4th URSI AT-RASC, Gran Canaria, 19-24 May 2024

25th anniversary of RCN Solec Kujawski longwave radio station and the introduction of digital time signal in Poland

Tomasz A. Miś *(1), Maciej Gruszczyński(2), Albin Czubla(2) and Józef Modelski(1)
(1) Warsaw University of Technology, Institute of Radioelectronics and Multimedia Technology
(2) Central Office of Measures, Warsaw, Poland

Abstract

2024 marks the 25th anniversary of the opening the RCN Solec Kujawski radio station, the successor of the Wrsaw Radio Mast site. The station, employing modern, semiconductor-based and energy-efficient technology, provides continental-wide signal coverage of the 1st Programme of the Polish Radio and the emission of a wide variety of technical signals. The most recent special signal introduced in November 2023 is the Polish state digital time signal within the eCzasPL Radio system, with higher-ranked capabilities than the similar DCF77 signal, allowing the synchronization of multiple electronic devices for numerous uses.

1. Introduction

On 9th September 1999 at 12.00 took place the official opening of the RCN (pol. 'Radiowe Centrum Nadawcze', en. 'Radio Transmitting Center') Solec Kujawski on 225 kHz, located to the south of the city of Solec Kujawski, Kujawy region, Poland, on the site of the former disused military ground [1].

The center was built as the successor of the RCN Konstantynów, used between 1974 and 1991 and equipped with a 646.38-m-tall half-wavelength mast-antenna (world's tallest structure until the completion of Burj Khalifa) [2]. Non-technical obstructions and lack of sufficient state pressure ultimately disallowed the reconstruction of the mast – which collapsed on 8th August 1991 due to errors in renovation – and forced the Polish Radio to seek for an alternative location for the new longwave station. The new station was desperately needed, as the now-orphaned 1st Programme of the Polish Radio, emitted on LW from the spare RCN Raszyn-Łazy with lower power, entered the MW and developing UHF broadcasting, taking over the frequencies previously allocated for other programmes of the Polish Radio. The properties of the longwave (153-285 kHz) radio broadcasting also allowed the reaching of the radio subscribers in the far East – after the collapse of the Warsaw Radio Mast, the LW from Raszyn-Łazy and MW broadcasting fulfilled this job only partially.

After thorough analysis of numerous locations – including Gowarczów and Bełchatów – the new radio station was to be established on the former military grounds Kabat to the south of the city of Solec Kujawski, located between Bydgoszcz and Toruń [3].

2. Antenna system

The Warsaw Radio Mast site had the practical advantage of being located nearly in the geometrical center of the country, which favored the use of a half-wavelength antenna system, exciting a strong ground wave and a far-reaching ionospheric wave. The non-central location of the future radio station in Solec Kujawski resulted in the design of a low frequency antenna array consisting of two active masts of 330 and 289 m each, radiating in an asymmetrical pattern with weaker lobe to the north-west and stronger lobe to the south-east, with the main axis of the array situated at the azimuth of 140°. This axis is also located along the direction previously reported as favorable for the terrain-related extension of low frequency signal range since 1931 [4]. In vertical plane, the radiation pattern resembles the one for the quarter-wavelength radiator [3].

The antenna system was designed not to possess the disadvantage of the Warsaw Radio Mast, which was insulated from the ground and supported by guy ropes divided into insulated sections shunted with varistors – this setup, when the varistors broke down, produced numerous issues in extreme weather conditions (charging and ionization by atmospheric electricity in storms) [2]. Both Solec Kujawski masts were designed using numerical analysis; the structures are ground-connected and fed via side shunts from a 120 Ω feeder line. The antenna system has the gain of 8 dBi; the reflection coefficient for 225 kHz ± 2 kHz does not exceed 1.2; for 225 kHz ± 4.5 kHz, its value does not exceed 1.35 [3].

3. Radio transmitter. Signal coverage

Both the RCN Konstantynów (1974-1991) and the substitutive RCN Raszyn-Łazy (1991-1999) used Swiss-made tube/valve longwave transmitters, Brown-Boveri SL 61 B3 (2000 kW) and ABB (ASEA-Brown-Boveri) SK 55 (LW-adapted, 500 kW), respectfully. For the RCN

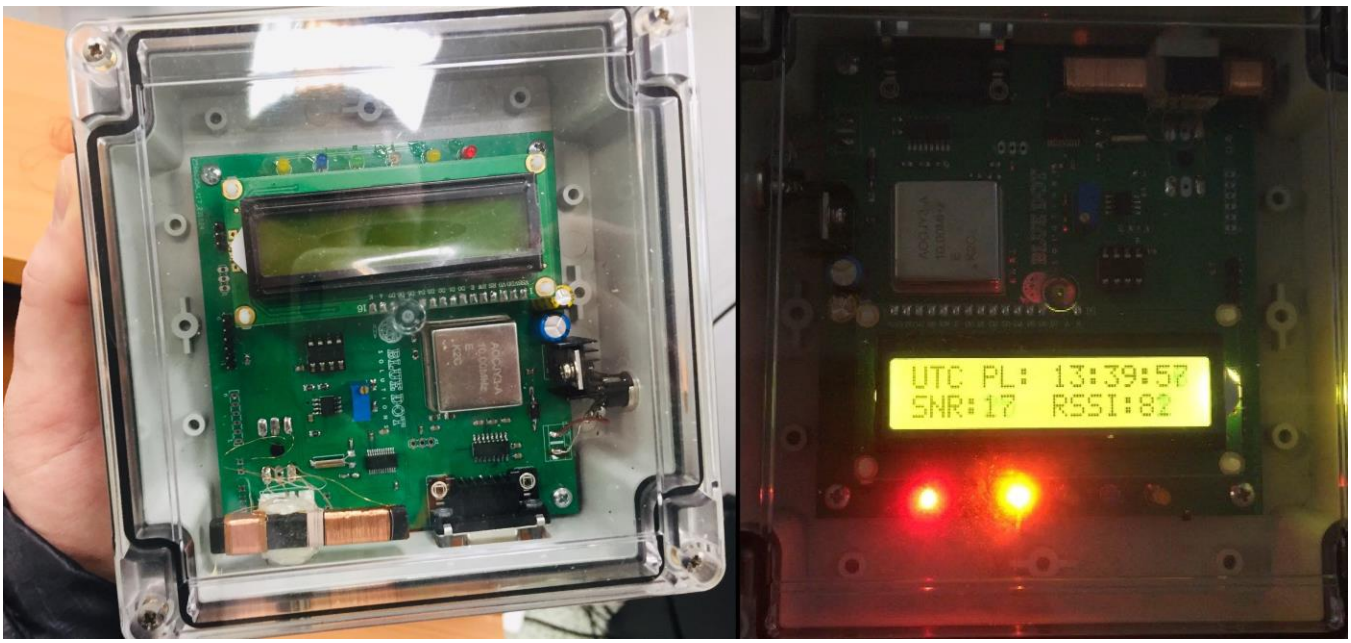

Figure 1. One of the prototype industrial-grade receivers of the eCzasPL-Radio digital time signal, operated by the Central Office of Measures, Warsaw, Poland.

Solec Kujawski, the transmitter was chosen as full-semiconductor-based: Thomcast S7HP in LW 1200 kW version. The transmitter operates at the nominal power of 1044 kW and consists of three blocks of 400 kW each, with each block consisting of 255 POWER MOSFET modules working on a common load. A faulty module can be replaced without the shutdown of the entire transmitter [5]. In the next years of the station's operation, the transmitter was substantially modernized.

The carrier frequency of 225 kHz is generated by a set of rubidium atomic oscillators, the accuracy of which (reaching pHz/Hz) is monitored by the Central Office of Measures in Warsaw, Poland – the rubidium generators substituted the previously used thermally-stabilized quartz generators, dating back to 1988 and the Warsaw Radio Mast [6] (now moved to the reserve).

Thomcast S7HP was chosen as a transmitter which allows the simulcast of the analogue (by the Thomcast's MPM-p3 system [3]) and digital transmissions, with the future introduction of full-digital longwave broadcasting in the now-updated DRM30 standard. The introduction of the digital broadcasting shall ultimately update the public broadcasting service realized by the Polish Radio in RCN Solec Kujawski, allowing the reception on wider ranges, very high tolerance to interferences, availability of broadcasting numerous types of information (not sound only) and the reception on mobile devices [7]. The currently emitted A3E broadcasting signal (double-sided analogue telephony with full carrier) includes the Dynamic Carrier Control (DCC), which lowers the signal level if the modulating signal falls below a given threshold (calm music, faint sounds, interrupted speech) – this and the fully-semiconductor-based power amplifiers provide very high overall transmitter efficiency and drastic reduction of energy costs.

Despite the approximately 2x lower transmitter power (in comparison to the RCN Konstantynów / Warsaw Radio Mast), RCN Solec Kujawski possesses continent-wide range, with confirmed receptions (by the first Author) e.g. from Esrange, Sweden (behind the Arctic Circle). Primarily however, the antenna and transmitter were designed to provide stable ground wave coverage for the entire Polish territory, with the farther regions accessible on ionospheric wave (usually at night). The accessibility of the entire country's population (and a large part of the Polonia) also results in the lowest possible transmission costs per listener/subscriber – unobtainable by UHF broadcasting. As measured in 1999, the signal strength of 77 dBuV/m is registered at 650 km distance from the station, which still allows a clear reception of the A3E signal [3].

The site remains one of the characteristic landmarks between the cities of Bydgoszcz and Toruń. It is not accessible to visitors from outside and remains under very strict control and very heavy protection by the state.

4. Introduction of the digital time signal: eCzasPL Radio

Thomcast S7HP allows the introduction of digital signals employing other-than-A3E modulation of the carrier frequency within the same transmitted signal. Nowadays, RCN Solec Kujawski is responsible for the emission of numerous PSK (phase-modulated) technical signals, intended for the power grid controls, industrial automation, industrial timing (e.g. the dawn and dusk signals), scientific and strategic purposes.

In November 2023, an important digital signal joined these transmission – the digital time signal within the eCzasPL Radio system, delivering the information on the Polish state time for electronic circuits for various uses [8]. The system employs PSK NRZ (Non-Return-to-Zero) modulation of subsequent frames similar in design to the frames of the DCF77 time signal system; each frame is transmitted every 3 seconds. This refreshing time, angular modulation instead of amplitude modulation and significantly higher transmitter power puts this system ahead of the DCF77. For the ground wave (without ionospheric reflections of the radio signal), the expected accuracy of the time signal shall fall below the order of milliseconds.

Exemplary designs of receiving and decoding circuits have been designed for the system by Blue Dot Solutions and published by the Central Office of Measures, to be produced or assembled individually [8]. One of the prototypes (in operation) is shown in Figure 1. The circuit in its basic form allows the connection of an external antenna (if required); the next versions of the circuit shall also provide a PPS (Pulse Per Second) output. Central Office of Measures has also published extensive information on the structure of the transmitted time signal frames, which shall be useful in the development of independent receiving circuits and their technical applications – in energy/power tariffing, functioning of ticketing systems, weather stations, transportation networks, clocks (industrial, institutional and private/consumer-grade) and many other.

5. Concluding remarks

RCN Solec Kujawski has been subjected to intense technical growth since its opening 25 years ago. With the analogue, strong and simple-to-receive broadcasting still playing an important role in a continental scale – especially regarding the current situation in Belarus and Ukraine – the center offers a wide variety of technical signals covering different types of services everywhere in the country and far beyond its borders. The introduction of the digital time signal within the eCzasPL Radio programme further exploits the technical possibilities of high quality data transmission provided on low frequency by the station.

Basing on the station's 25 years of success, a set of key features of a modern longwave/low frequency radio station can be formed:

- The combination of owner and broadcaster entities – the avoidance of a substantial costs of the station's functioning resulting from the separation of the main programme contractor(s) and the owner of the site;
- Modernized transmitting side of the station, using semiconductor technology exclusively, allowing multiple modulations and substantial reduction of electricity and maintenance costs;
- Concentration of emission of multiple types of data (not exclusively broadcasting) in the same site, lowering the costs of the introduction and operation of systems using those data but demanding a higher level of protection of the site itself;
- Adaptation to digital broadcasting (full digital or simulcast), allowing the possible reduction of radiated power, improved quality of broadcasting, increased amount of data and the use of mobile devices for reception;
- Training and education of new staff (engineers – e.g. [5], scientists) dedicated to the maintenance and constant development of the low frequency radio technology.

References

[1] Z. Chomicz, "80 years of the Polish Radio," Polskie Radio S. A. – Center for the History of Polish Radio Broadcasting, Warsaw 2005

[2] Radiowe Centrum Nadawcze w Konstantynowie (Radio Transmitting Center in Konstantynów): https://www.rcn.tlx.pl/ [accessed on 15th January 2024]

[3] D. J. Bem, "Antenna Array in the Radio Broadcasting Centre Solec Kujawski (Polish Radio, JSC)," *Telecommunications Review + Telecommunications News*, **8-9**, 2000, pp. 577-585

[4] T. A. Miś, J. Modelski, "Analysis of terrain-related propagation changes of Polish longwave radio stations," *Proceedings of the 23rd National Conference on Electronics*, Darłowo, Poland, 2nd-6th June 2023

[5] D. Czerwiński, "The tester of the D-class module amplifier," Bachelor's thesis, Technical and Agricultural Academy in Bydgoszcz, Faculty of Telecommunications and Electrical Engineering, 2006

[6] "Standard exciter setup 225 kHz. Technical description and user's manual," Institute of Communications, Warsaw-Miedzeszyn 1988

[7] "DRM Handbook, revision 4," DRM Consortium, February 2019

[8] eCzasPL Radio – meet the service: https://e-czas.gum.gov.pl/e-czas-radio/ [accessed on 15th January 2024]