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MULTISTANDARD TRANKING SYSTEM WITH THE USE NON-ORTHOGONAL SIGNALS

This article considers the features of advanced tranking radio systems. Based on the analysis of the characteristics and properties of the existing systems identified the main shortcomings and limitations of the application when operating in the different conditions. During the research priority areas identified for further development of these systems. The results of mathematical modeling of the main parameters of the base station perspective in terms of providing the multistandards.

Keywords: *TRS, DAA, PA, DBF, N-OFDM, OFDM, SDR, TDMA, TETRA.*

Introduction

Nowadays, Ukraine mainly is used analog radios, mainly the production of the USSR, who for their characteristics do not provide the security features of information, data, GPS-navigation and others.

In terms of this functionality systems TETRA (TErrestrial Trunked RAdio) with a Time Division Multiple Access (TDMA) [1] and APCO25 (Association of Public Safety Communications Officials International) with a Frequency Division Multiple-Access (FDMA) [2] are on the top line classification TCP. In each of these standards, the total number of proposed functions a voice transfer/data substantially are exceeding 100. The big advantage of digital TRS is the possibility of collaboration with the existing park analog radios, allowing them to implement phased construction. Thus, it is possible to fine adaptation of system solutions to the needs of the customer with additional software, for example, control applications and others. In this sense, the TETRA technology and APCO25, which for many years used by law enforcement agencies of European countries and other world countries is the most successful that occurred.

In turn, these standards TRS in terms of technology are far behind the other telecommunications transmission system, for example, mobile communication systems 4G/5G [3], unified communications [4], optical access systems [5] and others. As a result, basic infrastructure elements TRS, base station (BS) should build on modern schemes and technical solutions.

Main

Typically, for organizing TRS uses several classifications: the method of transmission of voice information; zones quantity; BS unification method in lots zone communication systems; type Multiple Access; way to search and destination channel; type channel management; way maintenance channel.

The analysis shows that the analog TRS received widespread. However, at the moment the development of these systems completely stopped due to a massive shift to digital technology. The development of digital TRS is due to several advantages over analog systems:

– more spectral efficiency through the use of complex types of modulation and low-speed algorithms for converting speech;

– high capacity communications systems;

– alignment the quality of verbal exchange across the range of a base station through the use of digital signals in combination with anti-interference coding.

In addition, digital TRS compared with analog provide benefits by implementing requirements for increased efficiency and safety communications, providing opportunities for the transmission of data over a wide range of communications services (including specific communication services for the implementation of the special requirements of service public safety) possibilities of interaction between subscribers of different networks. The big advantage of digital TRS is the possibility of joint work with the existing fleet of analogue radios, allowing them to implement phased construction.

It is known that TRS is all digital systems with a dedicated control channel, and primarily different means of access: FDMA or TDMA. In order to implement, and considering that the specification APCO Phase 2 focused on the combined use of FDMA and TDMA, as well as the prevalence in Ukraine and open TRS TETRA standard, continue to work considered TETRA TRS, which uses TDMA. TETRA standard involves the use of the frequency range of 150 to 900 MHz. However, TETRA Release 2 provides 38,4 ÷ 691,2 kbit/s, and radio interface allows you to implement QAM-64. Analysis of options using the method for example TETRA TDMA allows to define its strengths and weaknesses in TRS.

To determine the characteristics and parameters of perspective TRS TETRA base stations in the comparative evaluation of TRS Motorola Dimetra IP [6], Rohill Tetranode [7] and DAMM Tetraflex [8]. In terms of functional completeness are the priority TRS DAMM TetraFlex. However, the need to build systems of general security or TRS united several security agencies at the state level – should be given preference decision based on Motorola Dimetra IP Scalable.

During the analysis parameters of TETRA radio tract TRS found that TETRA base station coverage area in less than 2 ÷ 3 times than TRS BS analog or DMR (Digital Mobile Radio). Therefore, TETRA system requires the installation of a 3 ÷ 5 times more sites to cover similar territory.

TETRA Enhanced Data Service, TEDS is optimized for efficient use of the frequency spectrum and involves the use of different bandwidth and modulation type depending on conditions of signal propagation. TEDS uses 8 carrier frequencies on each 25 kHz, that is, respectively, 8, 16, 32 and 48 bearing width channels 25, 50, 100 and 150 kHz. Each carrier provides transfer rate 2,400 characters per second, and the total Symbol rate depends on the total carriers amount. This method, due to the low speed on each carrier, provides resistance to temporal modulation dispersion and therefore avoids the need for an adaptive equalizer. Unfortunately, until now, due to lack of frequency spectrum, used in mobile radio communications, deployment of broadband-enabled services using TEDS limited channel width not exceeding 50 kHz.

Increased bandwidth BS TRS possible through the use of new variants TDMA, based on modern technologies and methods of modulation with high spectral efficiency. As a result, the paper suggests several approaches to solve this problem:

– obtain additional operational gain by modifying algorithms Quadrature Amplitude Modulation, QAM;

– work with the existing park equipment standard TETRA;

– Introduction of multiple access based on Orthogonal Frequency Division Multiple Access OFDM;

– implementation of DSP scheme for hybrid OFDM/TDMA or OFDM/TDMA;

– providing multi standards modes, eg with DMR, APCO25 and others.

In this sense, to improve the capacity of the TRS standard TETRA base station for prospective suggested to use instead of a single carrier QAM signal type Multi-OFDM [9]. Since the application of OFDM flow of information distributed to a large number of low-speed subchannels, the length of the interval clock for each carrier is determined substantially more typical delay signals with multipath propagation of radio waves. This makes subjected to selective fading one broadband channel carriers on independently fading narrowband subchannels with frequency division multiplexing.

Before determining the basic parameters of the DSP BS in OFDM under TRS TETRA expedient to formulate the initial data, based on the TETRA standard requirements. Taking into account the duration of one time slot (Time Slot, TS) – 14,167 ms, and the amount of information transmitted – 510 modulation bits, technical transfer rate is 35.99915 kbit/s (≈36 kbit/s). To detect errors in the transmission channel radio and their correction in channel coding technology applied Forward Error Correction (FEC) and Cyclic Redundancy Check (CRC) in a 4-procedures: block coding, convolutional encoding and encryption interleaving after which information channels are formed. One radio channel occupies 25 kHz bandwidth. TEDS mode uses 8 carrier frequencies on each 25 kHz, that is, respectively, 8, 16, 32 and 48 bearing width channels 25, 50, 100 and 150 kHz.

However, in practice the deployment of broadband-enabled services using TEDS limited channel width not exceeding 50 kHz. Thus, as the assumptions advisable to take next.

– TETRA subscriber terminals connected to the base station in TDMA mode;

– a duration equal to TS 14.167 ms;
– signal delay can be up 7 ÷ 10 ms;
– TEDS mode uses 8 carriers the channel bandwidth of 25 kHz.

Further, it should formulate the requirements for basic parameters of BS OFDM:

1. BS of the OFDM must support standard TETRA terminals in subscriber mode TDMA. This means that the modified OFDM QAM algorithm implemented within one TS for subscriber terminals to support of improved DSP. If all terminals supporting the proposed approach, it can be implemented the access mode OFDM/TDMA or OFDMA, which gives additional increase in bandwidth TRS.

2. According to TEDS, the minimum number of subchannels carrying OFDM signal has to make.

3. The number of characters OFDM, which form the frame is an integer N.

Taking into account the above named, calculated from the signal BS OFDM.

To calculate the maximum quantity subchannels carriers (respectively – the dimension of the operation fast Fourier transform (FT) Place the duration OFDM symbol period (or period FT) equal length TS, that is, $T_u = 14{,}167$ initially ms, then: $M_{\max} = \frac{1}{T_u} = \frac{1}{14{,}167\,\text{ms}} = 283{,}34$.

Typically, the dimension FT algorithm is chosen according to the Cooley-T'yuki (in this case) $M_{\max} = 2^N$). Adverse consequences popularity algorithm is said that based on FT algorithm parameters were chosen parameters of the equipment, instead it had reverse sequence. In fact, efficient FT algorithms exist for almost any lengths conversion. One is the FT algorithm Vinogradov. It is more efficient in computing regard, the FT algorithm on the basis of 2. However, examples of practical use almost no difficulty solely due to irregular sales structure calculations. For these reasons determined by the quantity subchannels carriers OFDM – $M_{\max} = 256$.

The length of the guard interval can be 1/4, 1/8, 1/16 or 1/32 of the length of OFDM-symbol, but not less than 7 ÷ 10 microseconds. Thus, the decrease is less than 1/16 is not considered appropriate.

As a result, changing the value and quantity subchannels carriers between $M_{\min} = 8$ to $M_{\max} = 256$, determine the number of OFDM-symbols in one frame, the duration of which shall not exceed the length of the TS. Example Calculation results are presented in Table. 1. In practice, the obtained N OFDM symbols should allocate part in the pilot (≈6,25% of the total) and exclude boundary subchannels (≈18,75% of the total) in the event of their amplitude frequency distortion.

Thus, for a multiplicity length guard interval 1/16 in terms of the number of characters OFDM, it is advisable to choose the number of system parameters carriers from 8 to 32. The total data rate is calculated after the selection algorithm and code rate QAM.

Table 1. Parameters of digital signal processing OFDM

Parameters of OFDM signal	**Multiplicity length guard interval 1/16**					
Number of subchannels	256	128	64	32	16	8
Δf , kGz	0,097656	0,195313	0,390625	0,78125	1,5625	3,125
T_u , ms	10,24	5,12	2,56	1,28	0,64	0,32
T_g , ms	0,64	0,32	0,16	0,08	0,04	0,02
$T_s = T_g + T_u$, ms	10,88	5,44	2,72	1,36	0,68	0,34
Calculated number of characters	1,3	2,6	5,2	10,42	20,83	41,67
N symbols OFDM in one frame	1	2	5	10	20	41

In OFDM systems procedures for the use of Fourier imposed limitation that is caused by relatively large lateral petals frequency response FT filter. Because of this effect may occur semi-channel interference when the frequency of the carrying signal for some reason, uncontrolled shift of the maximum amplitude-frequency characteristics (AFC) FT filter. Thus, one of the major drawbacks OFDM method is that the frequency sealing limited bandwidth of the synthesized FT filters.

Given that QAM is used as a modern TRS TETRA, and so as a modulation symbol OFDM, for TCP in the proposed modification algorithms QAM, which boils down to the application the modulation scheme of the «rotating» signal constellation. This approach provides additional operational gain.

For promising BS, taking into account requirements to be able to work with the existing park equipment standard TETRA, standardization and openness for further modifications and implementation semi-channel modes as a basic defined technology Software-Defined Radio (SDR) [10]. On this basis the schematics receiving and transmitting paths perspective BS with OFDM.

Similar to DVB-T2, it is advisable to ensure the terminal subscribers mode MISO (multiple input – single output) using a coding scheme Alamouti, that the receiver processes the signal from the two transmit antennas or two BS (as if he is in the zone of action). As is known, MISO – is a particular case of MIMO – data transmission technology n antennae and their receiving m antennas. The method consists in the fact that the signal is used not one but several antennas, separated from each other.

As a result, the development of this approach is the introduction of MIMO mode, which is very well used in wireless LAN (802.11n etc.).

Another focus, as a 5G, is the use of nonorthogonal signals, such nonorthogonal OFDM (N-OFDM) [11]. This approach is to some extent offset the disadvantages of OFDM. In practice, to improve the security of TCP hurt procedure N-OFDM, like OFDM, should be used in conjunction with procedures for internal and external channel coding for error detection or correction.

Quite promising for TRS BS is the use of digital technology chart formation is based digital antenna arrays (DAA) [12]. A key feature of the digital antenna arrays –

digital beamforming radiation pattern antenna. Overall, the telecommunications system of the chart formation at the pattern antenna are able to effectively address these problems:

– improve the signal / noise ratio due to the formation of «zeros» DM-interference in the directions of signals including the neighboring airborne and ground stations, even the petals main DM;

– interference suppression signals that occur when multipath propagation as well as a significant reduction fading depth of modulation;

– maximize the effectiveness with Code Division Multiple Access (CDMA), Space Division Multiple Access, (SDMA), FDMA and TDMA;

– integration into a single information system of different functional purpose subsystems, such as navigation, radio and so on;

– increasing the intensity of useful signals by focusing DM highs in the areas of mobile correspondents;

– solving the problem of electromagnetic compatibility.

To demonstrate the efficiency of noise suppression procedures using DAA and the subsequent formation of maximum radiation pattern in the right direction was conducted mathematical modeling package MathCad, results are presented in Fig. 1, 2.

This angular coordinate signal was given equal – -200 and +200 relative to single obstacle to the normal 4-helementnoyi lattice. The amplitude of the signal was 10 standard units, and noise – 1000, the phase difference signal and the noise was equal to 450. It may be noted that as a result of noise removal is distortion of the signal response, which increases as the convergence angle coordinate diagram of the failure and the direction of the signal (watch. fig. 3).

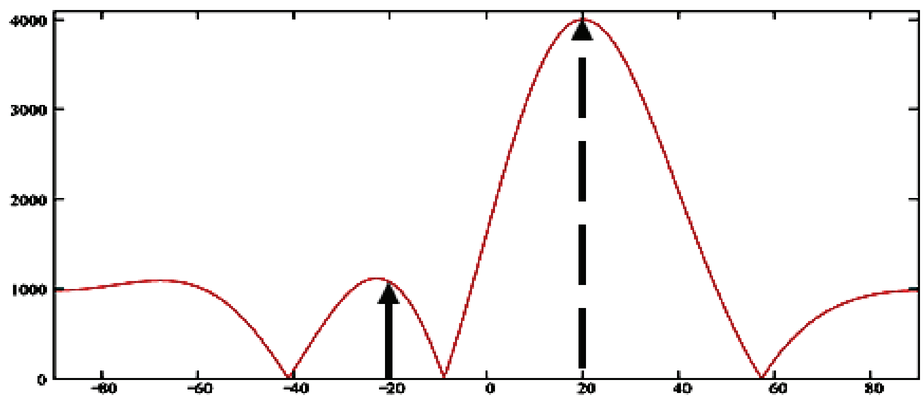

Fig. 1. Signal mixture to suppress noise (solid arrow – signal dotted – noise ratio)

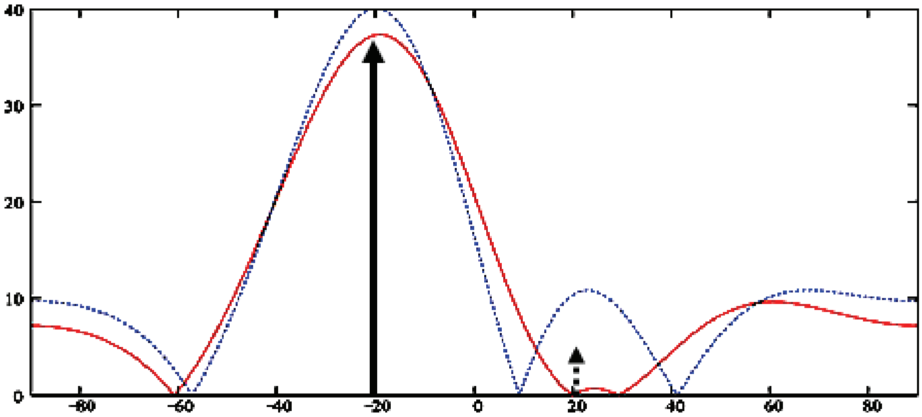

Fig. 2. mix Signal after suppressing noise (solid line) and add a lattice no-interference situation (dotted line)

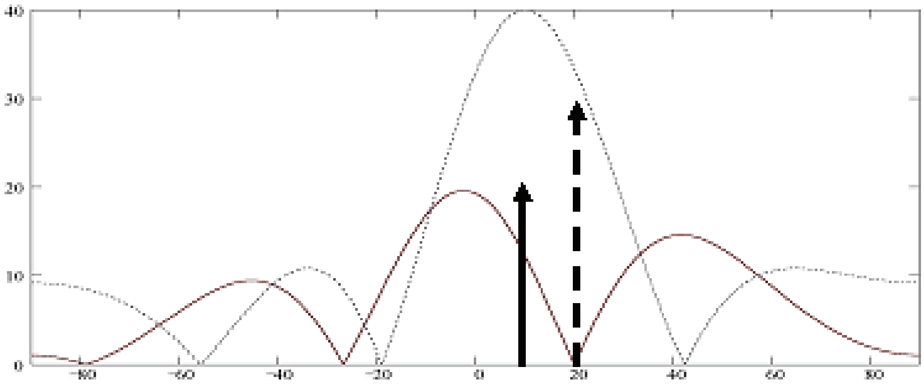

Fig. 3. The distortion response signal (solid line) after removing noise while hawking their angular coordinates 100 (the source of the disturbance is at 200), the dotted line – signal response without interference

Similar results were obtained when removing reviews two – three directors noise.

At present, the construction of base stations using constructs based on CompactPCI. An alternative and more modern solutions that implement PCI Express [13].

Conclusion

Thus, these priority areas of basic infrastructure will enable TCP to expand the range of services and amenities, as well as to satisfy existing demands in the creation of the National System for Mobile Communications public authorities. In addition, it will reduce a significant backlog in terms of technology from advanced TCP telecommunications transmission systems.

Literature

1. Terrestrial Trunked Radio (TETRA); Release 2; Designer's Guide; TETRA High-Speed Data (HSD); TETRA Enhanced Data Service (TEDS) [Electronic resource] / ETSI TR 102 580 V1.1.1 (2007-10). Technical Report. – Last access: http://www.etsi.org/deliver/etsi_tr/102500_102599/102580/01.01.01_60/tr_102580v010101p.pdf.
2. APCO P25 (Project 25) [Electronic resource] – Access: https://ru.wikipedia.org/wiki/APCO_P25.
3. Sliusar I.I. Determining the priority number of characteristics 5G system based on hierarchy analysis method. / I.I. Sliusar, V.I. Sliusar, R.V. Kulyk. // Modern trends of development of information and communication technologies and management tools, materials 6th International Scientific Conference. – Poltava: PoltNTU; 21-22 April 2016. – C. 59.
4. Sliusar I.I. Transfer of technology of unified communications in the interests of the educational process and management of higher education institution / I.I. Sliusar, Y.V. Utkin // Information management systems for rail transport. – Kharkiv: Ukrainian State University of Railway Transport, 2013. – № 5. – P. 39-43.
5. Converged Solutions for Next Generation Optical Access / I. Sliusar, V. Sliusar, S. Voloshko, V. Smolyar // IEEE Second International Scientific-Practical Conference «Problems of Infocommunications. Science and Technology» (PICS & T2015). – Kharkiv. – October 13-15, 2015. – P. 149-152.
6. Digital trunking radio system Motorola Dimetra IP Compact [Electronic resource] – Access mode: http://www.sagatelecom.ru/radiosystems/digital_systems/dimetra_ip_compact.php.
7. TetraNode access networks [Electronic resource] / Rohill. – Last access: http://www.rohill.nl/products/access-networks.
8. The power of true scalability with a TETRA system [Electronic resource] / Damm Cellular Systems A / S. – Last access: http://www.damm.dk/products/tetraflex-system-/.
9. Modern Wireless Networks: STATUS and prospects of development / I.O. Hepko, V.F. Olijnyk, Y.D. Thajka, O.V. Bondarenko. – K .: ECMO, 2009. – 672 p.
10. Sliusar I.I. The market of programmable logic integrated circuits expands its range. I.I. Sliusar, V.I. Sliusar // Informational and Informational Technologies. – №1. – 2009. – P. 40-44.
11. Sliusar V.I. Non-orthogonal frequency multiplexing (N-OFDM) signals. Part 1. / V.I. Sliusar. // Technologies and means of communication. – 2013. – No. 5. – C. 61-65.
12. Vishnevsky V.M. Broadband wireless data transmission networks. Vishnevsky. – Moscow: Technosphere, 2005. – S. 498-569.
13. Sliusar V.I. The introduction of PCI Express into CompactPCI is an attempt No. 2. / Sliusar V.I., Trotsko O.O. // Electronics: science, technology, business. – 2010. – No. 7. – P. 72-81.