

Prof. dr. Aljo Mujčić  
Prof. dr. Branko Blanuša  
Prof. dr. Azra Gazibegović-Busuladžić

## VIJEĆU UNIVERZITETA U SARAJEVU - PRIRODNO-MATEMATIČKI FAKULTET

**Predmet:** Izbor nastavnika u zvanje redovnog profesora za oblast “**Fizička elektronika i optoelektronika**” na Odsjeku za fiziku – 1 izvršilac sa nepunim radnim vremenom

Odlukom Vijeća Univerziteta u Sarajevu – Prirodno-matematički fakultet (br. 01/06-2818/2-2024), donesenoj na 5. sjednici koja je održana 28.11.2024. godine, imenovana je komisija za pripremanje prijedloga za izbor nastavnika u zvanje redovnog profesora za oblast: “Fizička elektronika i optoelektronika”, jedan izvršilac sa nepunim radnim vremenom (do 20% radnog vremena), u sastavu:

**Dr. Aljo Mujčić, redovni profesor** na Fakultetu elektrotehnike Univerziteta u Tuzli, uža naučna oblast “Telekomunikacije”, predsjednik;

**Dr. Branko Blanuša, redovni profesor** Elektrotehničkog fakulteta Univerziteta u Banjaluci, uža naučna oblast “Elektronika i elektronski sistemi”, član;

**Dr. Azra Gazibegović-Busuladžić, redovna profesorica** Univerziteta u Sarajevu – Prirodno-matematički fakultet, uža naučna oblast “Teorijska fizika”, član.

Na konkurs objavljen 08.11.2024. godine na web stranici Univerziteta u Sarajevu – Prirodno-matematičkog fakulteta, kao jedini kandidat prijavio se dr. Edvin Škaljo, vanredni profesor na Univerzitetu u Sarajevu – Prirodno-matematičkom fakultetu, Odsjek za fiziku. Nakon uvida u priloženu dokumentaciju Komisija podnosi sljedeći

## I Z V J E Š T A J

### BIOGRAFSKI PODACI KANDIDATA

Edvin Škaljo je rođen 1969 godine u Kaknju, Bosna i Hercegovina. Osnovnu i srednju školu završio u Zenici. Elektrotehnički fakultet u Banja Luci upisao 1988 godine i nakon toga odslužio vojni rok od 12 mjeseci te pristupio redovnom pohađanju Elektrotehničkog fakulteta (1989). Bila je to prva generacija čiji studij je bio 5 godina.

Privremeno je prekinuo studije u Banja Luci 1992. godine, i nakon 3 godine pauze nastavio studij na Elektrotehničkom fakultetu Univerziteta u Sarajevu - smjer telekomunikacije, na kojem je diplomirao 10.07.1996. godine.

Na Elektrotehničkom fakultetu Univerziteta u Sarajevu je odbranio magistarski rad 2005. godine. Doktorsku disertaciju odbranio je na Fakultetu elektrotehnike Univerziteta u Tuzli 2014. godine. U zvanje docenta na Prirodno-matematičkom fakultetu Univerziteta u Sarajevu izabran je 2014. godine, gdje stiče i zvanje vanrednog profesora 2019. godine.

Vanredni je urednik međunarodnog naučnog časopisa Fiber and Integrated Optics izdavačke kuće Taylor&Francis (London i Filadelfija). Predsjednik je Matične sekcije inženjera elektronike, automatike i telekomunikacija (EAT) Federacije Bosne i Hercegovine.

Edvin Škaljo je osnivač i predsjednik Međunarodne radionice o optičkim vlaknima u pristupnim mrežama (FOAN). FOAN je godišnji događaj u čiji rad i organizaciju su uključeni svjetski stručnjaci iz više od 25 zemalja svijeta, a do sada su radionice uspješno održane u 9 različitih

gradova Europe i Azije: Moskvi, Budimpešti, St Petersburgu, Almaty, Brnu, Minhenu, Lisabonu, Sarajevu, Ljubljani, Valensiji, Gentu i Atini. Na konferenciji FOAN koja je održana 2019 u Sarajevu bilo je prisutno 130 učesnika iz 24 zemlje svijeta.

Na poziv organizatora međunarodnih stručnih i industrijskih skupova kandidat često daje stručne prezentacije koje opisuju projekte ili dijelove projekata na kojim radi. Izdvajaju se nastupi na forumima kao što su:

- Pozivno predavanje (2023) na poziv Elektrotehničkog fakulteta Univerziteta u Ljubljani pod naslovom "The use of telecom fiber optics in sensor applications"
- Broadband World Forum (2012, 2013 i 2015) događaj na kojem svake godine prisustvuje više od 4000 posjetitelja;
- Eura Asia Economic Forum – EAEF2013 (2013), Xi'an, Kina sa oko 2000 učesnika;

Član je nekoliko svjetskih organizacija vezanih za optoelektroniku kao što je:

- IEEE, najveća inženjerska organizacija IEEE;
- OPTICA (bivša OSA);
- SPIE - International Society for Optics and Photonics;

U gore navedenim organizacijama ima status starijeg člana (SENIOR MEMBER). Pokrenuo je osnivanje OPTICA\_UNSA studentske sekcije pri Univerzitetu Sarajevo u kojoj ima poziciju savjetnika ispred organizacije OPTICA. Ova sekcija je aktivna od 2019. godine. Također je putujući predavač (Traveler lecturer) organizacije OPTICA (OSA). Kao predavač organizacije OPTICA izdvajaju se predavanja na:

- Kraljevskom univerzitetu - King Mongkut's Institute of Technology Ladkrabang Bangkok, Tajland - 2017;
- UCLA - University of California, Los Angeles - 2018;

Bio je član Upravnog odbora COST Akcije i to:

- European Network for High Performance Integrated Microwave Photonics, (2017 - 2021);
- NEWFOCUS - European network on future generation optical wireless communication technologies; (2021 -2024).

Uspostavio je laboratorije za Elektroniku i Fiber optiku na Odsjeku za fiziku Univerziteta u Sarajevu – Prirodno-matematičkog fakulteta.

Nagrađen je od strane Univerziteta u Sarajevu za rezultate naučnog rada u 2022. godini.

## **NAUČNI RADOVI I NAUČNOISTRAŽIVAČKA AKTIVNOST PRIJE IZBORA U ZVANJE VANREDNOG PROFESORA**

### **Magistarski rad**

Edvin Škaljo, "*Jednokanalne optičke veze velikih brzina*", Elektrotehnički fakultet Univerziteta u Sarajevu, 2006;

### **Doktorska disertacija**

Edvin Škaljo, "*Optimalna upotreba optičkih vlakana u pristupnim telekomunikacijskim mrežama*", Fakultet elektrotehnike, Univerzitet u Tuzli, 2014;

### Radovi registrirani u Web of Science Core Collection ili Scopus bazama podataka

1. Maslo, A., Hohzic, M., Mujcic, A., & Skaljo, E. (2019). Last Mile at FTTH Networks: Challenges in Building Part of the Optical Network From the Distribution Point to the Users in Bosnia and Herzegovina. In *Advanced Technologies, Systems, and Applications III: Proceedings of the International Symposium on Innovative and Interdisciplinary Applications of Advanced Technologies (IAT), Volume 1* (pp. 480-486). **WOS i SCOPUS**
2. Lipovac, Adriana, **Škaljo, Edvin**, Lipovac, Vladimir; Njemčević, Pamela. BER-Based Estimation of OFDM CFO-Caused Symbol Phase Deviation // Proceedings of the International Scientific Conference on Advances in Wireless and Optical Communications RTUWO 2018, Riga, Latvija, 2018. str. 1-5. **WOS i SCOPUS**
3. Hodzic, M., Maslo, A., & **Skaljo, E.** (2018). Analysis of Techno-Economic Profitability on the Example of Construction of an Optical Suburban Access Network in Srebrenica. In *Advanced Technologies, Systems, and Applications II: Proceedings of the International Symposium on Innovative and Interdisciplinary Applications of Advanced Technologies (IAT)*(pp. 759-767). Springer International Publishing. **WOS i SCOPUS**
4. Hodzic, M., **Skaljo, E.**, Suljanovic, N., & Mujcic, A. (2018). Transmission of Two Optical Signals Through the Fibber in Opposite Directions Using PLC Splitters— Practical Measurements. In *Advanced Technologies, Systems, and Applications II: Proceedings of the International Symposium on Innovative and Interdisciplinary Applications of Advanced Technologies (IAT)* (pp. 776-784). Springer International Publishing. **WOS i SCOPUS**
5. Munster, P., Horvath, T., Havlis, O., Vojtech, J., Radil, J., Velc, R., & **Skaljo, E.** (2017, May). Simultaneous transmission of standard data, precise time, stable frequency and sensing signals and their possible interaction. In *Optical Sensors 2017*(Vol. 10231, pp. 431-437). SPIE. **WOS i SCOPUS**
6. Munster, P., Radil, J., Vojtech, J., Havlis, O., Horvath, T., Smotlacha, V., & **Skaljo, E.** (2017, April). Simultaneous transmission of the high-power phase sensitive OTDR, 100Gbps dual polarisation QPSK, accurate time/frequency, and their mutual interferences. In *Fiber Optic Sensors and Applications XIV* (Vol. 10208, pp. 62-68). SPIE. **WOS i SCOPUS**
7. **Skaljo, E.**, Hodzic, M., & Mujcic, A. (2015, October). A cost effective topology in fiber to the home point to point networks based on single wavelength bi-directional multiplex. In *2015 International Workshop on Fiber Optics in Access Network (FOAN)* (pp. 11-16). IEEE. **WOS i SCOPUS**
8. Yu, Y. L., Liaw, S. K., Skaljo, E., Minh, H. L., & Ghassemlooy, Z. (2014). Bidirectional wavelength reconfigurable module based on tunable fiber bragg grating and remote pump amplifier. *Fiber and Integrated Optics*, 33(5-6), 383-394. **WOS i SCOPUS**
9. Yu, Y. L., Liaw, S. K., Hsu, H. Y., **Skaljo, E.**, Minh, H. L., & Ghassemlooy, Z. (2013, September). Bidirectional wavelength reconfigurable optical network using remote

- pump amplifier and tunable fiber Bragg gratings. In *2013 4th International Workshop on Fiber Optics in Access Network (FOAN)* (pp. 11-14). IEEE. **WOS i SCOPUS**
10. **Skaljo, E.**, Nemsic, B., Babic, S., & Mujčić, A. (2013). Integration of Mobile Backhaul and Broadband Fixed Access Networks in Urban Metropolitan Areas. *Fiber and Integrated Optics*, 32(2), 105-116. **WOS i SCOPUS**
  11. **Skaljo, E.**, Nemsic, B., Mujčić, A., & Babic, S. (2012, October). Clock recovery where GPON is used as a Mobile back-haul. In *2012 IV International Congress on Ultra Modern Telecommunications and Control Systems* (pp. 506-509). IEEE. **WOS i SCOPUS**
  12. Selmanović, F., **Skaljo, E.**, & Nemsic, B. (2012). Gigabit-capable passive optical network in telecommunication networks. *Fiber and Integrated Optics*, 31(2), 79-89. **WOS i SCOPUS**
  13. **Skaljo, E.**, Keiser, G., Mujcic, A., & Selmanović, F. (2012). Introduction to Special Issue on Second Fiber Optics in Access Networks (FOAN), Held in Budapest, October 2011. *Fiber and Integrated Optics*, 31(2), 59-61. **WOS i SCOPUS**
  14. Žgalj, A., **Skaljo, E.**, & Kadušić, E. (2011, November). Pulse width as an influencing factor in Optical Time Domain Reflectometry measurements. In *2011 19th Telecommunications Forum (TELFOR) Proceedings of Papers* (pp. 832-835). IEEE. **WOS i SCOPUS**
  15. **Skaljo, E.**, Mujcic, A., & Suljanovic, N. (2011). Usage of optical power meter in passive optical networks. *Fiber and Integrated Optics*, 30(5), 308-321. **WOS i SCOPUS**
  16. Akyel, C., Babic, S., & **Skaljo, E.** (2011, December). A new analytical model for square spiral inductors incorporating a magnetic layer. In *Asia-Pacific Microwave Conference 2011*(pp. 967-970). IEEE. **WOS i SCOPUS**
  17. **Skaljo, E.**, & Mujcic, A. (2010, October). Measurement of optical power in the upstream of PON signal from a single ONU at the side of the central office by optical power meter. In *International Congress on Ultra Modern Telecommunications and Control Systems* (pp. 998-1002). IEEE. **SCOPUS**
  18. Selmanovic, F., & **Skaljo, E.** (2010, October). GPON in telecommunication network. In *International Congress on Ultra Modern Telecommunications and Control Systems* (pp. 1012-1016). IEEE. **SCOPUS**
  19. **Skaljo, E.**, Hadziahmetovic, N., & Akyel, C. (2010, September). Impact of broadcast, multicast and unknown unicast at low speed DSL connections based at SHDSL. In *Proceedings ELMAR-2010* (pp. 187-190). IEEE. **WOS i SCOPUS**
  20. **Skaljo, E.**, Hodzic, M., & Bektas, I. (2009, October). Migration from g (e) pon to ngpon. In *2009 International conference on ultra modern telecommunications & workshops* (pp. 1-4). IEEE. **SCOPUS**

## Urednički tekstovi registrirani u Web of Science Core Collection ili Scopus bazama podataka

1. **Skaljo, E.,** & Keiser, G. (2016). Introduction to a Special Topics Issue of the Fifth Fiber Optics in Access Network (FOAN) Workshop, Held in Brno, Czech Republic, October 2015. *Fiber and Integrated Optics*, 35(2), 47-48. **WOS i SCOPUS**
2. Liaw, S. K., & **Skaljo, E.** (2014). Introduction to the Special Issue on the Latest Fiber-Optic Technologies Developments in East Asia. *Fiber and Integrated Optics*, 33(1-2), 1-3. **WOS i SCOPUS**
3. **Skaljo, E.,** Keiser, G., Selmanović, F., & Mujčić, A. (2013). Introduction to a Special Issue on the Third Fiber Optics in Access Network (FOAN) Workshop, Held in St. Petersburg, Russia, October 2012. *Fiber and Integrated Optics*, 32(2), 71-74.
4. **Skaljo, E.,** Keiser, G., Mujcic, A., & Selmanović, F. (2012). Introduction to Special Issue on Second Fiber Optics in Access Networks (FOAN), Held in Budapest, October 2011. *Fiber and Integrated Optics*, 31(2), 59-61.
5. **Skaljo, E.,** Keiser, G., Mujcic, A., & Selmanovic, F. (2011). Special Issue on Fiber Optics in Access Networks (FOAN), Held in Moscow, October 2010. *Fiber and Integrated Optics*, 30(5), 279-281. **WOS i SCOPUS**

## Naučnoistraživački projekti

Kandidat je bio učesnik u naučnoistraživačkom projektu:

CESNET E-Infrastructure – Modernisation, Registration number CZ.02.1.01/0.0/0.0/16\_013/0001797, <https://photonics.cesnet.cz/en>, 2017.

## UDŽBENICI I MONOGRAFIJE PRIJE IZBORA U ZVANJE VANREDNOG PROFESORA

- Udžbenik „**Fizika II sa primjenama u biologiji i medicini**“ objavljen 2018, ISBN 978-9926-453-06-0, COBISS.BH-ID 25901318;

## PEDAGOŠKE AKTIVNOSTI PRIJE IZBORA U ZVANJE VANREDNOG PROFESORA

Kandidat je od 2014. godine angažiran na Univerzitetu u Sarajevu – Prirodno-matematičkom fakultetu kao docent na predmetima

- Elektronika 1 – predavanja i vježbe na I ciklusu studija,
- Elektronika 2 – predavanja i vježbe na I ciklusu studija,
- Električna mjerenja neelektričnih veličina, predavanja na I ciklusu studija,
- Fizika, društvo i tehnologija, - predavanja na II ciklusu studija.

Radio je kao vanjski saradnik na Internacionalnom univerzitetu Sarajevo, kao nastavnik na predmetu Kompjuterske mreže (2017/18 i 2018/19).

Bio je mentor završnih radova na II ciklusu studija studentici Amini Habib sa naslovom rada „*Primjena Mach-Zehenderovog interferometra u razmjeni informacija pomoću svjetlovodnog vlakna*“; januar 2019.

## NAUČNI RADOVI I NAUČNOISTRAŽIVAČKA AKTIVNOST NAKON IZBORA U ZVANJE VANREDNOG PROFESORA

### Radovi registrirani u Web of Science Core Collection (WoS) ili Scopus bazama podataka

Radovi kandidata su iz oblasti elektronike i optoelektronike. U ovom dijelu Izvještaja navodimo naslove i apstrakte radova koji su objavljeni nakon izbora kandidata u zvanje vanrednog profesora.

1. Maslo, A., **Škaljo, E.**, Hodžić, M., & Mujčić, A. (2023, October). "Mechanical Reliability and Lifetime of Optical Fibers After 20 Years of Use". In *2023 International Workshop on Fiber Optics on Access Networks (FOAN)* (pp. 61-66). IEEE.

<https://doi.org/10.1109/FOAN59927.2023.10328099>

WOS:001322770700023

#### **Abstract:**

The Numerous papers have presented models for the mechanical reliability of optical fibres, or the lifetime of optical fibres, has been modelled in many works. Improvement of the mechanical and optical characteristics of standard single-mode fibres requires new tests and analyses. This paper provides an overview of scientific research into the mechanical reliability of optical fibres by some of the largest manufacturers. The investigation of the mechanical reliability and state of optical fibres after 20 years of real usage is the contribution of the paper, which concludes on its own. The contribution of the work is also in the analysis of the conditions under which optical cables - fibers were used. A prediction of the parameters limiting the lifetime of optical fibres was made based on the analyses that were conducted.

2. **Skaljo, E.**, Mujčić, A., & Maslo, A. (2023, October). "A Remote Reflecting Fiber Optic Method for Detecting Liquid Occurrences Over a Distance of 3 Kilometres". In *2023 International Workshop on Fiber Optics on Access Networks (FOAN)* (pp. 17-22). IEEE.

<https://doi.org/10.1109/FOAN59927.2023.10328113>

WOS:001322770700013

#### **Abstract:**

This article introduces a method for detecting liquids over long distances that is based on measuring the difference in the detected reflected power from the end of a conventional single-mode fiber in different mediums. The power of reflected light is affected by the medium outside the fiber, as well as the maximum distance between the sensor end and the detector. The proposed approach was tested on a length of 3.01 km. An investigation of the greatest distance with commercially available laser diodes (MQW - DFB) and a PIN diode is provided; remote measurements at distances more than 34 km are theoretically possible in ideal conditions. We found that the usage of reflecting connectors is the primary constraint in obtaining theoretically calculated distances.

3. Hodara, H., Mitchell, G., Mock, P., & **Skaljo, E.** (2023). "Review of OFC 2023: Optical Networks and Communications Conference". *Fiber and Integrated Optics*, 42(3-4), 93-150.

<https://doi.org/10.1080/01468030.2023.2244831>

WOS:001093012200001

#### **Abstract:**

We review the latest developments in Fiber-optic Telecommunications and Networks presented at OFC 2023 and compare the progress accomplished in the previous years. Topics of interest this year and discussed in this review include Long Haul and Intra Data Centers communications, Optical switches, sensors in submarine communications, some invited presentations (alas without papers such as in Optical Computers!), Secure Communications through Quantum effects, and Passive Optical Networks, PONs

4. Munster, P., Horvath, T., Dejdar, P. i **Skaljo, E.** (2022). "Remote Pumping in Point to Multi-point Networks". *Journal of Communications Software and Systems*, 18 (1), 54-62.

<https://doi.org/10.24138/jcomss-2021-0188>

WOS:000787552100001

#### **Abstract:**

A remotely pumped Erbium-doped system for the amplification of an optical signal for long-reach (LR) next-generation passive optical networks (NG-PONs) is presented in this paper. The next-generation

networks will be deployed with/over the current point to multi-point technology with/without backward compatibility. Remote pumping allows extending the reach of the optical distribution networks and the magnification of the splitting ratio as well, which is most important for increasing the number of end users in the PON network. In our laboratory, we have successfully verified the functionality of the unidirectional and bidirectional remote pumping system based on an Erbium-doped fiber inserted into the route and remote pumping from a central office. Our measurement results prove that it is possible to extend the total reaching point to the multi-point system without the difficult incidence in the optical distribution network. Based on the results, the proposed amplifying passive optical network approach is capable of being used in passive optical networks in C band for extending the total reach of system or increasing the split ratio.

5. Spurny, V., Munster, P., Tomasov, A., Horvath, T., & **Skaljo, E.** (2022). "Physical layer components security risks in optical fiber infrastructures". *Sensors*, 22(2), 588: <https://doi.org/10.3390/s22020588> WOS:000747770400001

**Abstract:**

Optical fiber communications are essential for all types of long- and short-distance transmissions. The aim of this paper is to analyze the previously presented security risks and, based on measurements, provide the risk level evaluation. The major risk is the possibility of inserting a splitter into the optical distribution network and capturing a portion of the entire spectrum, i.e., all channels in the optical fiber. Another significant security risk is crosstalk on multiplexers in networks with wavelength division multiplexing. The paper covers the macrobend attenuation evaluation of fiber and back-reflection measurements. Based on the measurements, risks were evaluated for both point-to-point and point-to-multipoint networks and, lastly, the paper covers crosstalk measurements of an optomechanical switch. Finally, all individual risks are evaluated according to the severity, and a proposal for risk minimization is provided.

5. Hodara, H., Mock, P., & **Skaljo, E.** (2022). "Review of OFC 2022 Optical Networks and Communications Conference Hybrid (Virtual/In-Person) Conference: 6–10 March 2022, San Diego, CA". *Fiber and Integrated Optics*, 41(3-4), 63-82. <https://doi.org/10.1080/01468030.2022.2111002> WOS:000853392000001

**Abstract:**

We review the latest developments in Fiber-optic Telecommunications and Networks presented at OFC 2022 and compare the progress accomplished since the previous year conference, OFC 2021. In particular, we note this year's emphasis on the application of Neural Networks (NN) as part of Artificial Intelligence (AI) and Machine Learning (ML), as well as continued research in quantum communications and key distribution. We also expect future conferences to include papers about optical variants of quantum computers, a field of great interest that can exploit many quantum systems, as well as papers on continuing developments in High-Speed Communications beyond 800 Gb/s, and increased use of coherent modulation and detection in Data Centers Interconnect, Cloud and Edge computing, the latter in support of 5 G Internet Of Things (IOT).

7. Maslo, A., Hodžić, M., **Skaljo, E.**, & Mujčić, A. (2021, October). "Machine Learning and Quality of Customer Experience in Leading Telecom Providers of Bosnia and Herzegovina". In *2021 13th International Congress on Ultra Modern Telecommunications and Control Systems and Workshops (ICUMT)* (pp. 241-245). IEEE. DOI: <https://doi.org/10.1109/ICUMT54235.2021.9631596> INSPEC:21486120

**Abstract:**

The Quality of Service (QoS) and the Quality of user Experience (QoE) are measures of the quality of satisfaction with the use of the service. The paper provides a detailed overview of QoS metrics applied by telecom operators in Bosnia and Herzegovina (BiH). Given that currently the focus of research is algorithms based on machine learning, which determine QoE, an overview of previous work in this field is given. The focus of the paper is an overview of activities on measuring QoS and QoE parameters performed by dominant telecom operators from Bosnia and Herzegovina.

8. Spurny, V., Munster, P., Horvath, T., & **Skaljo, E.** (2021, October). "Leakage of Information Through Passive Components in Optical Fiber Infrastructures". In *2021 13th International Congress on Ultra Modern Telecommunications and Control Systems and Workshops (ICUMT)* (pp. 271-273). IEEE.

**Abstract:**

Optical fiber communications are essential for all types of long and short distance transmissions. The aim of the article is to analyze the previously presented risks and evaluation of the two biggest and therefore the most critical risks. The first major risk is the possibility of inserting a splitter into optical distribution network and capturing portion of the entire spectrum, ie all channels in the optical fiber. The second significant security risk is crosstalk on multiplexer in networks with wavelength division multiplexing. Based on the measurements, risks were evaluated for both point-to-point and point-to-multipoint networks.

\*\*\*\*\* šest (6) zamjenskih radova za dva udžbenika \*\*\*\*\*

9. Lipovac, A., Lipovac, V., Hamza, M., & Škaljo, E. (2021, October). "OTDR based prediction of residual BER". In *2021 IEEE Microwave Theory and Techniques in Wireless Communications (MTTW)* (pp. 149-153). IEEE.

<https://doi.org/10.1109/MTTW53539.2021.9607061>

WOS:000843584800028

**Abstract:**

Optical time-domain reflectometer (OTDR) has long been and is still considered the main test tool for characterizing fiber optic links, i.e. basically identify and localize refractive and reflective events such as breaks, splices and connectors, and measure their insertion/return loss. Specifically, sufficient dynamic range and thus alike signal-to-noise-ratio (SNR) enable clear far-end visibility even of long fiber links. Moreover, under such conditions, the highest achievable optical bit-error-rate (BER) floor, is to the large extent determined by major reflective events such as the specific trace distortion caused by connectors and splices, each with significant return loss. Realizing this has provided the opportunity window to extend the standard OTDR capabilities list by the appropriate trace postprocessing to predict the BER floor. Accordingly, considering the SNR high, and thereby the inter-symbol interference dominant error generating mechanism, we applied the time-dispersion channel model that determines the BER floor by the rms delay spread of the (fiber) channel power-delay profile. We verified the BER floor prediction in the exemplar practical test situation, by measuring the actual BER on the same fiber link, and found the obtained values well matching the OTDR - based predicted ones.

10. Hodara, H., & Skaljo, E. (2021). "From 1G to 5G". *Fiber and Integrated Optics*, 40(2-3), 85-183.;

<https://doi.org/10.1080/01468030.2021.1919358>

WOS:000733634800001

**Abstract:**

Wireless Mobile Communications have undergone major "generational" changes since MacDonald of Bell Telephone Laboratories introduced the concept of cellular communications in 1979. Over the last four decades, the technology has evolved from the first generation, 1 G, followed by 2 G, 3 G, and 4 G, to reach today's threshold of the fifth generation, 5 G.

In order to grasp the magnitude of the impact 5 G is having on our society (*5 G internet is expected cover up to 65% of the world's population by the end of 2025!*), it is essential to understand the historical development of the previous generations. This review describes and explains the technology from 1 G to 4 G, culminating with the current state-of-the-art of 5 G, and its expected performance over the next ten years.

We cover the major technical features of 5 G that differentiate them from the previous generations, in particular, the introduction of the MM-Wave spectrum combined with MIMO, Multiple Input-Multiple Output antenna arrays. We single out these two features as they provide orders of magnitude increases in channel capacity (20 Gb/s Downlink data transfer rates with reduced latency of 1 ms) and internet connectivity on the order of billions.

11. Mešić, V., Škaljo, E., Mitrevski, B., Nešić, L., Hatibović, S., & Maličević, M. (2021). "Seeking missing pieces in learning about single slit diffraction: results from a teacher survey". *Physics Education*, 56(3), 035024:

<http://dx.doi.org/10.1088/1361-6552/abe992>

INSPEC:20463082

**Abstract:**

Single slit diffraction is part of many high-school physics curricula throughout the world. In this study, we aimed to investigate whether high-school physics teachers from Bosnia and Herzegovina, Serbia and North Macedonia are adequately prepared to discuss with their students about various aspects of the single slit

diffraction pattern, particularly about vertical length of diffraction fringes. To that end we conducted a written survey which included 57 high-school physics teachers. Besides asking teachers about students' difficulties in learning about single slit diffraction, we also asked them to specify their own difficulties with this topic and required them to solve a conceptual task. Almost every second teacher believed that vertical length of diffraction fringes can be increased by changing shape or width of the slit and only 1 out of 57 teachers managed to correctly answer why diffraction fringes become shorter when we move away from the central maximum. We concluded that physics teacher education programmes should be changed to develop understanding of both, horizontal and vertical aspects of the diffraction pattern. To that end it is useful to provide learning opportunities which encourage combining ray and wave model of light.

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12. Havlis, O., Vojtech, J., Velc, R., Slapak, M., Filka, M., & **Skaljo, E.** (2021). "Influence of phase-sensitive optical time-domain reflectometer on community antenna television transmission". *Optical Engineering*, 60(2)

<https://doi.org/10.1117/1.OE.60.2.026103>

WOS:000625363000026

**Abstract:**

Multiple studies have been carried out to analyze the mutual interaction of a phase-sensitive optical time-domain reflectometer ( $\Phi$ -OTDR) and parallel digital data traffic. However, interactions with analog transmission, e.g., community antenna television (CATV), have not been addressed. Our study examines and presents the influence of a developed sensing system  $\Phi$ -OTDR when operated simultaneously on parallel fibers with the transfer of data from an analog CATV system. Three scenarios are suggested and discussed for the measurements and optimization of the data network in the analog CATV data transfer. These scenarios are suggested to enable the verification of the mutual interactions between data networks with the analog data transfer and suggested sensing system and to determine how the data network with the analog data transfer may or may not be influenced by the sensing system. The optimization and measurements prove that the analog CATV data transfer was negatively influenced by the sensing system  $\Phi$ -OTDR, and the channel bit error rate increased by nearly half. The implementation of the sensing system  $\Phi$ -OTDR was realized for a data network, followed by the testing and optimization, which proved that the safe spectral distance between the CATV and the sensing system is 150 GHz and higher.

13. Maslo, A., Goran, N., Hodžić, M., **Škaljo, E.**, & Mujčić, A. (2020). "A practical analysis of attenuation in segment of home installation of FTTH networks". In *2020 28th Telecommunications Forum (TELFOR)* (pp. 1-4). IEEE.

<https://doi.org/10.1109/TELFOR51502.2020.9306628>

WOS:000666945500079

**Abstract:**

Home installation is the shortest segment of FTTH (Fibre to The Home) networks. Despite this, it can also be a bottleneck of the whole network. This segment can produce a huge attenuation of optical signal. This paper deals with attenuation loss in home installations especially because of micro bending and attenuation of fusion splices caused by incompatibility of different fibre types.

14. Maslo, A., Hodzic, M., **Skaljo, E.**, & Mujcic, A. (2020). "Aging and degradation of optical fiber parameters in a 16-year-long period of usage". *Fiber and Integrated Optics*, 39(1), 39-52.

<https://doi.org/10.1080/01468030.2020.1725185>

WOS:000515532900004

**Abstract:**

The first generation of installed optical cables in Eastern Europe has been in use for more than 20 years. This paper analyzes the change of optical fibers from the aspect of aging under the influence of transmitted signals and the aspect of parameter degradation during exploration. The paper provides the answer for how to repair the increased attenuation at 1310 nm. We also proposed the method of solution NG PON access for small remote villages that are situated along the analyzed route.

\*\*\*\*\* Zamjenski radovi za mentorstvo III ciklusa \*\*\*\*\*

15. Hodara, H., & **Skaljo, E.** (2019). "Beyond 400 Gbps: Reaching for Higher Data Rates and Connectivity". *Fiber and Integrated Optics*, 38(6), 305-322. Nov 2, 2019: <https://doi.org/10.1080/01468030.2019.1685789> WOS:000497027100001

**Abstract:**

In this paper, we discuss in details information and communication developments (1) that have arisen in support of a rapidly expanding internet (Internet of Things, IoT) coupled with a proliferation of data centers; (2) the ensuing data rates explosion capable of reaching 800 Gb/s with coherent technology over a single wavelength; as well as (3) an increased connectivity through 5G transport networks.

16. Lipovac, A., **Škaljo, E.**, Lipovac, V., & Njemčević, P. (2019, July). "Practical Prediction of CFO-Made OFDM Symbol Distortion". *Automatic control and computer sciences*, 53, 351-363. 2019 ;

<https://doi.org/10.3103/S0146411619040060>

WOS:000486333900008

**Abstract:**

The Carrier Frequency Offset (CFO) is considered to be a major drawback of the Orthogonal Frequency-Division Multiplexing (OFDM) signal. So, in many practical situations, specifically with LTE-Advanced downlink introducing carrier aggregation, estimation of the CFO-induced OFDM symbol phase deviation, is of interest. However, this demands complex test equipment, such as e.g. a Vector Signal Analyzer (VSA), which might not be always and everywhere available. Therefore, we applied the link abstraction principle on the Bit Error Rate (BER) that is considered to be determined just by the CFO-caused phase deviation, i.e. as if the channel was noiseless and time-dispersion-free (so that evident bit errors occur just due to the actual CFO). Furthermore, as the CFO-caused squared phase deviation is linear with the instantaneous (per-OFDM-symbol) Peak-to-Average Power Ratio (PAPR), which is related to the Error Vector Magnitude (EVM) and so with BER, we develop a simple model for analytical BER-based estimating of CFO. In this sense, we considered the easy-to-measure BER degradation as resulting just from the according additive white Gaussian noise (AWGN) source, which abstracts the CFO distortion. The proposed analytical model is validated by according Monte-Carlo simulations.

17. Maslo, A., Hodzic, M., Mujcic, A., & **Skaljo, E.** (2019, September). "Degradation of Optical Fiber Parameters During the Period of Usage: 2003-2019". In *2019 International Workshop on Fiber Optics in Access Networks (FOAN)* (pp. 72-77). IEEE; <https://doi.org/10.1109/FOAN.2019.8933804>

WOS:000526064000017

**Abstract:**

Changing the optical fiber parameters during long-term use can not be mathematically calculated. This paper analyses the change of optical fibers from the aspect of ageing under the influence of transmitted signals and the aspect of water influences. The analysis was carried out in such a way as to compare the measurements carried out after the installation of optical cables and measurements after 16 years of use. The analysis has been shown to vary greatly the loss of fiber optic splice for different wavelengths. These different loss for wavelengths 1310 nm and 1550 nm suggest that the loss of optical fiber has increased due to the impact of water.

\*\*\*\*\* dodatni indeksirani radovi \*\*\*\*\*

1. **Skaljo, E.**, Mujcic, A., Munster, P., Maslo, A., Hodzic, M., Duhandzic, M., & Karamemedovic, E. (2022). "Powering over single mode fiber by shortening working time of IoT device". In *ITM Web of Conferences* (Vol. 42, p. 01018). EDP Sciences.

DOI: <https://doi.org/10.1051/itmconf/20224201018> ;

INSPEC:21565143

**Abstract:**

*Fiber optics has revolutionized telecommunication with its superior bandwidth and distance it can span. For its use in IoT networks, some of the limiting factors are the high cost of new installations and the need to power the end device by electrical current. The installations are a part of long-term investments, and one can expect this to be an ever-smaller issue as more fibers are installed. Typically, the newly installed cables contain single-mode fibers. There are a lot of reports on transport of power over fiber, however, majority recommend using multi-mode fibers with a large core or double-clad fibers. In our approach, instead of increasing the core of the fiber, we focus on the possibility of shortening the working time of IoT devices,*

using the existing single-mode fiber for powering. Also, instead of an expensive PV (photo voltaic) cell with small dimensions and a high efficiency, we propose using the commercially available larger PV cells with an air gap between the end of the fiber and the cells. In accordance with our approach, we successfully conducted an experiment.

2. **Skaljo, E., & Keiser, G.** (2020). "Special Issue of the 8th FOAN (Fiber Optics in Access Network) Workshop Sarajevo, Bosnia and Herzegovina, September 2019". *Fiber and Integrated Optics*, 39(1), 1-3. Jan 2, 2020

DOI: <https://doi.org/10.1080/01468030.2020.1727105> WOS:000513454100001

**Abstract:**

As in previous years, FOAN 2019 was the event where representatives from industry, academia, and regulatory organizations met with the primary goal of bringing and presenting their latest researches, challenges, and ideas. Emphasis was on applications in telecom services, in order to improve Quality of Service and accelerate the achievement of business goals. FOAN 2019 was a friendly and exciting event in the city of Sarajevo that covered three full days. Attendees came from 22 countries in Europe, Asia, India, and America. In these three days the attendees discussed a wide range of topics in relation to Access Networks.

### **Radovi neindeksirani ili nisu na listi relevantnih baza**

- Amir Adilović, **Edvin Škaljo**, "EXPECTED IMPROVEMENTS OF MOBILE SYSTEMS BY INTRODUCING 5G TECHNOLOGY IN THE TELECOMMUNICATIONS INDUSTRY OF MOBILE SYSTEMS". VIII International Symposium New Horizons 2021 of Transport and Communications; Faculty of Transport and Traffic Engineering, University of East Sarajevo, Doboj 2021.

<https://plus.cobiss.net/cobiss/si/sl/bib/mnzs/135478017> COBISS.SI-ID - 135478017

**Abstract:**

*The development of new mobile technologies is expected to improve a set of technical means, organizational and administrative measures and documents, service staff, as well as a set of standards, protocols, methods for wireless voice and data transmission from subscriber to subscriber or from subscriber to information system. This drives economic growth and inclusion in the modern world of digitalization, which achieves a good connection between consumers and companies. The need in the world of digital economy to solve business problems is the need for new mobile technology with low latency, distribution and passability as important features. This technology is the technology of the fifth generation of mobile systems (5G) and is a continuation of 4G, 3G and 2G technology. Observing the global trends of mobile technologies, we will analyze the advantages of this technology through phases, namely: an overview of mobile systems through generations, 5G characteristics, 5G architecture, technical technological part of 5G and the use of 5G. In addition to the advantages, there are disadvantages due to countries in transition. New technology uses not only new technological, but also software functions. Multiple antennas are used on transceivers to increase signal speed and quality. Final outcome of this technology is that overloads and delays in signal transmission will be avoided. Such an efficient and reliable network, with better quality of service with new applications and higher speeds is a contribution to the community.*

- Tegos, S. A., Papanikolaou, V. K., Aparicio-Esteve, E., Skaljo, E., Louro, P., Panayirci, E., & Diamantoulakis, P. D. (2024). "**Optical Technology for Joint Communication and Sensing**". *Third White Paper*, EU COST ACTION CA19111 - NEWFOCUS. CONTRIBUTION FOR THE THIRD WHITE PAPER ON OWC. 2024; <https://hal.science/hal-04671609/>

**Abstract:**

The current trajectory of wireless communication technology is leading us to the next milestone, the sixth generation, or 6G, of networks. Historically, wireless networks have been at the forefront of delivering robust mobile broadband and ever-increasing data rates. However, we are witnessing a transformative phase in the evolution of these networks, a phase that expands the traditional focus from pure data transmission to a multifaceted approach that includes sensing and localization capabilities [1]. These functions, previously on the fringes of network design and capability, are now taking center stage. The Internet of Things (IoT) era requires networks that not only transmit data, but also have a high level of awareness of their operating environment. Such integration aims to transform passive networks into active systems capable of interacting

with and adapting to their environment in real time. It should be noted that this integration has already influenced standardization activities, including IEEE 802.11 [2]. In this context, optical wireless communication (OWC) is expected to play an important role in these advanced functionalities of future communication networks.

### **Naučnoistraživački projekti**

1. Voditelj projekta "*Napajanje senzora električnom energijom prenesenom preko optičkog vlakna*", projekt odobren od strane Ministarstva za obrazovanje, nauku i mlade Kantona Sarajevo 2021. godine
2. Član Upravnog odbora COST Akcije CA16220 (2017 - 2021), "*European Network for High Performance Integrated Microwave Photonics*",  
<https://e-services.cost.eu/action/CA16220/participants>;
3. Član Upravnog odbora COST Akcije (2021 -2024). "*NEWFOCUS - European network on future generation optical wireless communication technologies*";  
<https://e-services.cost.eu/action/CA19111/participants>

### **Nagrade za rezultate naučnog doprinosa**

Univerziteta u Sarajevu za rezultate naučnog rada u 2022 - Odluka broj 0101-12777-113/23

### **UDŽBENICI I MONOGRAFIJE NAKON IZBORA U ZVANJE VANREDNOG PROFESORA**

Kao zamjenu za dva udžbenika, kandidat je priložio šest (6) radova indeksiranih u relevantnim bazama (WOS i SCOPUS), uz obrazloženje da fakultet nije tražio od kandidata da napiše udžbenik, a na tržištu postoji veliki broj knjiga koje pokrivaju materiju Elektronike. Priloženi radovi se nalaze pod rednim brojem od 9 do 14:

9. Lipovac, A., Lipovac, V., Hamza, M., & **Škaljo, E.** (2021, October). "OTDR based prediction of residual BER". In *2021 IEEE Microwave Theory and Techniques in Wireless Communications (MTTW)* (pp. 149-153). IEEE.
10. Hodara, H., & **Skaljo, E.** (2021). "From 1G to 5G". *Fiber and Integrated Optics*, 40(2-3), 85-183.;
11. Mešić, V., **Škaljo, E.**, Mitrevski, B., Nešić, L., Hatibović, S., & Maličević, M. (2021). "Seeking missing pieces in learning about single slit diffraction: results from a teacher survey". *Physics Education*, 56(3), 035024:  
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12. Havlis, O., Vojtech, J., Velc, R., Slapak, M., Filka, M., & **Skaljo, E.** (2021). "*Influence of phase-sensitive optical time-domain reflectometer on community antenna television transmission*". *Optical Engineering*, 60(2)
13. Maslo, A., Goran, N., Hodžić, M., **Škaljo, E.**, & Mujčić, A. (2020). "A practical analysis of attenuation in segment of home installation of FTTH networks". In *2020 28th Telecommunications Forum (TELFOR)* (pp. 1-4). IEEE.

14. Maslo, A., Hodzic, M., **Skaljo, E.**, & Mujcic, A. (2020). "Aging and degradation of optical fiber parameters in a 16-year-long period of usage". *Fiber and Integrated Optics*, 39(1), 39-52.

## **PEDAGOŠKE AKTIVNOSTI NAKON IZBORA U ZVANJE VANREDNOG PROFESORA**

**Predmeti na kojima je Kandidat realizirao predavanja na Odsjeku za fiziku u periodu od 2019-2024. godine:**

Prvi ciklus studija:

- Elektronika 1;
- Elektronika 2;

Drugi ciklus studija:

- Fiber optika (predavanja i vježbe);
- Elektronika i mikrokontroleri (Predmet na Politehničkom fakultetu Univerziteta u Zenici, Odsjek Softversko inženjerstvo – kao spoljni saradnik)

**Mentorstva završnih radova II ciklusa studija na Univerzitetu u Sarajevu – Prirodno-matematičkom fakultetu i Elektrotehničkom fakultetu Banja Luka**

1. Dženan Gazić, "Upotreba mikro-kontrolora u plastenicima", 16.10.2023, PMF Sarajevo;
2. Enida Mostić, "Efekti korištenja Arduina u nastavi", 30.09. 2021, PMF Sarajevo;
3. Amir Adilović, pod nazivom "Pasivna optička mreža nove generacije NG-PON2 kao podrška za 5G mobilne sisteme", 20.05.2022 - ETF Banja Luka.

### **Zamjenski radovi za mentorstva završnih radova III ciklusa studija**

Na Odsjeku za fiziku Prirodno-matematičkog fakulteta nije bio organizovan doktorski studij na primijenjenoj fizici, stoga je Kandidat priložio tri zamjenska rada (pod rednim brojevima 15, 16 i 17 iz priložene bibliografije u prijavi za ovaj konkurs:

15. Hodara, H., & **Skaljo, E.** (2019). "Beyond 400 Gbps: Reaching for Higher Data Rates and Connectivity". *Fiber and Integrated Optics*, 38(6), 305-322. Nov 2, 2019: <https://doi.org/10.1080/01468030.2019.1685789> WOS:000497027100001

16. Lipovac, A., **Škaljo, E.**, Lipovac, V., & Njemčević, P. (2019, July). "Practical Prediction of CFO-Made OFDM Symbol Distortion". *Automatic control and computer sciences*, 53, 351-363. 2019; <https://doi.org/10.3103/S0146411619040060> WOS:000486333900008

17. Maslo, A., Hodzic, M., Mujcic, A., & **Skaljo, E.** (2019, September). "Degradation of Optical Fiber Parameters During the Period of Usage: 2003-2019". In *2019 International Workshop on Fiber Optics in Access Networks (FOAN)* (pp. 72-77). IEEE; <https://doi.org/10.1109/FOAN.2019.8933804> WOS:000526064000017

## PRIJEDLOG SA OBRAZLOŽENJEM

Na osnovu Zakona o visokom obrazovanju Kantona Sarajevo ("Službene novine Kantona Sarajevo", broj 33/17), člana 96. stav f), član 176. stav (1) i člana 194. Statuta Univerziteta u Sarajevu iz 2018. godine, jedini prijavljeni kandidat, dr. Edvin Škaljo, vanredni profesor Univerziteta u Sarajevu – Prirodno-matematičkog fakulteta, ispunjava sve zakonske uslove za izbor u zvanje redovnog profesora za oblast "Fizička elektronika i optoelektronika", jer je:

- proveo jedan izborni period u zvanju vanrednog profesora,
- nakon posljednjeg izbora, iz oblasti za koju se bira, objavio 19 radova u citatnim bazama podataka i 2 rada u drugim bazama podataka,
- kao supstituciju za objavu dvije knjige kandidat koristi šest objavljenih radova, što je u skladu sa članom 199. stav (1) Statuta Univerziteta iz 2018. godine,
- nakon posljednjeg izbora vodio jedan projekt u Bosni i Hercegovini i učestvovao u dva COST projekta kao član upravnog odbora;
- nakon posljednjeg izbora ima uspješno mentorstvo tri (3) kandidata na drugom ciklusu studija a kao supstituciju za mentorstvo na trećem ciklusu studija koristi tri objavljenih rada.

Vanredni profesor dr. Edvin Škaljo je do sada postigao značajne naučne rezultate koji su rezultirali objavom 47 radova i editorskih tekstova i citirani su 191 puta (izvor: Google Scholar). Odgovarajući  $h$  indeks tih radova je 7. Bio je voditelj jednog domaćeg naučnoistraživačkog projekta.

Kandidat posjeduje bogato pedagoško iskustvo. Mentor je više magistarskih radova. Uspostavio je laboratorije za Elektroniku i Fiber optiku na Odsjeku za fiziku Univerziteta u Sarajevu – Prirodno-matematičkog fakulteta. Autor je univerzitetskog udžbenika.

S obzirom na navedene činjenice, članovi Komisije smatraju da kandidat ispunjava sve Zakonom predviđene uslove za izbor u zvanje redovnog profesora. Sa zadovoljstvom predlažemo Vijeću Univerziteta u Sarajevu – Prirodno-matematičkog fakulteta da **izabere dr. Edvina Škalju, u zvanje redovnog profesora za oblast "Fizička elektronika i optoelektronika"** na Univerzitetu u Sarajevu – Prirodno-matematičkom fakultetu.

U Sarajevu, 18. 12. 2024. godine

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dr. Aljo Mujčić, redovni profesor

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dr. Branko Blanuša, redovni profesor

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dr. Azra Gazibegović-Busuladžić, redovna profesorica