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TRANSMISSION OF TIME AND FREQUENCY SIGNALS THROUGH AN OPTICAL FIBER

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Abstract

CSIR-NPL has for the first time used optical fibers to transmit standard time and frequency signals. This has been done to transport standard time and frequency signals from Primary Time Scale to a new Backup Time Scale. Time and frequency signals of 1 PPS and 5 or 10 MHz are required to be accurately transported for calibration of an ensemble of clocks, providing traceability to other national standards and comparison of two-time scales. To accomplish this task, use of Optical Fibers as a transmission medium is preferred over the conventional RF cable transmission medium as it provides the low attenuation[1], electrical isolation, low power loss, and cost-effectiveness. The paper describes the optical fiber link and its characterization.

1. Introduction

CSIR-NPL recently developed a new time scale called Backup Time Scale located in metrology building, approximately 300 meters away from the Primary Time Scale in order to have redundancy in case of failure of Primary Time Scale. Usually, we transfer time and frequency signals through RF cables but due to environmental condition dependency of RF coaxial cables, it was found that phase changes in the coaxial cable are sensitive to temperature variations. We demonstrate for the first time, the transfer the time and frequency signals through an optical fiber using a pair of transducers. Along with the transducers, the optical transmission system consists of a pair of Light Interface Units (LIU). The LIU is the optical fiber interconnecting unit, which is modular and suitable for optical fiber installation requiring fiber splicing. The following section describes the development of Timescales and a new optical fiber link. Testing and evaluation of the setup was performed and reported in Section 5.

2. Primary Time Scale Generate UTC(NPLI)

NPL maintains the primary time scale generating the Indian Standard Time (IST) which is traceable to Universal Coordinated Time (UTC) maintained by BIPM. The time scale maintained by NPL is designated as UTC(NPLI). The timescale, UTC(NPLI), is maintained with the help of five cesium (Cs) atomic clocks (model HP 5071A, Microsemi) and an Active Hydrogen Maser (model MHM2010, Microsemi). It is kept in a clean room with regulated environment conditions. The signals of UTC(NPLI) are fed to appropriate distribution amplifiers. The output of the distribution amplifier is fed to a newly installed transducer for the transmission of time and frequency signals.

3. Optical Transmission of Signals

The output of the transducer is fed to an optical fiber. We use single mode fiber having an extremely small core (5-10 microns in diameter) and very low attenuation.

3.1 Hardware for transmission of signals

The transducers used for 10 MHz and 1 PPS signal are different. We use SC-ST (Subscriber Connector - Straight Tip) for 1PPS and FC (Ferrule core) connector for 10 MHz signals with single mode fiber optic cabling.

3.2 Fiber Optic Transmitter and Receiver

A transducer is a device which includes a LED or LASER source and signal conditioning electronics that is used to inject an electrical signal into the optical fiber. Optical to electrical converter capture the light from a fiber optic cable, decode the binary data and then convert into an electrical signal. The paper describes the successful use of transducers for transferring signals over optical fiber. For 1 PPS Optical Transmission, we use the fiber optic module, MEINBERG CON/TTL/FOS, which converts an input signal into one and more single-mode fiber output signals with a signal delay of 4.9 ns. For frequency optical transmission, we use LuxLINK INSR-1001 with input/ output Impedance of 50 ohms and delay of 25ns.

Fig. 1. Fiber optic transmitter and Receiver

4. Optical Fiber Setup

For developing fiber optic transmitting system, we use fiber pigtails and LIU (used for routing, terminating and managing optical cable terminations). A fiber optic patch cable with connectors at both ends is used to connect the transducer to LIU. The complete setup is shown in Fig 2.

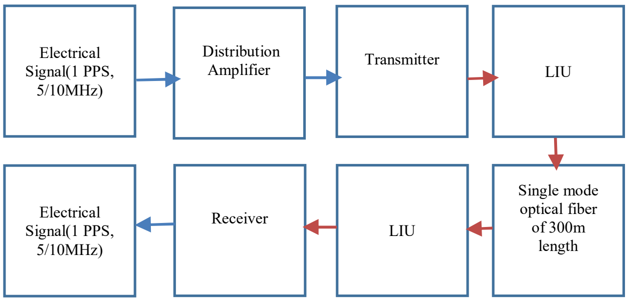

Fig. 2. Schematic of Optical Fiber layout.

Electrical Signal   Optical Signal

5. Test and Evaluation of Optical Fiber

The UTC(NPLI) signals are taken through a distribution amplifier to the Fiber optic transmitter. Input TTL waveform of 1PPS signal is shown in Fig 3 and the pure sinusoidal waveform of 5 MHz is shown in Fig 4.

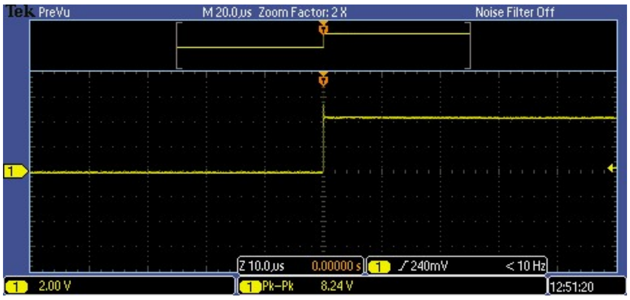

Fig. 3. 1 PPS Input Waveform with a peak to peak voltage of 8.24 V

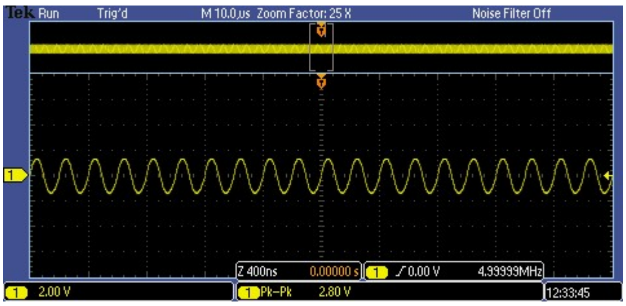

Fig. 4. 5 MHz Input Waveform with a peak to peak voltage of 2.8 V

The optical transmitter converts electrical signal to an optical signal which is then passed through a patch cable to LIU. Each LIU contains 24 ports. All the 24 ports are connected to different optical fibers. We perform the measurements of transmission of optical signal through all the laid optical fibers. For the purpose of redundancy, we laid another optical fiber through a different route and successfully tested the transmission of signals through the different route also.

The measured signal levels of 1 PPS, 5 MHz, and 10 MHz signals after transmission is shown in Table 1.

For Basement OFC 1				
Fiber Port Number	Measured Voltage of Signals (V)			Power (dBm)
	1 PPS	5 MHz	10MHz	10MHz
1	5.84	1.2	3.52	-24.09
2	5.92	1	2.64	-26.69
3	5.84	1.12	3.2	-25.78
4	5.84	1	3.52	-25.15
5	5.76	1.2	2.88	-26.46
6	5.92	0.8	3.44	-24.17
7	5.92	0.96	2.56	-27.57
8	5.92	1.12	2.96	-26.61
9	5.84	1.08	3.2	-25.38
10	5.76	1.2	3.2	-25.52
11	5.76	1.12	3.36	-25.09
12	5.84	1.2	3.36	-24.77

Table1. Measured Signal levels after Transmission over Optical fiber of approximately 300 meters

5.1 Output Waveform

We study the Standard 1 PPS, 5 MHz and 10 MHz signals after transmission through Meinberg and LuxLink transducer. Time and Frequency signals were found to have very good accuracy and low attenuation.

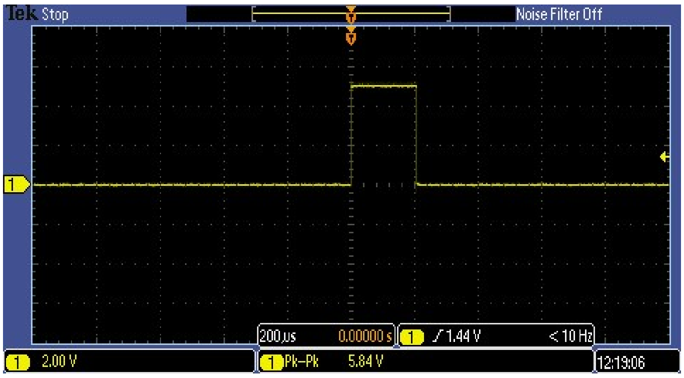

Fig. 5. Standard 1 PPS signal after transmission through Meinberg transducers and an optical fiber of approximately 300 m.

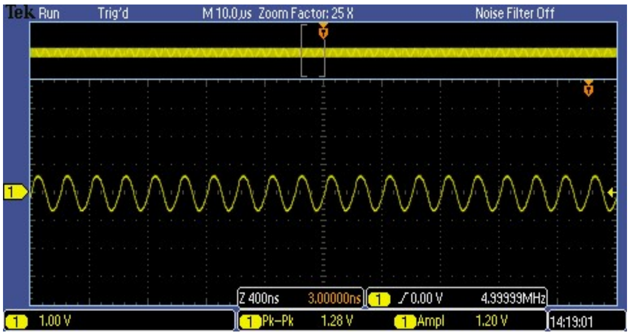

Fig. 6. Standard 5 MHz signal after transmission through LuxLink transducers and an optical fiber of approximately 300 m.

6. Conclusion

CSIR-NPL has for the first time transmitted electrical signals over the optical fiber. This has helped in the calibration of backup time scale and also the distribution of standard time and frequency signals to other metrology laboratories (like Length standards).

The present work will help CSIR-NPL in the establishment of time dissemination systems in the country over the optical fiber. It is also planned to study the phase and frequency characteristics of the transmitted signals and compare them with signals transmitted through the coaxial cable.

7. Acknowledgment

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8. References

[1]. Prof. R.K. Shevgonkar " Fiber Optics", Department of Electrical Engineering, IIT Bombay.