6 steps of its travel.
7. Set the Vertical position for channel B to about 4 steps of its travel.
8. Connect the set-up shown in Figure 7.2 below :

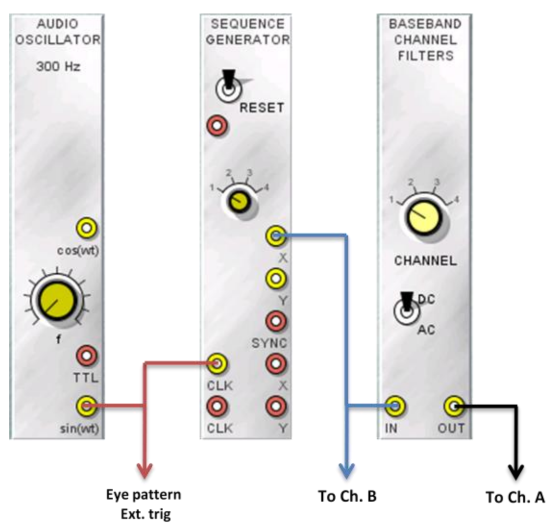

Figure 7.2

The set-up in Figure 7.2 can be represented by the block diagram in Figure 7.3 below. A typical eye pattern displays of a binary sequence which has been transmitted over a band limited channel, with negligible noise. The AUDIO OSCILLATOR serves as the bit clock for the SEQUNCE GENERATOT. A convenient rate to start with is 2 KHz.

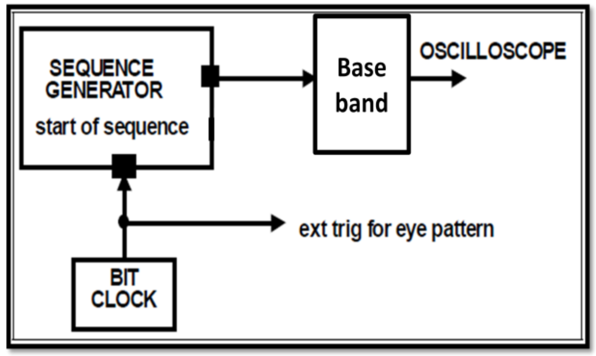

Figure7.3: Data displays

9. Set the AUDIO OSCILLATOR to a frequency 2 kHz.
10. Select a short Sequence of the SEQUENCE GENERATOR switch 2.
11. Select the CHANNEL #2 of the BASEBAND CHANNEL FILTERS module.
12. You should have a display on CH A. similar to that of Figure7.4 below.

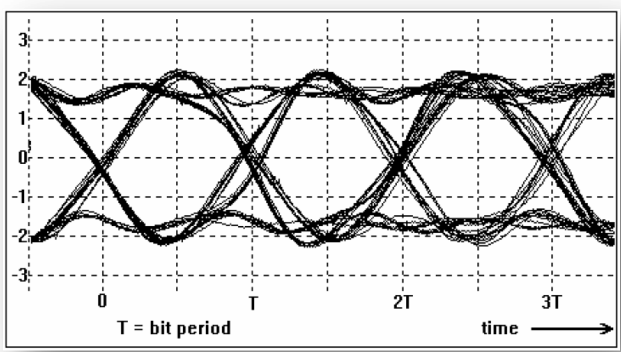

Figure7.4: A 'good' eye pattern

13. Increase the data rate until the eye starts to close. Figure7.5 shows an eye not nearly as clearly defined as that of Figure7.4.

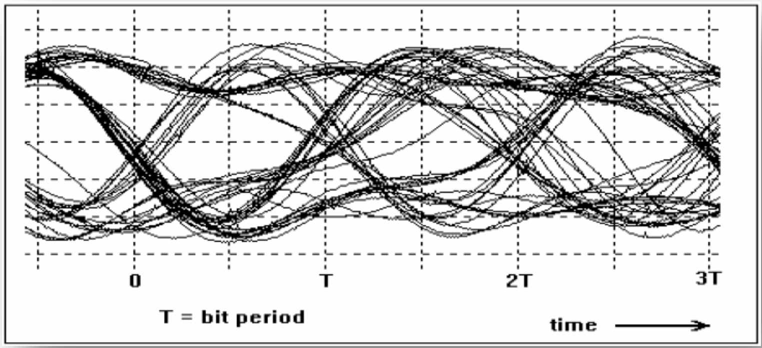

Figure7.5: A faster data rate

There is one ‘eye’ per bit period. Those shown in Figure7.5 are considered to be ‘wide open’. But as the data rate increases the eye begins to close.The actual shape of an eye is determined by the filter (channel) amplitude and phase characteristics (for a given input waveform).Timing jitter will have an influence too.

Eye pattern assessment

A typical detector, which operates on the data stream, can be set up to make its decisions at a precise instant within the bit period. As to whether or not the signal is above or below a certain voltage level. If above it decides the current bit is a HI, otherwise a LO. The eye pattern can be used to determine the “best “decision instant. To observing the eye pattern, increase the data rate until the eye pattern indicates that errors are likely to occur.

Note that this method of quality assessment can be used to observe data on a channel, in real time, without in any way interfering with the transmission.

Exercise

Make an assessment of the maximum data rate, controlled by the frequency of the ADUIO OSCILLATOR, at which a sequence of pulses can be transmitted through each of the two channels (3#, 4#).

8. Eye patterns

Administrator Lab edition

8.1 Requirement

Displaying the eye pattern of a binary sequence, which transmitters over a band limited channel. And make assessment of the maximum data rate.

8.2 Preparation

- SEQUENCE GENERATOR
- AUDIO OSCILATOR
- BASBAND CHANNEL FILTER

8.3 Experiment

Procedure

1. Set the scope's Trigger Source control to the EXT position.
2. Set the Input Coupling control for both channels to the DC position.
3. Set the scope in Acc mode.
4. Set the scope's Timebase control to the 200us/div position.
5. Set the Vertical Attenuation control for both channels to the 2V/div position.
6. Set the Vertical position for channel A to about 6 steps of its travel.
7. Set the Vertical position for channel B to about 4 steps of its travel.
8. Connect the set-up shown in Figure 8.1 below :

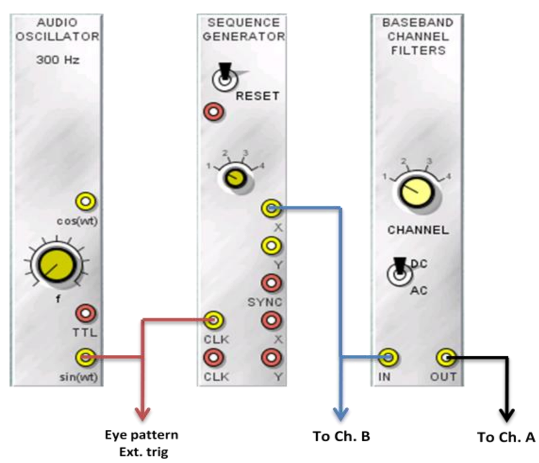

Figure 8.1

9. Set the AUDIO OSCILLATOR to a frequency 2 kHz.

10. Select a short Sequence of the SEQUENCE GENERATOR switch 2.

11. Select the CHANNEL #2 of the BASEBAND CHANNEL FILTERS module.

12. You should have a display on CH A. similar to that of Figure8.2 below:

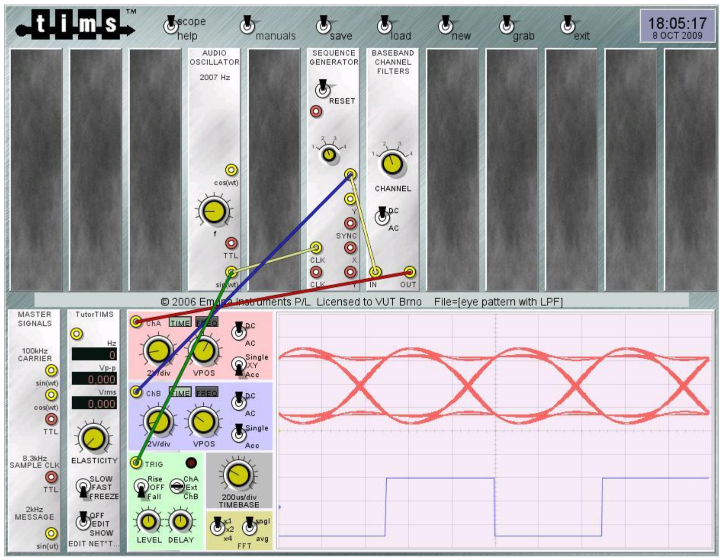

Figure 8.2

13. Increase the data rate until the eye starts to close. Figure8.3 shows an eye not nearly as clearly defined as that of Figure 8.2.

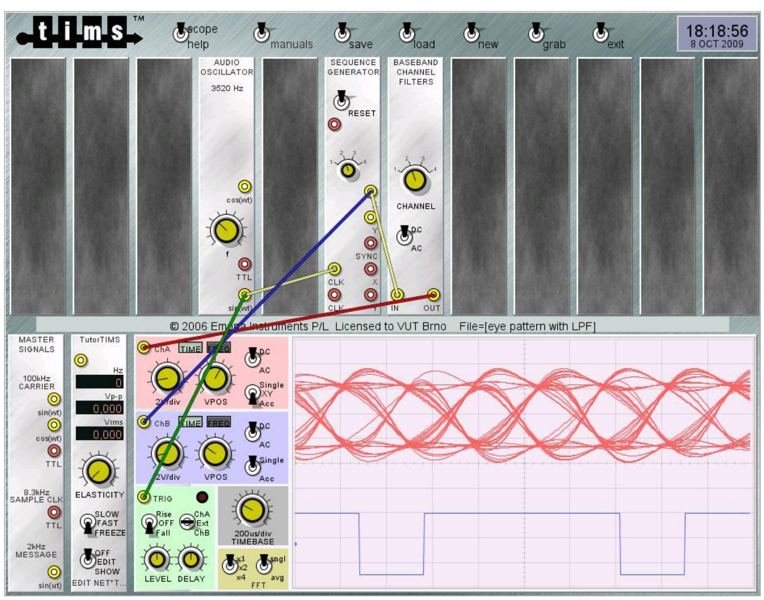

Figure 8.3

Eye pattern assessment

The actual shape of an eye is determined (in a liner system) primarily by the filter (channel) amplitude and phase characteristics (for a given input waveform).
Timing jitter will have an influence too.

The detector must make a decision, at an appropriate moment in the bit period, as to whether or not the signal is above or below a certain voltage level. If above it decides the current bit is a HI, otherwise a LO. You can judge, by the thickness of the bunch of traces at the top and bottom of the eye, compared with the vertical opening, the degree of difficulty in making this decision.

Notice that the noise and other impairments will produce the occasional transition which will produce a trace within the apparently trace free eye. This may not be visible on the oscilloscope, but will none the less cause an error. Turning up the oscilloscope brilliance may reveal some of these transitions.

Exercise:

Make an assessment of the maximum data rate, controlled by the frequency of the ADUIO OSCILLATOR, at which a sequence of pulses can be transmitted through each of the two channels (3#, 4#).

Solution: To make an assessment of the maximum data rate through each of the two channels:

For CHANNEL 3# the maximum data rate is 2375Hz as shown in Figure 8.4 below:

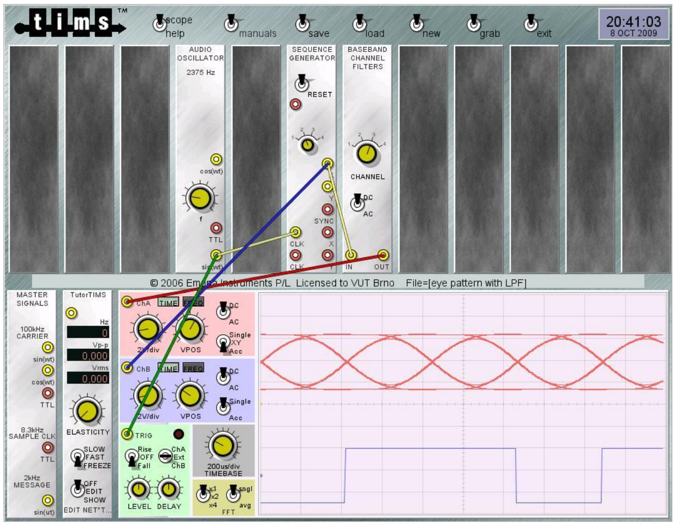

Figure 8.4

For CHANNEL 4# the maximum data rate is 3559Hz as shown in Figure 8.5 below:

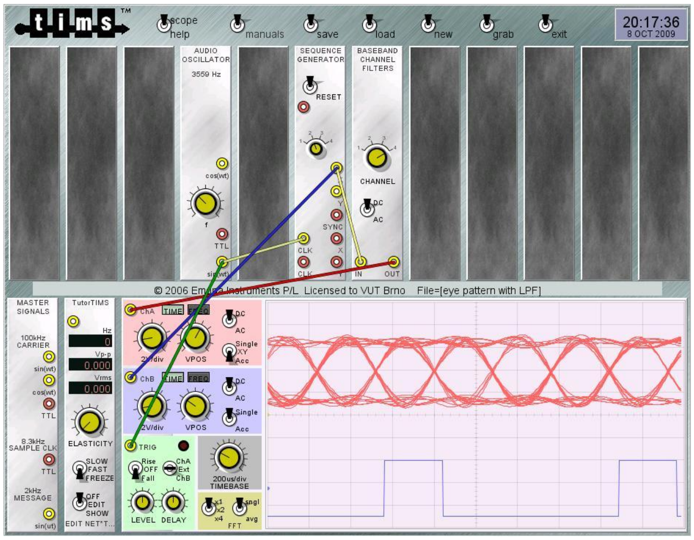

Figure 8.5

9. The TIMS Instruments Specifications

Lab Equipments Hardware and software	specifications
TIMS-301 hardware	• Basic & advanced modules. • Scalable. • It includes scope with it. • It has Plug-in modules. • It has fixed modules (standard). • Free to make mistakes. • Simple building blocks to make a real communication system.
BISKIT-101 hardware	• Basic modules. • Non-scalable. • It doesn't include scope. • Free to make mistakes. • Simple building blocks to make a real communication system. • Waveforms can be displayed on whatever equipment is available.
TutorTIMS – Simulation Software	• Basic & advanced modules. • Scalable. • No programming or syntax entry is required. • Three versions of Tutor TIMS are available (TutorTIMS-Advanced, TutorTIMS-Basic, and TutorTIMS-Freeware). • Possible saving the experiment and restore it at anytime. • It includes scope with it. • Free to make mistakes. • Simple building blocks to make a real communication system.

10. Conclusion

I have designed three advanced tasks in such smart and concise manner to help the student to absorb the content of the experiments, to implement them, and obtain the results easily, in contrast to that tasks, I have designed detailed manuals to explain the procedures, operations and the steps which used to implementing that experiments, and obtaining the final results. Also I have examined the instruments which have been used to implement these experiments such as Biskit hardware and Tutor simulation –software. I got good results and successful implementation, for example in the Biskit hardware 101 advantage of the ease of use, it saves a lot of time for the student to understand the initial principles and the concepts of Telecommunication, but it cannot be used to implement advanced experiments because they require a lot of slides as they are available in the Emona TMIS 301 hardware. For the Tutor simulation –software, it is characterized by a lot of facilities to implementing the experiments and saves and loads them at any time later to continue working on them. Its software does not require any programming or syntax entry to use it. And being software exclusively for universities and institutes of education, the student cannot obtain a special version to keep it, but it can be used through entering the University network from anywhere in the world which means it does not require attending the student to the lab to work on it.

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