TRANSMISSION SYSTEMS ENGINEERING TEACHING

A COMPUTER-AID APPROACH

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SUMMARY

The purpose of this paper is to discuss a training methodology in telecommunications transmission systems engineering based on a computer-aid approach. It's described the importance of simulation and considered an experiment.

1. INTRODUCTION

One problem encountered by information technology graduates in their first experience of the communications industry lies in the difficulty of analysing and/or designing systems which factor in the greatest possible number of variables for producing alternative solutions to specific physical situations. Possible ways of dealing with this problem are the simulation and the development of laboratory prototypes.

Both these solutions are valid from the stand point of training future graduates. At least two difficulties arise, however, as systems become more complex: it is harder to analyse and/or design them because of the growing number of parameters and variables that have to be taken into account in approximating the real situation, while training centres are not usually well enough endowed to subsidize the development of prototypes or models that can cope with the widening range of information technologies.

This paper discusses an alternative approach consisting in a computer-aid approach or digital simulation [1].

The paper begins with a justification of the uses of digital simulation and highlights its advantages.

In the paragraph 3. are considered the steps for planning simulation experiments.

The paragraph 4. deals with aspects of the modeling of transmission systems.

A simple experiment is considered in paragraph 5., which can be used for analysing digital radiocommunication systems.

The conclusion is that greater complexity can be simulated not only for a very modest investment in time and money but to the advantage of the educational system.

2. IMPORTANCE OF SIMULATION IN TEACHING

In itself, the use of digital simulation, i.e. a digital technique for conducting experiments with a digital computer which requires certain types of logic and mathematical models describing the performance of a system or some of its components over ex-

tensive periods of time, does not exhaust the necessary objectives of organized training in transmission systems.

Some of the following should also be taken into account in training a systems engineer:

- developing his ability to seek interrelations between the different component parts of the system;
- enhancing his capacity for understanding the context within which any system has to be defined;
- expanding his capacity to generate different alternatives to enable him to take a decision or solve a specific problem.

Although these are not the only skills to be developed, they lend themselves perfectly to improve by means of a tool as powerful as digital simulation.

The scientific and technical training of a graduate as a future designer is usually based on a learning process applying in the conventional step-by-step method:

- 1: observation of the physical system;
- 2: formulation of a hypothesis;
- 3: prediction of the system's performance by mathematical analysis;
- 4: conducting experiments to test the hypothesis.

Sometimes, however, it is inconvenient to follow these four steps in view of the difficulties involved. In such cases, digital simulation may be regarded as a satisfactory substitute for some of the steps described.

What are the reasons supporting these claims in favour of digital simulation?

The following may be quoted:

1. simulation makes it possible to study and experiment with the complex interactions occurring within a given system;
2. detailed observation of the system simulated leads to a better understanding of the system and offers suggestions for improving it which could not otherwise be obtained;
3. the experience gained in designing a simulation model with a computer may be more useful than the actual simulation. The knowledge acquired in designing a simulation study often suggests changes in the system;
4. simulation can be used for experimenting with new situations on which little or no information is available, with a view to teaching graduates to anticipate the unforeseen.

These are not the only reasons, nor are they exhaustive. The above reasons suggest that the versatility of digital simulation gives engineers greater stimulus to creativity than does the development of model prototypes, by offering them a broader field to work on.

3. PLANNING SIMULATION EXPERIMENTS

Conducting an experiment by using a digital computer as the simulation instrument, as described above, means applying a modus operandi which may be summarized as follows:

1. Definition of the simulation objective. The problem must be defined.
2. Block diagram of a system.
3. Subdivision of the system.
4. Modelling the blocks.
5. Assembly of the system model.
6. Analysis of the system model.
7. Documentation.

4. SIMULATION OF TRANSMISSION SYSTEMS

Digital simulation involves the use of a computer to gether with a model program to translate aspects of the situation studied. In the case discussed in this paper, reference is made to simulation techniques suitable for the design of digital transmission systems. Figure 1.

The usual blocks to be considered in the simulation are the following:

- a) modulated signal source;
- b) transmitter and receiver filters;
- c) noise sources;
- d) demodulator;
- e) system behaviour evaluator.

- a) Modulated signal source.

A modulated signal can be generated as follows:

- the digital data are obtained from a random number generator.
- one-to-one correspondence is then established between bits and modulating waveforms. This requires a sequence of samples for each bit. The choice of sampling speed is important, since it determines the number of samples that must be used to represent each symbol to be transmitted over the transmission channel.

- b) Transmitter and receiver filters.

The filters are among the most complicated channel elements. The usual technique (if they are not digital filters as such) is to synthesize digital filters from analogue filters [3]. This feature offers advantages as regards channel modulation since the effects of distortion and intersymbol interference have to be reproduced.

- c) Noise sources.

The simplest noise to simulate, although not the only one, is white gaussian noise generated as a sequence of random numbers. Within the group of possible random number generators, preference is given to one which produces repeated outputs; another advantage of such generators is that they make it possible to detect repetition of the experiment and simulation faults.

lation faults.

- d) Demodulator.

This block performs the function of demodulating the received signal. The output from the demodulator is a sequence of samples representing the signal recovered from one which has been distorted.

- e) System behaviour evaluator.

The last step in a simulation exercise is to evaluate or measure the system behaviour. Some form of "instrumentation" at the functional level must be modelled and simulated. For instance, there is the measuring method known as the "eye diagram" which provides qualitative information on the performance of the digital transmission system.

5. AN EXPERIMENT

The experiment described below is suitable for inclusion in courses on digital transmission systems, and it is performed by using TOPSIM III [4].

The methodology for constructing the different models to be simulated follows the principles outlined above

The block diagram of the system on which the experiment is based is given in figure 2, where an uncoded QPSK signal, two six pole Butterworth filters, and coherent demodulator are considered. Carrier and symbol recovering are also considered.

The source of information (not shown in figure 1) creates a PN bit sequence which is made to correspond to a waveform sequence whose time pattern may be rectangular or of any other type, e.g. enhanced cosine.

The block MOD represents a QPSK modulator with modulation parameters to be chosen.

In this experiment the filters are considered in cascade.

The sampling frequency is fixed by the problem proposed.

The block DEM represents a coherent demodulator.

The blocks CAR.REC. and SYMB. SYNC. represent two circuits: carrier recovery and symbol synchronizer.

The last block to be simulated corresponds to the evaluation stage. This is the most important part of the simulation method and must be properly designed to take advantage of the flexibility offered by simulation techniques.

This experiment uses the criterion of evaluating system performance by means of the bit error rate.

Such simulation can use TOPSIM III programming, and a mini or mainframe computer.

6. CONCLUSION

The purpose of this paper was to describe a methodology for training in telecommunication transmission systems based on the digital simulation of specific systems. Its main asset is its versatility in invention and innovation in transmission situations.

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Fig.1

Fig.2