CARRIER RECOVERY SIMULATION USING GUI

Ing. Jan PROKOPEC, Ing. Aleš PROKEŠ, PhD.
Department of Radio Electronics FEEC BUT,

This paper describes education software, developed in Matlab environment using GUI. Application allows visual demonstration of carrier recovery problems of digital modulations techniques, especially in case of phase shift keying. Controlling of GaGe CompuScope card is realized by basic functions provided by manufacturer in Software Development Kit and their modifications. Synchronization is realized by algorithms based on Maximum Likelihood Estimation (MLE).

1   Introduction

Graphical User Interface (GUI) is very useful tool for developing of simple applications, which allows user control the program or for settings function's arguments. Thus we used that for creation of education software. Software is presently used in laboratory exercise of the course Communication Theory for demonstration of the carrier recovery in digital communications, especially in systems using phase shift keying.

Simulations of the synchronization systems are applied on real signals obtained from the generator of digital modulations SMIQ02B (Rhode&Schwarz) digitized by A/D input card CompuScope 1250.

2   GaGe CompuScope 1250

CompuScope 1250 (CS 1250) is basic product of analog input PCI card designed by GaGe. It features 12 bit resolution and 50 MS/s sampling rate in single channel mode and 25 MS/s in dual channel mode. Sampling rates 20 MS/s and 10 MS/s in single channel mode, 10 MS/s and 5 MS/s in dual channel mode are also available. The card has 1 MSample (12 bit) depth of RAM, it can be upgraded up to 8 MSample. Other parameters are listed bellow:

- Impedance 1MΩ, 25 pF or 50 Ω, software selectable

- Coupling AC or DC

- Bandwidth 25 MHz

- Voltage Range up to $\pm$ 5 V

- Accuracy $\pm$ 0,5% of full scale

- SNR 60 dB@ 50 MS/s.

Software Development Kit (SDK) for Matlab and SDK for C++ are available. SDK for Matlab was used, which contains basic functions for controlling of card.

3   Graphical User Interface

The part of the main application window used for setup is shown in Figure 1. Users can work with previously saved signals or configure sample rate and directly capture signal from card's input. Students can only set sample rate, symbol rate, Signal to Noise Ratio (SNR), baseband or passband simulation and type of synchronization system.
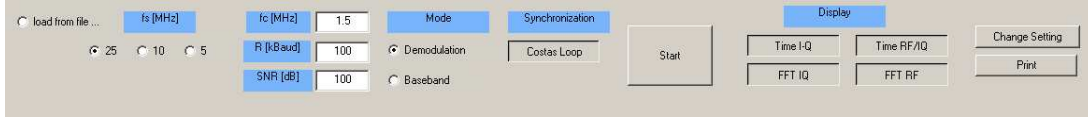

Figure 1: Setting of simulation parameters

Initialization of card, which includes setting of sample rate, selection of single or dual mode, voltage range etc. must be performed at first.

If the passband simulation is selected, RF signal is demodulated. Demodulation is realized by Costas Loop or by the Adaptive Phase Tracking (APT) system. Costas loop can be used for BPSK, QPSK and 8PSK. The block diagram of the Costas loop is shown in Figure 2.

Adaptive Phase Tracking is next synchronization system, which can be used for BPSK and QPSK. This system is very fast, but needs high sample rate. We assume, that one symbol of received signal contains information about many rising edges of carrier. This information is compared with information retrieved from recovered carrier. If the phase offset between received and recovered carrier is detected, phase of the recovered carrier is corrected. Requirement of high sample rate result from this assumption, because for good resolution we need $f_S = 16 f_C$, where f_S is sample rate and f_C is carrier frequency [4].
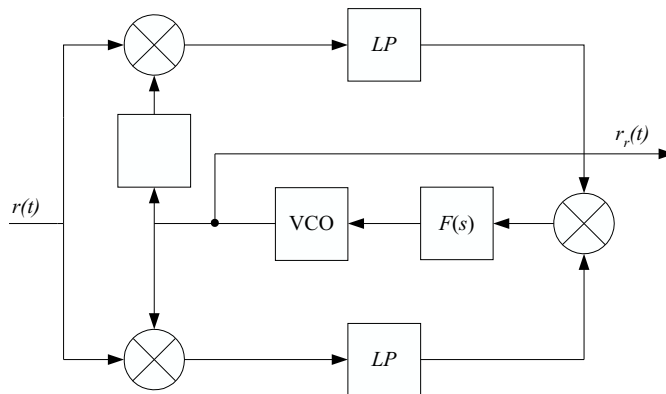

Figure 2: Block diagram of the Costas loop

If the baseband simulation is selected, baseband signals (I-arm and Q-arm) from signal generator are captured, processed and then used for phase error detection and correction. This system is known as the Phase Derotator shown in Figure 3. Detection is performed by Maximum Likelihood estimation and correction by CORDIC algorithm. Results of baseband simulation shown, that this system has good properties in case of SNR higher than 20 dB.

Simulation can start after complete setting of parameters. If the initialization of card is not correct, program is terminated and user must repeat settings. The buttons for result display are enabled when simulation is completed.
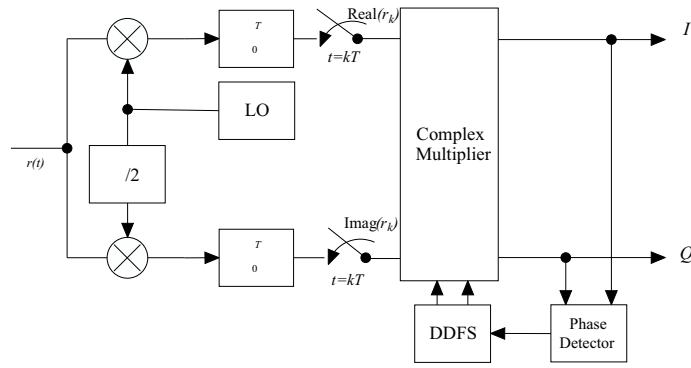
Figure 3: Block diagram of Phase Derotator

Figure 4 shows main window with graphical representation of results. Students can display demodulated signals in time, IQ diagram of demodulated signals, RF spectrum of signals and baseband spectrum. Differences between various types of modulations are seen from frequency domain and that is good for students.
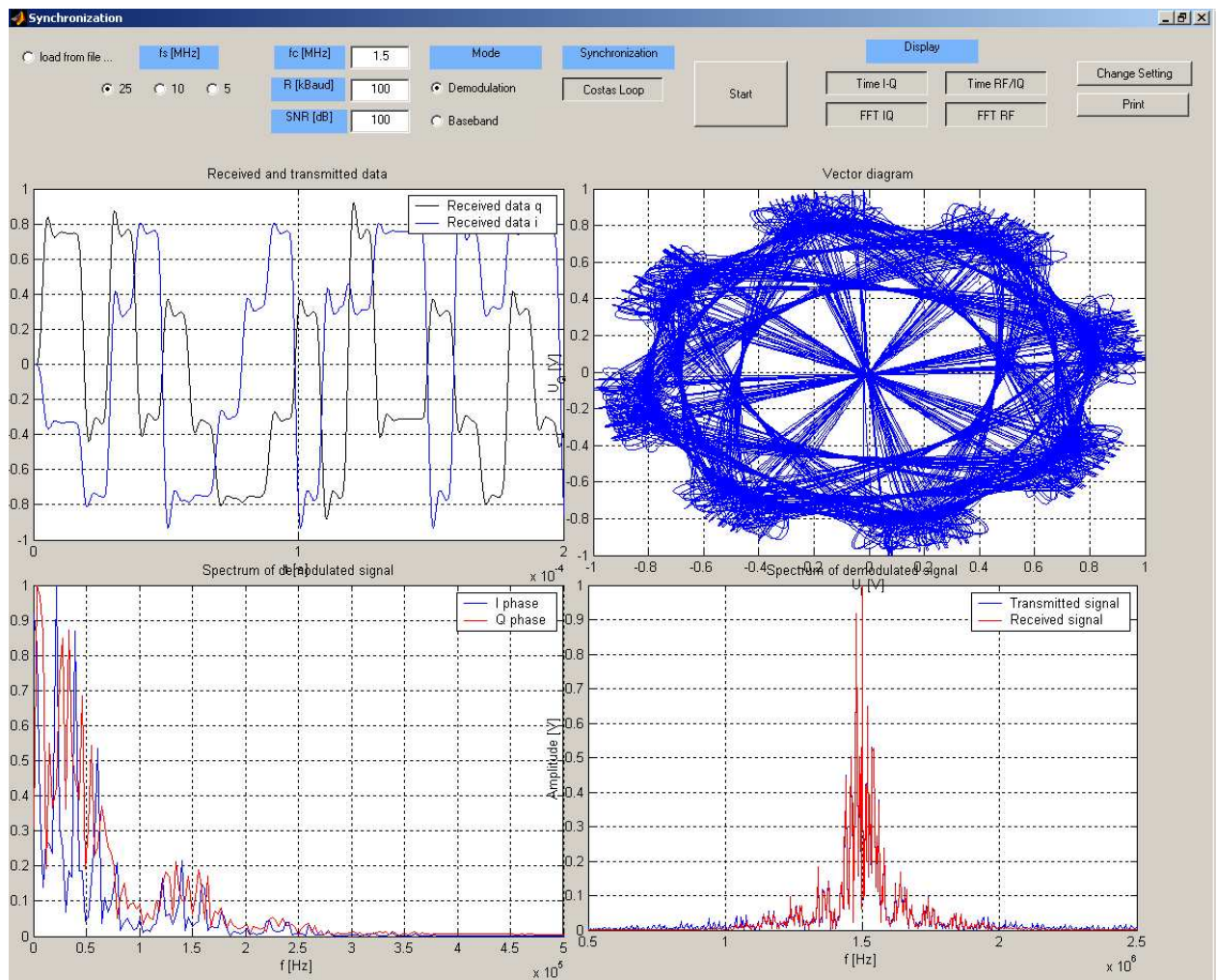

Figure 4: Main window with graphical representation of an 8PSK processing

4   Conclusion

The simple education software, created in Matlab environment was presented in this paper. Program uses only basic components of the Matlab: GUI and Signal Processing Toolbox. Software Development Kit for CompuScope card was used for controlling of A/D card. Students have simple tool for graphical representation of phase shift keying synchronization problems.

Acknowledgements

References

[1] Compuscope 1250 Hardware Manual, GaGe, 1999

[2] Software Development Kit for Matlab, users manual, GaGe, 1999

[3] MENGALI, U., D'ANDREA, A., N, Synchronization Technigues for Digital Receivers. New York Plenum, 1997

[4] PROKOPEC, J. Digitální synchronizace nosné. V *Sborník příspěvků a prezentací akce Odborné semináře 2002.* ev.. REL01V. Brno: UREL FEKT VUT v Brně, 2002, s. 161–171.

[5] BENVENUTO, N., CHERUBINI, G. *Algorithms for Communications Systems and their Applications.* Chichester: JOHN WILEY&SONS, 2002. 1285 pages. ISBN 0-470-84389-6.

[6] PROAKIS, J. *Digital Communications*, 3rd edition. New York: MCGRAW-HILL, 1995. 928 pages. ISBN 0-07-051726-6.

Contacts

Ing. Jan Prokopec
Department of Radio Electronics
FEEC BUT
Purkyňova 118
612 00 Brno
prokopec@feec.vutbr.cz
Phone: +420541149156

Ing. Aleš Prokeš, PhD.
Department of Radio Electronics
FEEC BUT
Purkyňova 118
612 00 Brno
prokes@feec.vutbr.cz
+420541149149