

METHOD FOR PRECISE SYNCHRONIZATION BETWEEN MULTIPLE VECTOR SIGNAL GENERATORS

B. A. HOVHANNISYAN<sup>1\*</sup>, N. G. MARGARYAN<sup>2\*\*</sup>, G. A. TSATURYAN<sup>3\*\*\*</sup>,  
S. V. ANTONYAN<sup>3\*\*\*\*</sup>, G. A. OHANYAN<sup>2\*\*\*\*\*</sup>, M. T. MANVELYAN<sup>2\*\*\*\*\*</sup>

<sup>1</sup> Chair of Radiophysics and Electronics, YSU, Armenia

<sup>2</sup> Synopsys Armenia CJSC, Armenia

<sup>3</sup> National Instruments AM LLC, Armenia

An important task of modeling and testing radar systems is to synchronize the order of the sub-degree of the radiated signals between the two ports of the transmitters. The simulation of synchronization of two NI PXI 5840 vector transceivers was performed with the separation of the power of the local oscillator and the clock generator. The simulation was done in the LabVIEW software environment using the developed program.

**MSC2010:** 94A99; 42B05.

**Keywords:** synchronization, LO sharing, phase locked loop (PLL).

**Introduction.** The synchronization of two signals is based on the “master-slave” principle. The output power of the local oscillator and clock generator for synchronous generation is divided between the “master” and “slave” vector transfer devices. Thanks to the phase locked loop (PLL), the separation of the output power of the common clock generator makes it possible to transmit and receive synchronized signals from transmitters with multiple outputs.

The PLL starts with a stable input oscillator frequency ( $f_{OSC}$ ). This frequency is typically fixed and very stable over temperature and process. The divider reduces this frequency to the phase detector frequency. The phase-frequency detector compares the phase of the divider with the phase of the  $N$  divider and produces the current correction pulses that have a duty cycle that is proportional to the phase error between the two inputs to the phase detector. Then passing through the low-pass filter (LPF) called the loop filter, the correction signal is transmitted to a voltage-controlled oscillator (VCO) (Fig. 1).

\* E-mail: babken.hovhannisyanyan@ysumail.am \*\*\*\* E-mail: samwellantonyan@gmail.com

\*\* E-mail: narek.margaryan3@ysumail.am \*\*\*\*\* E-mail: gor.ohanyan1@ysumail.am

\*\*\* E-mail: grigor.tsaturyan99@gmail.com \*\*\*\*\* E-mail: manvel.manvelyan@ysumail.am

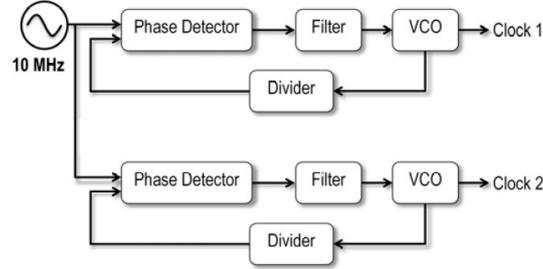


Fig. 1. Direct clock sharing architecture.

VCO is a frequency to voltage converter with a  $K_{VCO}$  transmission coefficient. The VCO output signal passes through the divider to match the frequency  $f_{osc}$  of the reference signal. The frequency of the VCO is determined as follows:

$$f_{VCO} = f_{osc}N, \quad (1)$$

where  $N$  is the division coefficient of the divider [1].

PLLs introduce unwanted noises, which also include phase noises. In the frequency range, they are treated as spectral noise power and measured in  $dBc/Hz$ . Phase noise reduction is substantially facilitated when using dividers. Passing through the divider with a division coefficient  $N$ , the phase noise is attenuated, which is quantified by the following formula:

$$d = 20\log(N). \quad (2)$$

For example, if the division coefficient is  $N = 2$ , the phase noise is reduced by  $6\text{ dB}$  [2]. The simultaneous generating problem can be solved with NI TClk technology, which is described as follows. Suppose two (or more) generators independently generating their own clock signal. At the moment of rising (or falling) edge of these clock signals, two (or more) devices receive a trigger signal about simultaneous generation (Fig. 2). Two signals are coherent if the relative phase remains stable over time. This definition can also be applied to signals at different frequencies whose relative phase remains stable after a certain  $N$  cycle. For example, the phase of a  $2\text{ Hz}$  signal will be repeated with the phase of a  $1\text{ Hz}$  signal every  $1\text{ s}$  [2, 3].

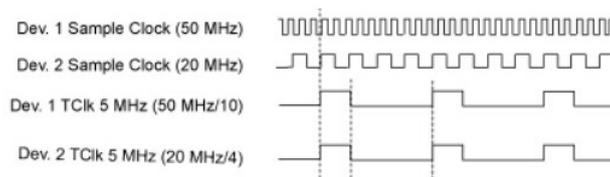


Fig. 2. NI TClk method.

**Problem Statement.** Using the same LO and the same clock generator, investigate the synchronization level of two vector signal transmitters, expressing it in degrees. NI PXI-5840 vector signal transceivers that transmit at a carrying

frequency of  $4.4\text{ GHz}$  were used as a source of generation of synchronized signals. As a result of the conversion, the transmitter generated pulses with harmonics of  $4.4 - 0.2 = 4.2\text{ GHz}$  and  $4.4 + 0.2 = 4.6\text{ GHz}$  with  $-20\text{ dBm}$  power. It is necessary to ensure synchronized radiation of radio pulses and to provide synchronized radio frequency transmission.

**Research results.** In Fig. 3 it is shown a block diagram of the system under study.

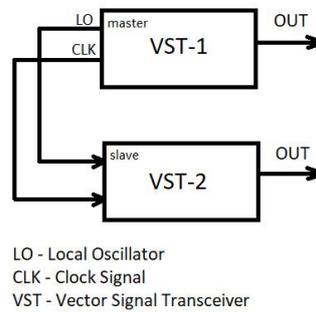


Fig. 3. Generalized block diagram of the system.

Synchronous reception is also important for synced systems. First of all, synchronous calibration of the receivers was performed, and then synchronization of the transmitted signals. For measuring the level of phase deviations synchronized signals are generated from transmitters to receivers with synchronized inputs. Fig. 4 shows a histogram of phase deviations obtained as a result of the study. Measurements were carried out during  $1\text{ h}$  of continuous transmission. As follows from the figure, the synchronization level is approximately  $0.05^\circ$ .

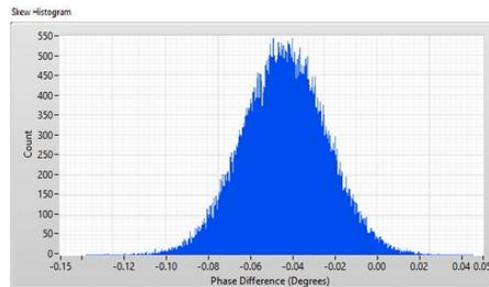


Fig. 4. Histogram of the visualized phase deviation.

**Conclusion.** A program was developed for the LabVIEW software environment to model the synchronization of NI PXI-5840 vector transmitters and receivers in order to measure the synchronization level. The behavior of the phase deviation between the two devices over time was obtained in the form of a histogram. Based

on the analysis of the results, it was concluded that it is possible to obtain synchronization up to  $0.05^\circ$ , by sharing the power of the LO and the clock generator, without considering the reception error.

Received 12.02.2020

Reviewed 28.02.2020

Accepted 30.03.2020

## REFERENCES

1. Banerjee D. *PLL Performance, Simulation and Design*. Dog Ear Publishing. 5th ed. (2017), 4 p.
2. Salarpour M., Farzaneh F., Staszewski R.B. Synchronization-Phase Alignment of All-Digital Phase-Locked Loop Chips for a 60 GHz MIMO Transmitter and Evaluation of Phase Noise Effects. *IEEE Transactions on Microwave Theory and Techniques*, **67** : 7 (2019).
3. National Instruments NI Tclk Overview.  
DOI: [zone.ni.com/reference/en-XX/help/370956M-01/nitclk/nitclk-overview/](https://zone.ni.com/reference/en-XX/help/370956M-01/nitclk/nitclk-overview/).
4. National Instruments NI-TClk Technology for Timing and Synchronization of Modular Instruments. DOI: [www.ni.com/tutorial/3675/en/](https://www.ni.com/tutorial/3675/en/).

Բ. Ա. ՀՈՎՀԱՆՆԻՍՅԱՆ, Ն. Գ. ՄԱՐԳԱՐՅԱՆ, Գ. Ա. ԾԱՏՈՒՐՅԱՆ,  
Մ. Վ. ԱՆՏՈՆՅԱՆ, Գ. Ա. ՕՂԱՆՅԱՆ, Մ. Տ. ՄԱՆՎԵԼՅԱՆ

### ՎԵԿՏՈՐԱՅԻՆ ՆԱԳՈՐԴԻՉՆԵՐԻ ԾՇԳՐԻՏ ՄԻՆՔՐՈՆԱՑՄԱՆ ԵՂԱՆԱԿ

Ռադարային համակարգերի մոդելավորման և թեստավորման կարևոր խնդիրն է հաղորդիչների երկու մաքուրյցների միջև ենթաստիճանների ճառագայթավող ազդանշանների փուլերի սինքրոնացումը: Իրականացվել է երկու NI PXI 584 վեկտորային հաղորդիչ-ընդունիչների սինքրոնացման մոդելավորում՝ հետերոդինի և քակարային գեներատորի հզորությունների բաժանման միջոցով: Ներազգրությունները կատարվել են LabVIEW ծրագրային միջավայրում, օգտագործելով այդ նպատակով մշակված ծրագիր:

Б. А. ОГАННИСЯН, Н. Г. МАРГАРЯН, Г. А. ЦАТУРЯН,  
С. В. АНТОНЯН, Г. А. ОГАНЯН, М. Т. МАНВЕЛЯН

### СПОСОБ ТОЧНОЙ СИНХРОНИЗАЦИИ МЕЖДУ НЕСКОЛЬКИМИ ВЕКТОРНЫМИ ГЕНЕРАТОРАМИ СИГНАЛА

Важной задачей моделирования и тестирования радиолокационных систем является синхронизация порядка субстепени излучаемых сигналов между двумя портами передатчиков. Выполнено моделирование синхронизации двух векторных приемопередатчиков NI PXI 584 с разделением мощности гетеродина и тактового генератора. Моделирование проводилось в программной среде LabVIEW с использованием разработанной программы.