The closely related quantities of time and frequency are of crucial importance for science and technology as well as for nowadays, technical societies and individual human beings. These are basic quantities for telecommunications, navigation and practically any kind of scientific research.

Nowadays the second – the SI unit of time – is defined by a superfine transition in a cesium atom, resulting in radiation located in a microwave part of electromagnetic spectrum (around 10 GHz). Operating highest-level standards reproducing SI units is a task of national metrological institutes (NMI), which are also responsible for conducing research towards development of new, more accurate references. Many NMIs have from many years actively researched the field of so-called optical clocks with either single ions or cold atoms, where the radiation is produced in an optical domain by an optical transition (the frequency around 430 THz) between two very long living levels. Such signal sources are superior to current cesium sources (by a few orders of magnitude) in terms of uncertainty and stability so it is highly probable that in some future they will become a basis of the official SI standards.

Both cesium and optical atomic clocks must be compared against similar standards to continuously estimate their accuracy and stability, so there is a need to transmit signals from the standards between time and frequency laboratories. Any transmission medium, however, introduces inevitable noise to the signal degrading its stability and making accurate comparison difficult. Thus the development of standards is necessarily interrelated with simultaneous development of various transfer techniques. Nowadays the best possible medium for such transfer is an optical fiber.

Thanks to the development in the field of fiber-optic transfer techniques it is now possible not only to compare optical clocks (that is interesting mostly to NMI itself) but also to deliver their signals to remote users. For the users it is of great importance because anyone that needs highly stable signals does not need to operate their own standards (that is both complex and expensive) but may access them through collaboration with a local NMI.

Each start-of-the-art time and frequency laboratory nowadays is able to “produces” three basic signals: two related to current definition of the SI unit of time, supplied by a cesium clock, namely the frequency signal (with typical frequency of 5 MHz or 10 MHz) and time signal 1PPS (pulse per second), as well as the signal from an optical clock (often called an optical carrier).

This project is focused on researching the techniques of joint distribution of all these three signals to a remote user using a single optical fiber, realized in form of a hybrid transfer system. Such solution is reasonable because signal from an optical clock does not convey information about time directly, thus 1PPS signal (synchronized with global UTC time) may be used as a series of markers that allow locating in time events occurring in an optical domain. On the other hand ultrastable optical carrier may play a role of reference for fiber optic transfer of “cesium signals”, improving stability and accuracy of the link.

Proposed research will result in better understanding of capabilities and limits of fiber optic transfer of signals from atomic sources on one hand and development specialized metrological tools in form of hybrid transfer systems. Such systems will enable distribution of highly stable signals to interested users, like scientific and research laboratories working on optical clocks, atomic and molecular spectroscopy, astronomy or astrophysics, and also advanced telecom, metrological or navigation centers. Developed techniques of transferring the reference signals will be also useful for probable redefinition of the unit of time that will certainly be related to optical clocks in the future. Cesium clocks will still be used because of their reliability and generation of theirs signals directly in an electrical domain. The need, however, will exist to compare “optical” second against the “cesium” one in order to preserve consistency of metrological units. Developed hybrid transfer system may play a role of convenient tool to help in this task.