Telecommunications
Communications Technologies

Basic Modems and Data Transmission (ASK/FSK/BPSK)

Courseware Sample

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TELECOMMUNICATIONS
COMMUNICATIONS TECHNOLOGIES

BASIC MODEM AND DATA TRANSMISSION (ASK/FSK/BPSK)

Courseware Sample

by
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Foreword

Digital communication offers so many advantages over analog communication that the majority of today's communications systems are digital.

Unlike analog communication systems, digital systems do not require accurate recovery of the transmitted waveform at the receiver end. Instead, the receiver periodically detects which waveform is being transmitted, among a limited number of possible waveforms, and maps the detected waveform back to the data it represents. This allows extremely low error rates, even when the signal has been corrupted by noise.

The digital circuits are often implemented using application specific integrated circuits (ASIC) and field-programmable gate arrays (FPGA). Although this "system-on-a-chip" approach is very effective for commercial and military applications, the resulting systems do not allow access to internal signals and data and are therefore poorly suited for educational use. It is for this reason that Lab-Volt designed the Communications Technologies Training System.

The Lab-Volt Communications Technologies Training System, Model 8087, is a state-of-the-art communications training system. Specially designed for hands-on training, it facilitates the study of many different types of digital modulation/demodulation technologies such as PAM, PWM, PPM, PCM, Delta Modulation, ASK, FSK, and BPSK as well as spectrally efficient technologies such as QPSK, QAM, and ADSL. The system is designed to reflect the standards commonly used in modern communications systems.

Unlike conventional, hardware-based training systems that use a variety of physical modules to implement different technologies and instruments, the Communications Technologies Training System is based on a Reconfigurable Training Module (RTM) and the Lab-Volt Communications Technologies (LVCT) software, providing tremendous flexibility at a reduced cost.

Each of the communications technologies to be studied is provided as an application that can be selected from a menu. Once loaded into the LVCT software, the selected application configures the RTM to implement the communications technology, and provides a specially designed user interface for the student.

The LVCT software provides settings for full user control over the operating parameters of each communications technology application. Functional block diagrams for the circuits involved are shown on screen. The digital or analog signals at various points in the circuits can be viewed and analyzed using the virtual instruments included in the software. In addition, some of these signals are made available at physical connectors on the RTM and can be displayed and measured using conventional instruments.

The courseware for the Communications Technologies Training System consists of a series of student manuals covering the different technologies as well as instructor guides that provide the answers to procedure step questions and to review questions. The Communications Technologies Training System and the accompanying courseware provide a complete study program for these key information-age technologies.

Courseware Outline

BASIC MODEMS AND DATA TRANSMISSION (ASK / FSK / BPSK)

Unit 1 Baseband Data Transmission

Baseband data transmission. Pseudo-random binary sequences.

Ex. 1-1 Pseudo-Random Binary Sequences

Test signals. Characteristics of random data. PRBS Characteristics.

Unit 2 Amplitude shift keying (ASK)

Disadvantages of baseband data transmission. Data transmission using modulation/demodulation. Amplitude shift keying (ASK). Types of demodulation. Units of data transmission rate. ASK performance.

Ex. 2-1 Generation and Reception of ASK Signals

Generating ASK signals. The spectra of ASK signals. ASK signal demodulation.

Unit 3 Frequency shift keying (FSK)

Frequency shift keying (FSK). FSK communications standards. FSK performance.

Ex. 3-1 FSK Principles

FSK modulation. Time-domain characteristics of FSK signals. Frequency-domain characteristics of FSK signals. FSK demodulation.

Ex. 3-2 Bell 202 Modem (1200 baud)

The Bell 202 and CCITT V.23 MODE 2 modem standards.

Unit 4 Binary Phase Shift Keying (BPSK)

Comparison of ASK, FSK, and BPSK. BPSK performance.

Ex. 4-1 Generation and Demodulation of BPSK Signals

Binary phase shift keying. Generation of BPSK signals. Time and frequency characteristics of BPSK signals. Demodulation of BPSK signals. The BPSK Demodulator. The phase-locked loop (PLL). The Costas loop mixer.

Courseware Outline

BASIC MODEMS AND DATA TRANSMISSION (ASK / FSK / BPSK)

Unit 5 Troubleshooting Basic Modems

Troubleshooting communications equipment. Troubleshooting activities.

Ex. 5-1 Troubleshooting an ASK Communication System

Signal flow tracing. The divide-in-half method. A systematic troubleshooting procedure. Troubleshooting the ASK application.

Ex. 5-2 Troubleshooting an FSK Modem

Troubleshooting the FSK application.

Ex. 5-3 Troubleshooting a BPSK Communication System

Troubleshooting the BPSK application.

Appendix A Glossary of New Terms

Sample Exercise

Extracted from

Basic Modems and Data Transmission

(ASK / FSK / BPSK)

Troubleshooting an ASK Communication System

EXERCISE OBJECTIVE

When you have completed this exercise, you will be able to apply a systematic technique of signal flow tracing to diagnose instructor-inserted faults in the ASK application.

DISCUSSION OUTLINE

The Discussion of this exercise covers the following points:

DISCUSSION

Signal flow tracing

Signal flow tracing is the principal technique applied in troubleshooting, once a problem has been determined and enough information concerning the problem and its symptoms has been gathered. When performing troubleshooting exercises with the Communications Technologies Training System, it is important to refer to the System Diagram as well as to the block diagrams of each virtual module showing the locations of the test points. In addition, reviewing previous exercises can provide valuable information concerning system operation, and lead to more efficient troubleshooting.

The technique of signal flow tracing consists of analyzing signals at different points along their path. In some cases, an oscilloscope and a function generator are the only test equipment needed to troubleshoot digital communications equipment. In other cases, instruments such as a logic analyzer and a spectrum analyzer will be required.

The choice of which signal to analyze, and where to analyze it, should never be done on a random basis. A straight-forward, logical approach leads to quicker identification and correction of a problem. Knowing the operating principles of the equipment also reduces the time and effort required to diagnose a fault.

Signal flow tracing can be approached in two ways. They are basically the same except for the direction followed in analysis:

- Signal flow tracing from input to output
- Signal flow tracing from output to input

Depending on the ability and training of the troubleshooter, and the functional complexity of the equipment, one or the other of the two approaches will be preferred. Extensive knowledge of equipment operating principles is necessary to trace signals from output to input, while troubleshooting equipment with only one output and multiple inputs can often be better performed in this way.

In this manual, we suggest you perform signal flow tracing from input to output. We suggest this approach for the following reasons:

- The approach is well adapted to the communications technologies presented in this manual.
- It is the best method for students who have little experience in troubleshooting.

The divide-in-half method

A more rapid technique used by experienced personnel is the divide-in-half method. Basically, this method requires that the input and output of the equipment be checked to verify defective operation. Next, the complete circuit path is divided in half and signals near the center are checked to determine if the problem is in the first or the second half. Following this, the defective section is again divided in half to further locate the problem. This successive divide-in-half approach is applied until the last remaining functional block is checked and the fault located. Figure 5-1 illustrates the procedure for a problem located at functional block B. The dotted lines show where signals are checked and the circled numbers indicate the steps in sequential order.

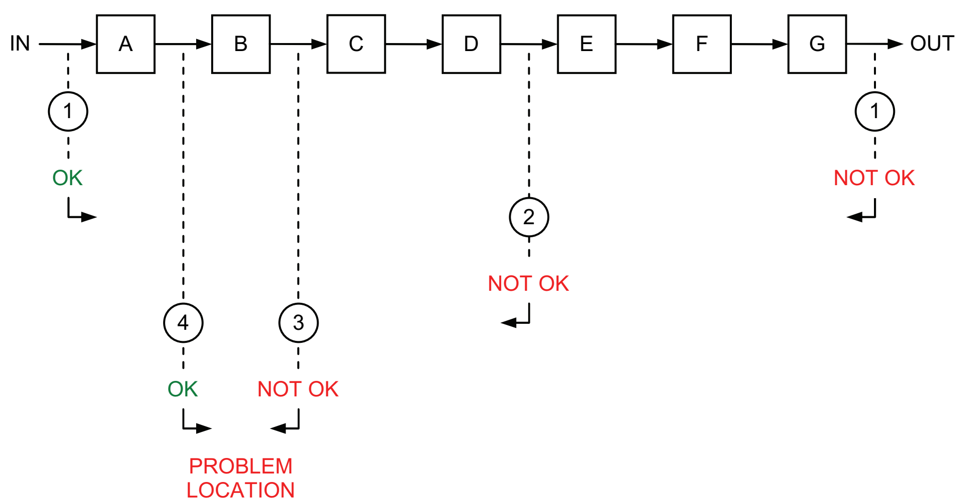

Figure 5-1. The divide-in-half method of troubleshooting.

A systematic troubleshooting procedure

A systematic troubleshooting procedure is summarized in the following steps:

1. Observe the problem and note its symptoms. Using various tests, identify the module(s) or mode(s) which may be defective. If possible, perform a visual inspection for loose or damaged wires, connectors and components.

2. Check the power supplied to each suspected module and note all status LEDs and other indicators. In the Communications Technologies Training System, the RTM has a LED to indicate that power is supplied to the module, and each of the plug-in modules has a status ("OK") LED that lights when the module is detected by the software.

3. Apply the appropriate signals and use signal flow tracing within the circuits suspected to be defective in order to locate a defective part of circuitry.

4. Verify if there are other branches of circuitry meeting at the point where defective operation was discovered. If so, verify that these branches are operating normally before concluding that the part of circuitry located in the previous steps is really defective.

5. Once a defective part of circuitry has been located, make sure that its malfunction plausibly explains the problem observed. If not, there may be another defective part of circuitry that contributes to the problem.

6. Diagnose the problem.

Note: *This procedure is summarized on the Troubleshooting Worksheet at the end of each exercise.*

Of the many different types of faults, the most difficult to identify are those that do not appear to prevent the system from working properly. This may be the case when a fault affects only certain controls or certain operating modes of a module, or when the problem is noticeable only under certain conditions. In these cases, familiarity with the nature of the signals and with the system's operation is essential. During the troubleshooting procedure, it is best to follow the signal flow from the system's input to output while varying the operation parameters.

Troubleshooting the ASK application

The ASK application is the simplest of the applications presented in this manual. Once you have identified the defective circuit (ASK Modulator or ASK Demodulator), signal flow tracing from output to input should allow you to rapidly locate the fault and diagnose the problem.

PROCEDURE OUTLINE

The Procedure is divided into the following sections:

- Set up and connections
- Troubleshooting faults in an ASK communication system

PROCEDURE

Set up and connections

1. Turn on the RTM Power Supply and the RTM and make sure the RTM power LED is lit.

File ▶ Restore Default Settings *returns all settings to their default values, but does not deactivate activated faults.*

2. Start the LVCT software. In the *Application Selection* box, choose ASK and click OK. This begins a new session with all settings set to their default values and with all faults deactivated.

Tip: If the software is already running, choose Exit in the File menu and restart LVCT to begin a new session with all faults deactivated.

3. Make the Synchro external connections shown on the *System Diagram* tab of the software. For details of connections to the Reconfigurable Training Module, refer to the *RTM Connections* tab of the software.

Tip: Click the **Synchro** button to show the required external connections.

4. As an option, use a conventional oscilloscope during this exercise to observe any of the outputs on the RTM (refer to the *RTM Connections* tab of the software for the available outputs). Use BNC T-connectors where necessary.

Troubleshooting faults in an ASK communication system

5. Complete the upper section of the troubleshooting worksheet.

6. Make the following settings:

Binary Sequence Generator:

Generation Mode ....Pseudo-Random
n 2
Bit Rate ....500 bit/s
Delay...................................0 ms

Function Generator

Function ....Sine
Output Level........................1.2 V
Frequency...........................1500 Hz

7. Click the *ASK Modulator* tab in order to display the ASK Modulator diagram.

Show the Probes bar (click in the toolbar or choose View ▶ Probes Bar). Connect the probes as follows:

Oscilloscope Probe	Connect to	Signal
1	TP2	DATA INPUT
2	TP5	MODULATOR OUTPUT
E	TP3	BSG SYNC. OUTPUT

8. Show the Oscilloscope (click [icon] in the toolbar or choose Instruments ▶ Oscilloscope). Figure 1-6 shows an example of what you should observe.

Oscilloscope Settings:
Channel 1 .... 5 V/div
Channel 2 .... 2 V/div
Channel E .... 5 V/div
Time Base .... 1 ms/div
Trigger Slope .... Rising
Trigger Level .... 2 V
Trigger Source .... Ext

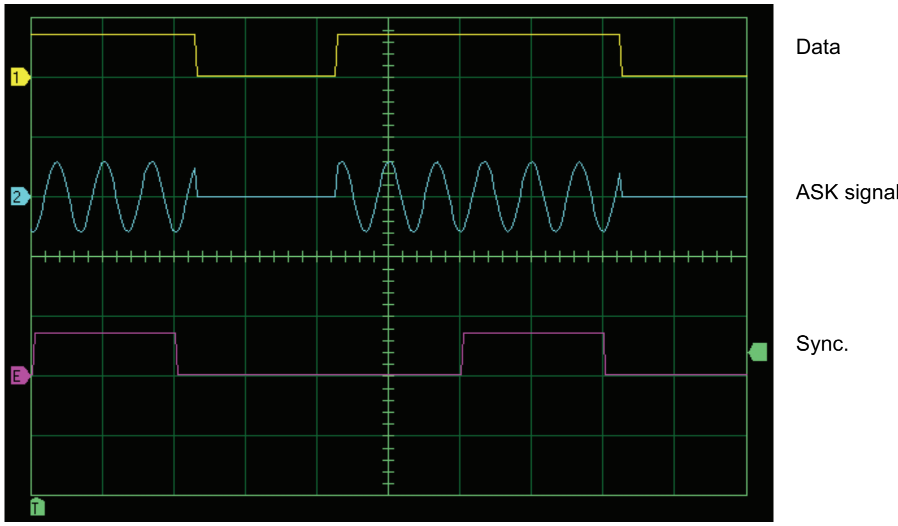

Figure 5-2. Data and ASK signals.

9. Observe the signal at each of the test points of the ASK Modulator and the ASK Demodulator. While doing this, vary the parameters of the input signals in order to become very familiar with the operation of the module.

10. Ask the instructor to activate a fault.

11. Carry out the Troubleshooting Procedure in order to locate the fault and diagnose the problem.

12. If desired, ask your instructor to activate another fault. Troubleshoot the new fault using a copy of the Troubleshooting Worksheet.

13. When you have finished using the system, exit the LVCT software and turn off the equipment.

CONCLUSION

In this exercise, you used a systematic, step-by-step troubleshooting method to locate a fault inserted in the ASK application.

This exercise has allowed you to acquire useful knowledge concerning troubleshooting, and you have been able to verify that a sound approach leads to quicker identification of the problem source. While you should not neglect any personal talents for troubleshooting that you may have discovered, it is important to combine these talents with the fundamental principles given in the exercise. This will reduce the chances of making errors when troubleshooting.

REVIEW QUESTIONS

1. Define troubleshooting.

2. What are two fundamental steps that should be used as a guide in any troubleshooting job?

3. What are the four levels of activity designed to identify, locate, and correct a problem? List them in the order in which they are performed during troubleshooting.

4. Why is signal flow tracing from output to input instead of from input to output a more difficult method to apply in troubleshooting?

5. In certain cases, a fault may not appear to prevent a system from working properly. What approach should you take in this case?

TROUBLESHOOTING WORKSHEET

Student's Name: ______________________________

Instructor's Name: ______________________________

Fault:* ______________________________

Troubleshooting Procedure:

1. Identify the defective module(s) or mode(s) and check visually for damage.
2. Verify that power supplied to all modules. Note all status LEDs and other indicators.
3. Apply the appropriate signals and use signal flow tracing to locate the problem.
4. Verify any other input branch, if present.
5. Make sure the malfunction located plausibly explains the problem observed.
6. Diagnose the problem.

Problem Description and Symptoms: ______________________________

____

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____

____

Defective circuit: ______________________________

____

Diagnosis: ______________________________

____

Instructor's Comments: ______________________________

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Notes: ______________________________

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* At instructor's discretion

Other Sample Extracted from

Basic Modems and Data Transmission

(ASK / FSK / BPSK)

Unit Test

1. Troubleshooting communications equipment is basically the same as troubleshooting any other electrical, electronic, or mechanical device.

   a. True.
   b. False.

2. Before troubleshooting any equipment the best way to start is to

   a. check that the power is on.
   b. call the manufacturer of the equipment.
   c. read through the instruction manual to learn how the equipment operates.
   d. check that the power is off.

3. To successfully perform troubleshooting it is necessary to

   a. have had some experience operating the particular equipment.
   b. understand the equipment and its operation.
   c. talk to the equipment manufacturer.
   d. have the instruction manual of the equipment.

4. The two fundamental rules that serve as a guide for troubleshooting are

   a. read the instruction manual and use your personal initiative.
   b. observe the symptoms of the problem and identify the specific functional blocks related to the problem.
   c. learn how the system functions and substitute defective parts in the system.
   d. none of the above.

5. Locating and diagnosing equipment malfunctions by systematic checking is known as

   a. regular maintenance.
   b. equipment checking.
   c. equipment repair.
   d. troubleshooting.

6. Signal flow tracing is best performed using

   a. a random basis approach.
   b. only the imagination of the troubleshooter.
   c. a straight-forward logical approach.
   d. the divide-in-half method.

7. Signal flow tracing from output to input

   a. is exactly the same as signal flow tracing from input to output.
   b. is faster than the divide-by-half method.
   c. requires extensive knowledge of equipment operating principles.
   d. is a method used only to maintain communications equipment.

8. The divide-in-half technique of troubleshooting

   a. is well adapted for use by inexperienced personnel.
   b. is unsuitable for troubleshooting communications equipment.
   c. is rapid, but requires good knowledge of the equipment.
   d. requires much more time than other methods.

9. One of the first things to verify when troubleshooting is

   a. the equipment's power input.
   b. the electric company's line voltage.
   c. the frequency of the ac power circuit.
   d. none of the above.

10. A fault may not appear to prevent a system from working properly. In this case, you

    a. use the divide in half method to troubleshoot the system.
    b. follow the signal flow from the system's input to its output while varying the operation parameters.
    c. let the equipment warm up and take a coffee break.
    d. call your instructor and ask him to insert a fault in your system.

Instructor Guide Sample Exercise

Extracted from

Basic Modems and Data Transmission

(ASK / FSK / BPSK)

Exercise 5-1 Troubleshooting an ASK Communication System

ANSWERS TO REVIEW QUESTIONS

1. Troubleshooting is the act of locating and diagnosing malfunctions or breakdowns in equipment by means of systematic checking or analysis.

2. The two fundamental steps are: first, observe the symptoms of the problem, and second, relate the problem to specific functional blocks.

3. 1. System level observations and tests

   2. Signal flow tracing

   3. Signal and component measurements

   4. Module or component substitution and replacement

4. It is a more difficult method to apply because extensive knowledge of equipment operating principles is necessary. Troubleshooting from output to input means that you must decide whether the output is correct based upon your theoretical knowledge and practical experience. This may be insufficient when working with unfamiliar equipment. When troubleshooting from input to output, you begin with a known signal and you check whether or not the following signals is a correctly transformed version of this known signal.

5. In this case, it is best to follow the signal flow from the system's input to its output while varying the operation parameters.

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