SCP-RPSC - The New Technology for Microwave Broadband Mobile Communications

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Abstract – **A retrospective review of a new technology, named SCP-RPSC, is given in this report. It is particular useful as the radio front end of the mobile microwave broadband communication systems with terrestrial and satellite positioning. A list of possible applications is given too.**

Keywords – **SCP, RPSC, RPSC-MA, broadband microwave mobile communications**.

I. Introduction

The terrestrial and satellite broadband mobile communications are currently a strong growth market, driven chiefly by major projects to deploy vast regional or world-wide networks. They need new and wider frequency bands, available at higher frequencies – up to millimetre wave frequency bands. One of the biggest technical problems of these mobile networks is the way of access to the satellite or terrestrial base stations, particular the used antenna systems. The need to change the polarization, to track Low Earth Orbiting Satellites (LEO,s) or High Altitude Platforms (HAPS), to select one of several Geo Stationary Orbit Satellites (GEO,s) positions, as well as the requirements for two way broadband mobile communications at low price and mass market production leads to unsolved by traditional antennas problems. Their solution needs entirely new approach, which is subject of the last decade research activity of the author. The name of the new technical solution is Spatial Correlation Processing – Random Phase Spread Coding (SCP-RPSC). A retrospective review of the research step by step approach, used by the author, is given in the report with the main bibliography for details.

II. SCP technology

The main objectives of the SCP technology [1, 3, 5, 6, 7, 10, 20, 21] are:

- To receive one or more radio signals coming from one or several spatially distributed sources (satellites, base stations), insuring high gain of the antenna systems and using fixed or mobile receiving terminals, equipped with SCP signal processing systems.
- To ensure spatial selectivity high enough to cancel the same frequency channel interference, coming from different space directions, using simple one-channel receiver and signal processing techniques.

The objectives stated above are achieved by a patented method for radio communications, which proposes application of additional pilot signal transmitted in the band of information signals and available in the receiver by one of the known methods for access. The SCP receiver terminal is equipped with antenna array with random phase aperture excitation. The phase shifts among the signals, coming from the antenna elements, are random at the antenna output, regardless of the information source direction. These random phase spread signals correlate with the recovered pilot signal, phase spread in the same manner, in a signal recovery unit (Fig.1). The result of the correlation process between pilot and information signals is the recovered information signal at base band.

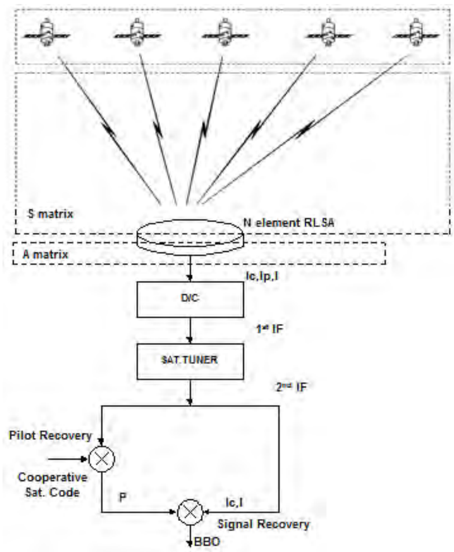

Fig.1. Block scheme of a SCP-CDMA system

One of the main parts of the SCP system is the random phased antenna. In principle all kind of antenna arrays could be used, but for Ku and Ka bands particular suitable is the Radial Line Slot Antenna (RLSA). Until now it is used as phased array for fixed satellite reception.

The main features of the SCP approach are:

- Simple, cheap and flat passive radial line antenna, suitable for mass production in Ku and Ka frequency bands.
- One channel convenient microwave receiver with simple signal processing.
- Omni directional for the cooperative satellite or terrestrial base station, but with high figure of merit G/T.
- Selection of different satellites and polarizations by PN-codes.

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- Applications in existing S-DVB systems with minor modifications of the ground transmitters, compatible with the existing satellite transponders.
- Multi-beam and soft handover features.

III. RPSC TECHNOLOGY

The idea to use SCP principle in transmit mode [2, 9, 15, 16] was born during the SCP project research. The transmitting antennas, as well as the receiving random phase antenna arrays in SCP technology are pure passive, without any active or nonreciprocal elements. The specific SCP processing is situated in the receiver (Fig.2). According to the basic electromagnetic antenna lows the replacement of the passive transmitting antenna with passive random phase antenna array in the transmitter, and vice versa in the receiver should not change the system working principles and system parameters. The transmitted by the random phase antenna array signals have specific phase spread. It can be considered as random spatial coding.

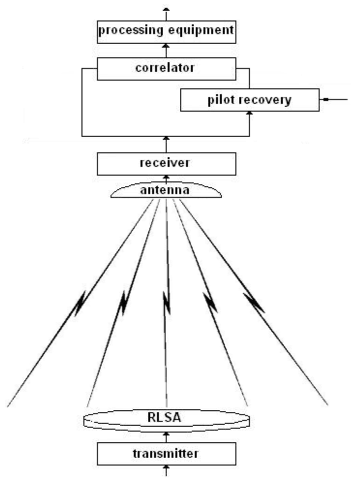

Fig.2. Block scheme of a RPSC system

The main features of the RPSC approach are:

- Providing of full duplex radiocommunication system with one simple and cheap transmit-receive antenna.
- The transmitted random poly-phase spread signals will not cause significant harmful interference to the conventional satellites, using the same frequency channels. The interference will be similar to that, caused by the sidelobes of an antenna array with random elements distribution.
- The transmitted random poly-phase spread signals are uniformly radiated in the space above the antenna. Several satellites, equipped with the same SCP receivers and providing space diversity, receive them. The knowledge of the receiving satellites positions for the transmitting equipment is not necessary (as it is for a conventional satellite earth station).
- The transmitted random poly-phase spread signals have low detection probability for the conventional microwave receivers, leading to low active jamming probability.
- The SCP-RPSC approach could be a breakthrough technology, leading to unpredictable increase of the frequency reuse factor in satellite and terrestrial wideband networks. Close situated subscriber terminals could communicate with base stations, using the same frequency channel without interference. The isolation between the terminals will be provided by their specific random phase spread coding.

IV. SCP-RPSC APPLICATIONS

A. Satellite Digital Video Broadcasting (DVB-S)

Proposal for a SCP-CDMA GEO satellite system, suitable for DVB-S communications in Ku-band for fixed and mobile terminals, is given in [4]. The proposed algorithm for system parameters evaluation, based on link budget calculations, gives good results – Figure of merit (G/T) better than 14 dBi/K for 60 cm antenna diameter at very low prize (in order of several $). Similar proposal for quasi GEO satellites at elliptical polar orbits is given in [8].

B. Space Links

- *Inter Satellite Links (ISL)*

The space segment of the future global satellite systems for broadband communications can be designed in number of ways, depending on the orbital type of the satellites and the payload technology available on board. The use of different satellite orbits to provide complementary services, each optimized for the particular orbital type, is certainly feasible. Satellites can be used to connect with each other and the ground networks, through the use of Feeder Lines, Inter – Satellite Links or Inter-Orbit Links, which when combined with on-board routing facilities, can be used to form a network in the sky. The unique properties of the SCP-RPSC approach will give a new support for the future broadband LEO,s communication systems in the service feeder lines, inter-satellite and inter-orbit lines domain. The possible applications of the SCP-RPSC technology in these microwave lines of several different types LEO,s constellations are considered in the report [18]. A review of the possible advantages, supported by a critical analysis, is given too.

- *Feeder Lines*

The company O3b, supported by Google, is building a new network of MEO satellites with steerable Ka-band beams to provide lower-cost, fibber-grade access for cellular backhaul and IP backbone trunking in traditionally underserved areas. The main O3b network parameters and architecture are presented in the report [32]. Information concerning the satellite constellation and orbit, satellite and ground antenna beam steering, as well as inter-satellite handover procedures are given. The possible applications of

SCP-RPSC technology in O3b MEO satellite system are discussed too.

- *SPS Lines*

One of the most important use of satellite technologies in the future will be in Solar Power Satellites [SPS]. The concept of generating solar power in space for wireless transmission to receivers on the ground has been discussed in details during the last four decades. All of the sophisticated SPS systems will need broadband wireless communications for telemetry and control purposes among the different parts of their architectures. Another important problem of the future SPS systems will be the transmission of video and telemetric information among SPS mounting robots and satellite or ground based control centers. The unique properties of the SCP-RPSC approach will give a new support for the future SPS mobile broadband communication systems [17].

C. High Altitude Platform Systems

A new radio technology to realize the last mile access to the broadband fixed networks, named High Altitude Platform Systems (HAPS), is discussed in the reports [14, 24, 29]. Such a mode of service delivery offers advantages as coverage can be rapidly set-up over any location and can be just as easily removed or relocated; high elevation angles can be achieved to the mobile users; efficient frequency re-use schemes can be employed to maximize network capacity; the round-trip delay is relatively short; the cost is considerably less than terrestrial or satellite counterparts. The goal of the reports [14, 24, 29] is to discuss the possibilities and the advantages of the implementation of SCP-RPSC technology in HAPS communications, particularly as subscriber terminal front end equipment. The proposals deal with Line of Sight (LOS) mm-wave propagation environment, which is accepted by the communication community as the only way to communicate in these frequency bands. However, in high building city environment most of the terminal links will be shadowed, which will need more and more new base stations. A possible solution is the Non-LOS mm-wave systems, working properly in high building city environment. The possibilities of SCP technology to create simultaneous several narrow virtual antenna beams could be a good solution of the problem, leading to effective use of the reflected beams by gathering the signals in phase at baseband [31].

D. WIMAX

The goal of the reports [19, 25] is to discuss the possibilities and the advantages of the implementation of SCP-RPSC technology in *Wi-MAX* communications. The implementation of this technology in subscriber terminals is discussed first. After that the possible base station applications are treated too. The applications of SCP-RPSC technology simultaneous at base station and terminal stations are possible, but they will need additional research and investigations.

E. Military applications

A review of the mobile satellite communication systems with military applications is given in report [11]. The profits of SCP-RPSC technology for such kind systems are listed and analyzed too.

F. Telemedicine

The benefits for telemedicine systems, using SCP-RPSC mobile satellite communications, are given in the report [12].

G. Aeronautical and Global Navigation Satellite Systems (GNSS)

The benefits for aeronautical systems and GNSS, using SCP-RPSC mobile satellite communications, are given in the reports [22, 23, 30].

V. IMPROVEMENTS OF REGULATORY STATUS OF SATELLITE SERVICE USING VEHICLE-MOUNTED ANTENNAS AND RPSC MULTIPLE ACCESS TECHNIQUES

Satellite connectivity while driving traditionally has been possible by using handheld personal terminal equipment with low gain omni directional antennas. Recently, the new satellite interactive broadband communication systems use high gain satellite tracking antennas, installed on vehicles. Vehicle-Mounted Earth Stations (VMES) currently can operate on conventional Ku-band frequencies (14 GHz Uplink, 11-12 GHz Downlink) but only on a secondary basis. This means VMES can not claim interference protection from primary services such as fixed satellite systems and Earth Station on Vessels (ESV). A co-primary allocation of VMES in the conventional Ku-band would be in the public interest, as it would address a growing commercial demand for on the move services. However, a co-primary allocation would also have to be conditioned on strict adherence to interference avoidance mechanism, which in the best way obviously is satisfied by the RPSC technology [26, 28].

The Radio-communication Sector of ITU is now seeking submissions from industry and governments on various technical, regulatory and economic ideas in order to increase the efficient use of satellite orbits and frequencies. The SCP-RPSC could be a breakthrough technology, leading to unpredictable increase of the frequency reuse factor in satellite and terrestrial wideband networks. Close situated subscriber terminals could communicate with terrestrial or satellite base stations, using the same frequency channel without interference. The isolation between the terminals will be provided by their specific random phase spread coding, due to their specific random design. We can consider this principle of operation as a new multiple access approach, named by us Random Phase Spread Coding - Multiple Access (RPSC-MA) [27].

VI. Conclusions

The practical implementations of SCP-RPSC principles will drastically change the existing paradigm in the mobile microwave broadband satellite and terrestrial communication business in general. Many of the existing problems of the proposed systems, dealing with frequency and orbital resource sharing, beam pointing, beam shadowing, terrorist jamming etc., will be solved successfully.

References

[1] V. Demirev, “Method and System for Space Diversity Communications”, Patent WO/2003/013022, PCT/BG2002/000016, 3.02.2003, H04B1/07 (2006.01), H04B 7/02 (2006.01), Priority №105671/04.07.2001,BG.

[2] V. Demirev, “Radiocommunication Method and System with poly-phase spread coding”, Patent WO/2003/107552, PCT/BG2003/000027, 27.12.2003, H04B1/69 (2006.01), H04B 7/06 (2006.01), Priority №106819/13.06.2002, BG.

[3] V. Demirev, V., “SCP technology – the new challenge of broadband satellite communications”, ICEST’04, Conference Proceedings, pp. 159-162, Bitola, Macedonia, 2004.

[4] V. Demirev, A. Efremov “SCP-CDMA GSO’s system proposal”, ICEST’04, Conference Proceedings, pp. 163-166, Bitola, Macedonia, 2004.

[5] V. Demirev, “The probability theory with application in SCP technology”, ICEST’04, Conference Proceedings, pp. 167-168, Bitola, Macedonia, 2004.

[6] В. Демирев, В. Витков, С. Каменополски, А. Ефремов, “Изследване на някои параметри на технологията SCP с MATLAB симулации”, Телеком,04, Трудове на конференцията, том 1,стр.321 -326, Варна, България, 2004.

[7] V. Demirev, A. Efremov, “Some Important Parameters of the SCP Technology”, ICEST’05, Conference Proceedings, V.2, pp.516-518, Nis, Serbia and Montenegro, 2005.

[8] R. Markov, V. Demirev, “Application of SCP technology in Quasi-GEO satellite systems”, ICEST’05, Conference Proceedings, V.2, pp.519-521, Nis, Serbia and Montenegro, 2005.

[9] V. Demirev, “Review of SCP-RPSC technology”, ICEST’05, Conference Proceedings, V.2, pp.630-633, Nis, Serbia and Montenegro, 2005.

[10] В. Демирев, Д. Илиева, “Информационен капацитет по Shannon на SCP система, ограничена по топлинен шум”, Телеком, 05, Трудове на конференцията, том 1, стр.95-100, Варна, България, 2005.

[11] В. Демирев, “Спътниковите комуникации – тенденции и приложения”, CIO Journal, 11, стр.34-38, 2006.

[12] V. Demirev, “Broadband satellite SCP-RPSC Communications – the new chance for the telemedicine”, CEMA, 07, Conference Proceedings, pp. 17-21, Sofia, Bulgaria, 2006.

[13] В. Демирев, А. Ефремов, Е. Михайлова, “Информационен капацитет по Shannon на ограничена по интерференция SCP система”, Телеком,06, Трудове на конференцията, стр.272-277 , Варна, България, 2006.

[14] В. Демирев, В., М. Николова, “Приложение на технологията SCP-RPSC в широколентови HAPS”, Телеком,06, Трудове на конференцията, стр.283-288 , Варна, България, 2006.

[15] В. Демирев, “Приложение на вероятностната теория в технологията SCP-RPSC”, Телеком,06, Трудове на конференцията, стр.278-282, Варна, България, 2006.

[16] V. Demirev,, “SCP-RPSC technology – the new challenge in the broadband satellite communications”, Caspian Telecoms,07, Conference Proceedings, pp.178-181, Istanbul, Turkey, 2007.

[17] V. Demirev, “Application of SCP-RPSC Mobile Communications in SPS Technology”, ISRSSP,07, Conference Proceedings,, pp. 129-132, Sofia, Bulgaria, 2007.

[18] V. Demirev, “SCP-RPSC Technology in the Feeder Lines of the LEO,s Communication Systems”, CEMA,07, Conference Proceedings, pp. 1-5, Sofia, Bulgaria, 2007.

[19] В. Демирев, “Приложение на технологията SCP-RPSC в микровълновите Wi-Max системи”, Телеком, 07, Трудове на конференцията, 29, Варна, България, 2007.

[20] V. Demirev, “Review of SCP Test Set-up and Results – I”, CEMA, 08, Conference Proceedings, pp.7-10, Athens, Greece, 2008.

[21] V. Demirev, “Review of SCP Test Set-up and Results – II”, CEMA, 08, Conference Proceedings, pp. 11-13, Athens, Greece, 2008.

[22] В. Демирев, “Приложение на технологията SCP-RPSC в широколентовата мобилна спътникова система MOWGLY”, Телеком, 08, Трудове на конференцията, стр.121-126 , Варна, България, 2008.

[23] В. Демирев, “Приложение на технологията SCP-RPSC в широколентовите спътникови комуникации за въздушния транспорт”, Бултранс,10, Трудове на конференцията, стр. 34-37, Созопол, България, 2010.

[24] В. Демирев, “Основни характеристики на микровълновите HAPS системи, базирани на технологията SCP-RPSC”, Телеком, 10, Трудове на конференцията, стр.172-179 , София, България, 2010.

[25] V. Demirev, “SCP-RPSC WI-MAX systems – the new approach for the next generation microwave access strategies”, Caspian Telecoms,08, Conference Proceedings, Istanbul, Turkey, 2008.

[26] V. Demirev, “SCP-RPSC Technology – The Perfect Solution of the Broadband MSS Problems”, Computer and Communication Engineering, vol.4, N1, pp.43-46, 2010.

[27] V. Demirev, “Random Phase Spread Coding Multiple Access - the New competitor of CDMA in the broadband wireless networks”, Journal of Applied Electromagnetism, vol.13, Number 1(June 2011), pp. 26-32, 2011.

[28] V. Demirev, “The regulatory aspects of SCP-RPSC technology – could they solve the VMES problems”, Journal of Applied Electromagnetism, vol.13, Number 1(June 2011), pp. 33-38, 2011.

[29] В. Демирев, “Широколентови радиокомуникационни системи, базирани на летателни апарати”, Бултранс,2011, Трудове на конференцията, стр. 43-46, Созопол, България, 2011.

[30] В. Демирев, “Приложение на технологията SCP в системите за спътникова навигация”, Бултранс,2011, Трудове на конференцията, стр. 47-50, Созопол, България, 2011.

[31] V. Demirev, “SCP Rake Receiver - The Possible Solution of N-LOS HAPS and WIMAX mm-Wave Networks”, CEMA,11, Conference Proceedings, pp. 18-21, Sofia, Bulgaria, 2011.

[32] В. Демирев, “Приложение на технологията SCP-RPSC в спътниковата MEO система O 3 b на Google”, Телеком,11, Трудове на конференцията, София, 2011.