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A Spatially Modulated Efficient Channel Coding Scheme for CCSDS based Advanced Orbiting System Architecture using connected RS-Turbo Codes

Akanksha Tiwari[1], Vikas Kumar Sahu[2]

Research Scholar, ET&T Department, SSCET, Bhilai[1]

Assistant Professor, ET&T Department, SSCET, Bhilai[2]

Abstract: A communication satellites play an outsized character in the socio-economic growth of a country, nevertheless the satellite communication system design trade-offs proliferation with the involvedness of the requirements. Surrounded by various satellite communication know-hows, advanced orbiting systems endorsement is an outstanding one projected by CCSDS (Consultative Committee for Space Data System). In AOS, the error correction coding schemes commonly used are convolutional coding, Turbo coding and RS coding. This paper introduce the implementation procedure of RS-Turbo hybrid code, than make the quantitative analysis of performance in AOS by the data of software simulation experimentation, the work starts with random frame generation, that is converted into a compact information by using spatial modulation (representing data streams in form of constellation points and antenna number). Finally, the communication is performed using BPSK modulation, the inference is that the proposedcode has higher coding gain, smaller complexity cost and less error probability. The advantages of this proposed coding scheme from different points are analyzed. In particular, the impact of proposed coding scheme on measurement accuracy is explained at the end of the paper.

Keywords: Advanced Orbiting System (AOS), Consultative committee for space data systems (CCSDS), Channel coding, forward error correction (FEC) code, convolutional code, Reed-Solomon code, RSC code, Turbo code, orthogonal spatial division multiplexing, space time codes, spatial modulation, satellite communication.

I. INTRODUCTION

NASA formally initiated the planning and development of a permanently manned space station in the early 1980s.The use of satellite in communication system is very much a fact of everyday in life. This is evidence by the many homes, which are equipped with antennas and dishes. These antennas were used for reception of satellite signal for television. What may not be well known that satellites also form an essential part of communication system worldwide carrying large amount of data, telephone traffic in addition to television *signal*.Satellite communication is widely used in many fields, such as medical treatment, education, maritime affairs, and meteorological forecast [1] and so on.

After four years of intensive work in close cooperation with Space Station Freedom personnel, the CCSDS has recently produced a final Recommendation for the standard protocols to be used for AOS space/ground data communications [2]. Rooted in a robust set of special-purpose space data link protocols, a very flexible repertoire of standard data communication services is provided to user. In addition to fast and efficient mechanisms for flowing high- rate telemetry, video and audio data through the space channels and interactive operations using the standard stack of commercially-supported protocols that exists within the framework of worldwide Open Systems Interconnection (OSI) may be extended into space.

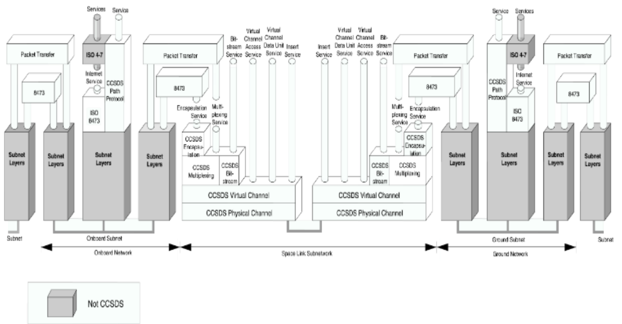

Figure 1. Consultative committee for space data systems (CCSDS) Principal Network Service Model for Advanced orbiting system.

Because of the long distance and the complex environment of AOS communication system, the channel has great randomness (lot of random errors and burst errors). Factors of atmospheric absorption, weather conditions, geographical environment and the moving speed of the ground mobile station will make the electromagnetic wave influenced by reflecting, diffraction, scattering, Doppler frequency shift and all kinds of noises, which led to the deterioration of system performance and that makes it difficult for receiver to recover the correct information [3].

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Channel coding used in AOS can solve this problem to a certain extent. However, with the development of AOS technology, the data types transmitted in AOS system have been diversified, and some of the data requires to be transmitted with high reliability, which cannot be realized by using channel coding only. Therefore, How to improve the transmission reliability of such kinds of data is an important question Among the satellite communication technologies, advanced orbiting systems(AOS) recommendation is an excellent on proposed by Consultative Committee for Space Data Systems(CCSDS) [2].

If we introduce the error control coding (FEC codes) into AOS system, this problem will be solved. Turbo code has strong error correction capability, and its error-correction performance is near the Shannon limit, so the application of Turbo code is extensive in the field of communication. As a result of the “Error Floor” phenomenon, it's hard to decrease the BER (Bit Error Rate) of Turbo code when the BER is smaller than10^{6}. A basic model of channel coding used in a communication system is shown in figure below:

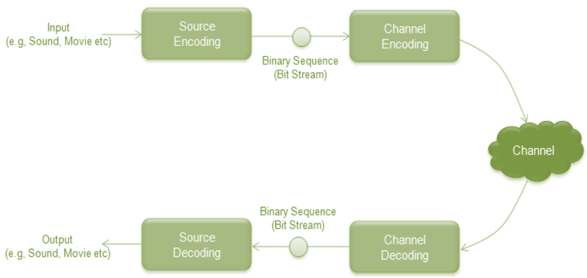

Figure 2. An example of channel coding scheme within a communication system.Channel Coding is a method to replace 'original data bits' with 'some other bits’ (normally longer than the original bits).

AOS is an international protocol introduced by the CCSDS (Consultative Committee for Space Data Systems), which is applied in the data management system of satellite & satellite, satellite & ground. The data packet channel multiplexing is mainly used to improve utilization of the space data channel. For solving this problem of performance improvement, AOS put forward the scheme of RS-Turbo combined code. The near Shannon limit error-correction performance is demonstrated in [4]. The “Error Floor” phenomenon is profoundly analysis in [5]. In [6] and [7], it is proposed that the performance of RS-Turbo code is better than Turbo code.

Unfortunately, the research on RS-Turbo code was mainly focused on the performance comparison simulation, and they didn’t pay more attention to the application performance in AOS, and the impact on the CCSDS system.

In this paper, we introduce the detailed experimentation of RS-Turbo combined code in AOS system and analysis of the impact on measurement accuracy. Firstly, we introduce the implementation procedure of RS-Turbo combined code, than make the quantitative analysis of performance in AOS by the data of software simulation and experimentation, the work starts with random frame generation, that is converted into in to a compact information by using spatial modulation (representing data streams in form of constellation points and antenna number). Finally, the communication is performed using BPSK modulation and we propose the advantages of this hybrid code, especially the advantage in measurement accuracy promotion. The edifying steps of this paper is as follow, the section I shows the basic introduction, background and overview of AOS architecture. Background and related work in this field is discussed in section II, The proposed architecture and system model for the channel coding. Simulation results are presented in section IV and a conclusion and summary is presented in section V.

A. *Background*

In the late 1970s, widespread attention was focused on the problems of space mission data handling. It was observed that the overall scientific return from space was being constrained by very high mission costs and unresponsive service, while technology was forcing the return of massive volumes of space derived telemetry that literally threatened to drown users in data that they could not afford to analyze [9].

A major cause of the data handling problems was the lack of any cohesive set of standards for space data communication; every spacecraft used its own unique set of Time-Division Multiplexed (TDM) telemetry formats and, correspondingly, customized ground data handling systems had to be designed and operated to support each space project. Furthermore, missions always pushed communication links to the limits and (by operating without margin) returned data streams containing a high density of errors. These factors made automation impossible, causing mission costs to be driven up by labor-intensive operation and reliability to suffer.In response to these problems, the concept of packet telemetry emerged as a solution to the standardization issueusing the new techniques of “layering” that were evolving in the late 1970s under the aegis of OSI [10].

B. *An overview of the AOS Architecture*

The standard user services and protocols within the AOS architecture have been fully described elsewhere [11], and this article will therefore only provide a summary overview of the highlights. The AOS architecture models the bidirectional intercommunication of data between spacecraft and their supporting ground networks in terms of an abstract “CCSDs principal Network” (CPN).

The CPN contains three sub networks: an “onboard network” in a space vehicle connected via a CCSDS “Space link Sub network” (SLS) either to a “ground network” or an onboard network in another space vehicle. The SLS is the central component of a CPN, and is where CCSDS specifies the full protocols stack [12]. The onboard and ground networks are assumed to be of commercial derivation, and CCSDS only specifies the mechanisms to traverse them at the network layer and above. The services provided by the CCSDS Principal Network (CPN) are: Frame generators, frame extraction,

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frame buffers, encoding, modulation, channel effects, demodulation, decoding.

In Contrast, the Path service is used for continuously transferring (at data rates ranging from low to ultra-high) large volumes of structured, delimited data units between fairly static source and destination end points. The path service is rooted in a very lean special-purpose CCSDS packet, which contains the minimum necessary on-line protocol in order to provide high speed, throughput, and communication efficiency [13]. A key feature of the SLS is the provision of "virtual channels", which allow one physical space channel to be shared among multiple traffic streams, each having different service requirements. Fixed-length "virtual channel data units" (which are almost identical to the "telemetry transfer frames" used by conventional missions) provide this link-layer protocols.

A high-performance Reed-Solomon block code may be applied to the link-layer protocol data units to provide extremely clean data transfer through the space channels. The selected standard Reed-Solomon code or convolutional code (which is identical to that used in conventional CCSDS systems) is the cornerstone of the new generation of space mission data handling systems. Its performance is so high that it enables virtually error-free data transmission to be achieved from even the furthest reaches of the solar systems. The ramifications of a clean data link are profound, since the capability to achieve error-free transmission makes traditional TDM techniques largely obsolete. Because the incoming data streams can be trusted, automation of the data handling networks is facilitated; by providing uncorrupted data transfer, onboard data compression and preprocessing becomes feasible; and by allowing data sets to be autonomously assembled and labeled by the source, asynchronous data sampling is made possible [14-15].

The key advantages of employing AOS lie in the more reliable performance obtained through *diversity* and the achievable higher data rate through *spatial multiplexing*. The simplest way of achieving variety in the systems is through replication coding that sends the similar info symbol at dissimilar slots of time from dissimilar transmit antennas. A more bandwidth efficient coding scheme is Space time coding, where a block of information symbols are transmitted in the dissimilar order from every antenna.

II. BACKGROUND AND RELATED WORK IN DETAIL

Satellite communication is widely used in many fields, such as medical treatment, education, maritime affairs, and meteorological forecast[1] and so on. AOS is a good technology among all the satellite communication technologies. AOS handles and exchanges data in a standardized way, and it can convey different types of data such as audio, video, science experiments and meteorological data in the space link. At present, AOS is playing a significant role in the field of aerospace communication technology.

With the development of space missions in the past fifty years, the technologies of satellite communications are greatly improved and have been widely used in various industries and fields, such as education, medical system, maritime communications, weather forecasting, aerospace and so on [8-11]. Among the satellite communications technologies, the Advanced Orbiting Systems (AOS) [11] recommendations plays a significant role in modern space missions.

Because of the long distance and the complex environment of AOS communication system, the channel has great randomness. Factors of atmospheric absorption, weather conditions, geographical environment and the moving speed of the ground mobile station will make the electromagnetic wave influenced by reflecting, diffraction, scattering, Doppler frequency shift and all kinds of noises, which led to the deterioration of system performance. Channel coding used in AOS can solve this problem to a certain extent. However, with the development of AOS technology, the data types transmitted in AOS system have been diversified, and some of the data requires to be transmitted with high reliability, which cannot be realized by using channel coding only.

In order to provide a flexible and convenient data processing service, the international Consultative Committee for Space Data System (CCSDS) has developed Advanced Orbiting System (AOS). The CCSDS Recommendation provides video, image and audio transfer [12], and supports asynchronous and synchronous transfer mode. It can transmit many kinds of different type data on a physical channel. AOS provides a convenience for the exchange and processing of information. At the same time, it is compatible with the conventional space data services [13].

In many AOS spatial tasks, specific coding schemes are adopt to meet the requirements of service quality[2]. The protocol specifies three kinds of error correction coding schemes: convolutional code, Turbo code and RS code. Convolutional code is a kind of unblocked code which is more applicable to the Forward Error Correction (FEC). Its performance is better than block code, and the operation on it is relatively simple. The bit error rate (BER) performance of Turbo code is close to the Shannon limit[3], but its computational complexity is higher. RS code is mainly used to deal with burst errors.

Introduced in 1993 by *Berrouet al.* [14], turbo coding is an extremely power efficient error correction technique based on the principles of parallel code concatenation, recursive encoding, non-uniform interleaving and iterative decoding. Simulation results in [14] show that the coding gain of a rate 1/2 turbo code together with BPSK modulation in an additive white Gaussian noise (AWGN) channel can register up to 11 dB, which is within 0.5 dB of the Shannon capacity limit. Per many reports and literature available with respect to near capacity performance, turbo codes have been applied in many new generation communication standards.

For example, it has been available as an option in the DVB-Return Channel Satellite standards [15] and UMTS [16].

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The combined channel coding specified in the current digital video broadcasting by satellite (DVB-S) standard [17] allows the inner convolutional code to employ various rates while the outer code utilizes a shortened Reed-Solomon (RS) code. It is straightforward to replace the 1/2 rate convolutional code by a rate 1/3 turbo code with appropriate puncturing. When a turbo code replaces a convolutional code, a variety of techniques suitable for legacy DVB-S systems should be re-studied. For example,*Valenti* [18] studied the performance of different rate RS codes when a turbo code is inserted into a DVB system, and *Ferraret al.* [19] presented a statistical model that allows analytical evaluation of the performance of turbo code and RS code, which mainly focused on the scheme application to UMTS.

In wireless communication systems, deploying the multiple-input multiple-output (MIMO) concept together with an efficient coding and modulation scheme [20] has been shown to be an effective way to increase link capacity without sacrificing bandwidth. In the case of frequency-nonselective fading channels, space-time (ST) codes [21]have been proposed to explore spatial and temporal diversities that are available in MIMO links. In the case of frequency-selective channels, the MIMO concept has been deployed with orthogonal frequency-division multiplexing (OFDM) modulation, called MIMO-OFDM, to obtain available diversities and combat frequency selectivity of the channels. Various space-frequency (SF) codes and space-time-frequency (STF) codes were proposed for MIMO-OFDM systems [22].

Spatial modulation (SM), an attractive modulation scheme for multi-antenna communications [23], [24], can alleviate the requirement of multiple transmit RF chains in MIMO systems. In SM, the transmitter has multiple transmit antennas but only one transmit RF chain. A lot of recent research has focused on SM and SSK in point-to-point as well as cooperative relaying settings. Bit error performance of SSK and SM in single-user point-to-point communication, Transmit diversity schemes for SM MIMO (i.e., systems that combine SM and space-time coding), Multiuser SM MIMO on the downlink has been analyzed earlier.

III. THE PROPOSED SYSTEM

In this paper, introduce an orthogonal spatial division multiplexing in which divide the central signal streams into both time and frequency. Also to increase the spatial diversity we are going to introduce spatial modulation along with proposed channel coding scheme for the AOS environment.The figure below shows the transmitter side block diagram of AOS configuration.

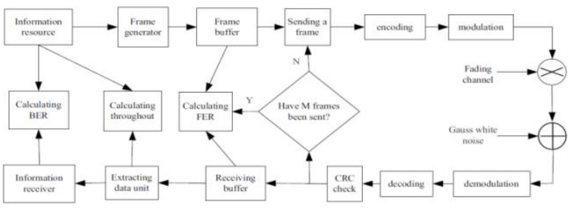

Figure 3. Simulation model of communication system for advanced orbiting system by the CCSDS Principal Network.

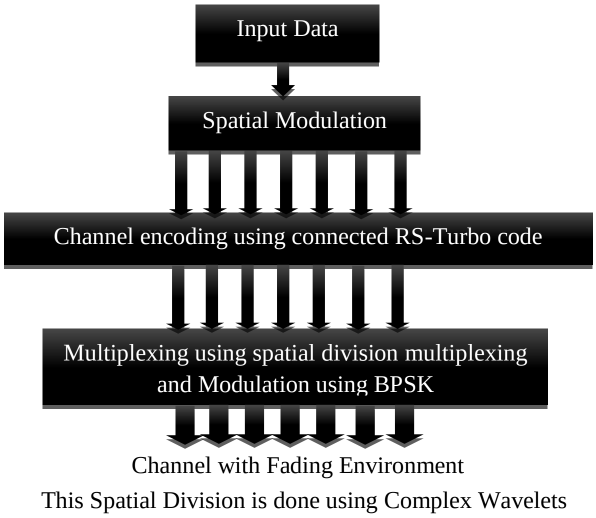

Figure 4. Shows the transmitter side model of proposed work, we have to send only constellation points with respect to antenna number.

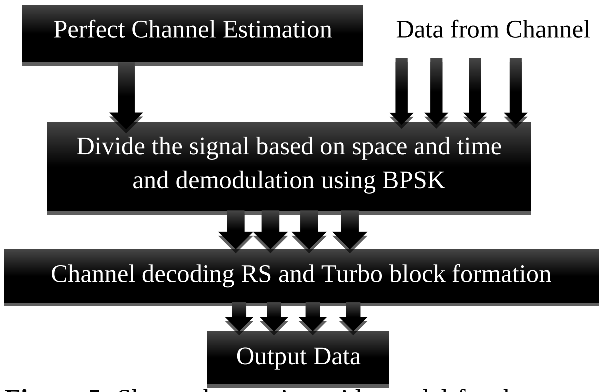

Figure 5. Shows the receiver side model for the proposed work. Perfect channel estimation is done to find best suited channel. Also, Channel consist with Rayleigh Fading Environment.

Additionally, this chapter also explains a detailed view of technologies used in the proposed work as follow:

A. Spatial Modulation

Spatial modulation (SM) is a recently developed transmission technique that uses multiple antennas. The basic idea is to map a block of information bits to two information carrying units:

1. A symbol that was chosen from a constellation diagram.
2. A unique transmit antenna number that was chosen from a set of transmit antennas.

The use of the transmit antenna number as an information-bearing unit increases the overall spectral efficiency by the base-two logarithm of the number of transmit antennas. At the receiver, a maximum receive ratio combining algorithm is used to retrieve the transmitted block of information bits. Here, we apply SM to proposed data transmission scheme.

In SM, a block of any number of information bits is mapped into a constellation point in the signal domain and a constellation point in the spatial domain. At each time instant, only one transmit antenna of the set will be active.

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The other antennas will transmit zero power. Therefore, ICI at the receiver and the need to synchronize the transmit antennas are completely avoided. At the receiver, maximum receive ratio combining (MRRC) is used to estimate the transmit antenna number, after which the transmitted symbol is estimated.

B. Transceiver of proposed system

The digital data if first up-converted by a BPSK modulation scheme and then the symbols are put into parallel streams that the CWT (complex wavelet transform) block is going to work on. After ICWT is taken an appropriately sized cyclic prefix is appended at the end of the signal. Finally, the signal is sent into the channel. This channel is either the AWGN or the flat fading Rayleigh channel. At the receiver the first task is to remove the cyclic prefix and then apply CWT. Afterwards, the parallel streams are serialized and then the symbols put through the demodulator for obtaining the input source data.

Once the cyclic prefix is removed taking ICWT of the signal is equivalent to multiplying the constellation points by sinusoids whose frequencies are equal to the frequency of a carrier signal and then summing these products.Space time coding is performed in both spatial and temporal domain introducing redundancy between signals transmitted from various antennas at various time periods. It can achieve transmit diversity and antenna gain over spatially uncoded systems without sacrificing bandwidth.

C. Design and implementation of RS code

RS code, proposed by Reed and Solomon in 1960, is one of the most important and widely used non-binary BCH code. It has strong correction ability on random errors. RS truncation code is a new kind of RS code. For the proper code length, it truncated the information bits symbol based on RS complete code. The errors correction ability of RS truncation code is stronger than RS complete code. RS codes are widely used in communication systems and data storage systems for error control.

Select $RS(255, 249)$ truncation code on $GF(2^5)$ as AOS code standard, error correction capability is t=2, the derivation of RS coding principle is as follows: Assume the primitive polynomial is (1).

$$p(x) = x^4 + x + 1 \quad (1)$$

Define α as the primitive element of this primitive polynomial, so the generator polynomial is (2).

$$g(x) = (x + a)(x + a^2)(x + a^3)(x + a^4) = x^4 + a^{13}x^3 + a^6x^2 + a^3x + a^{10} \quad (2)$$

The message bytes $\in GF(2^4)$, define:

$$m = (m_0, m_1, m_2, m_3), m_i \in GF(2), 0 \le i \le 3$$
$$S(\alpha) = m_0 + m_1\alpha + m_2\alpha^2 + m_3\alpha^3 \quad (3)$$

Multiply the coefficients of $g(x)$by $S(\alpha)$.

$$\alpha^{10} \cdot S(\alpha) = (m_0 + m_2 + m_3) + (m_0 + m_1 + m_2)\alpha + (m_0 + m_1 + m_2 + m_3)\alpha^2 + (m_1 + m_2 + m_3)\alpha^3 \quad (4)$$

$$\alpha^3 \cdot S(\alpha) = m_1 + (m_1 + m_2)\alpha + (m_2 + m_3)\alpha^2 + (m_0 + m_3)\alpha^3 \quad (5)$$

$$\alpha^6 \cdot S(\alpha) = (m_1 + m_2) + (m_1 + m_3)\alpha + (m_0 + m_2)\alpha^2 + (m_0 + m_1 + m_3)\alpha^3 \quad \ldots (6)$$

$$\alpha^{13} \cdot S(\alpha) = (m_0 + m_1 + m_2) + m_3\alpha + m_0\alpha^2 + (m_0 + m_1)\alpha^3 \quad (7)$$

Then we get the diagram of RS code, as shown in Fig. 6.

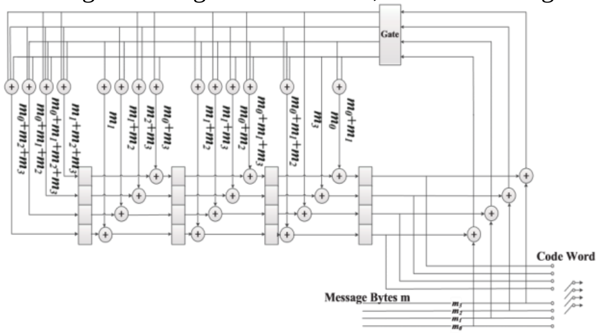

Figure 6. Trackillustration of Reed-Solomon encoding

D. Design and implementation of Turbo code

In 1993, $C.Berrou$ proposed the concept of Turbo code. It has the characteristics of random-like code. The most important characteristic is the near Shannon limit performance and the excellent performance curve. With the strong ability of anti-jamming and anti-fading in high-noise environments, Turbo code has a wide range of applications on Aerospace, mobile communications, and many other aspects.

Select RSC(2, 1, 4) encoder, code rate is 1/3, interleave length is L=8160, interleave depth is I=4 (3GPP project), the principle structure of Turbo encoding and decoding is shown in Fig. 7.

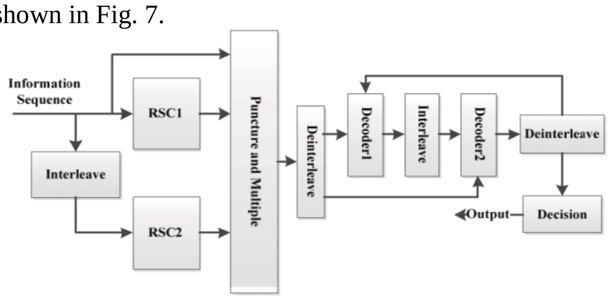

Figure 7. Standardconfiguration of Turbo encoding and decoding

Because of the weakness of burst errors correction, we introduce the interleavers into encoding process. The interleavers could make weight of codeword having random properties. The burst errors are evenly distributed to different codeword, so the burst errors become errors with relative independence. In this way, we can improve the weak performance of convolutional code on burst-error correction. As shown in Fig. 7, information sequence after the interleavers and original information sequence both encode by the RSC encoder, then the multiplexer puncture the sequence output by RSC encoder. Here we complete the Turbo encoding process.

In decoding process, we adopt SISO (Soft Input Soft Output) iterative decoding method and Log-MAP algorithm. As shown in Fig. 7, the sequence after deinterleaved is decoded by decoder 1, then we put the soft decision of decoder 1 into interleavers. The soft

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decision is used as prior information for the 2th decoding. When the decoder 2 received interleaved prior information, it begins the 2th decoding.

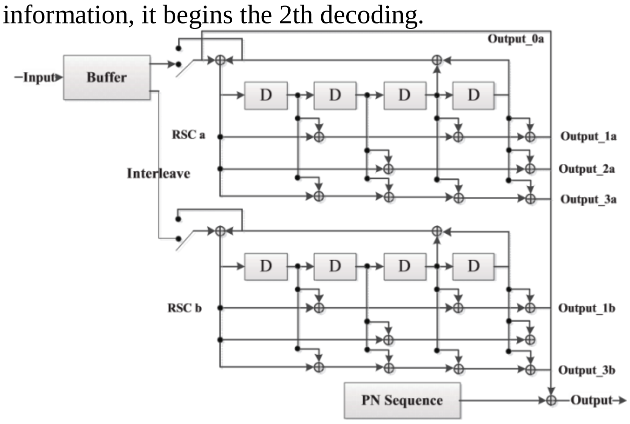

Figure 8. Track illustration of Turbo encodingIn Fig. 3, “D” represents shift register, "⊕" represents XOR. The RSC encoders output codeword sequentially from “Output_0a” to “Output_3b”.

The decoder 2 output is soft decision, after deinterleaved, we put it as feedback back into decoder 1 for next round decoding. After several rounds iterative decoding, the hard-decision outputs recovery sequence. Here complete the whole Turbo decoding process.We design the Turbo coding circuit diagram (see Fig. 8), particularly, there is pseudo-randomization disposal after encoding. The receiver could better capture, track and synchronize with the signal. Specifically, use the PN sequence to do XOR with Turbo code sequence.

E. Design and implementation of RS-Turbo code

In 1970s, Forney proposed the scalable coding scheme, which was called combined code later. It mainly used multiple short codes combined to form long code in coding process, and used multilevel decoding in decoding process for realizing multilevel error-correction. As the minimum distance of Turbo code is small, performance curve becomes flat when the BER is smaller than10^{-5} , this phenomenon is called “Error Floor”. The reasons for this phenomenon could mainly attribute to following two aspects: the few error in low-weight codeword caused by residual error; the instability of iterative decoding process. However, the RS code has very strong capabilities of error correction on random and burst errors. So we can join the RS code and the Turbo code to improve the “Error Floor” phenomenon, and improve the code performance on the premise of complexity control. In this paper, we choose Turbo code as the internal code, and choose RS code as the outer code. Having implemented RS code and Turbo code encoder, we could just join them, as shown in Fig. 9, then we get the RS-Turbo code encoder.

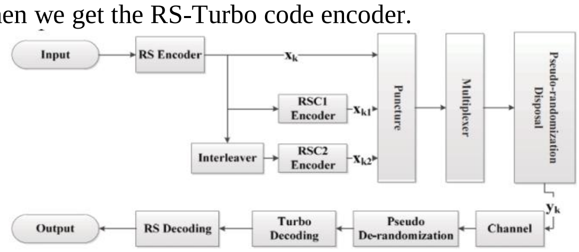

Figure 9. Principle structure of RS-Turbo code

IV. RESULTS & DISCUSSION

In this section we will be presenting the link level performance of SM coded spatially multiplexed by RS-Turbo channel coding scheme using either BPSK or QPSK modulation. All simulations have been carried out using the readily available MATLAB platform R2013b (Version 8.2.0.703), a graphical user interface is created for the simulation of proposed work on developing coding scheme for advanced orbiting system and writing dedicated functions for different parts. The simulation results obtained have been presented in four parts. The first part provides the bit error rate performance for BPSK modulated data transmitted over a Rayleigh fading channel.

Primarily, construct telemetry and measurement frame reference from AOS. Secondly, then we send the frame modulated by BPSK into simulated space channel. Finally, after the receiver demodulated and decoded the signal, the BER and FER (Frame Error Rate) statistical results. The receiver used RS iterative hard decision decoding and Turbo iterative decoding with Log-MAP algorithm.
It is proved that, the bit error rate is decreased. On the other hand the consideration of this gain is the higher decoding complexity and increasing iterative decoding delay.

The above simulation and experiment results consistently showed that the RS-Turbo combined code has a higher coding gain than convolutional or Turbo code. This is because the RS code can provide high reliability iteration stop condition. After the Turbo decoding, if the code error is smaller than *t* bits, the RS code is able to fully correct the error. In this way, it does not only reduce the number of Turbo decoding iteration, but also reduce the FER and BER. According to the relevant experiment results, the FER of RS-Turbo code can be reduced by about 100 times.

The packet forwarding delay in satellite would decrease by the reduction of the encoding and decoding delay, according to the pseudo code ranging principle, the ranging error would also decrease by the reduction of packet forwarding delay in satellite, so we could discover that the ranging variance of the RS-Turbo combined code. In summary, on the precondition of same coding gain, RS-Turbo combined code is better than Turbo code and convolution code on the aspects of complexity costs and iterative decoding stability. RS-Turbo combined code is also more to meet the needs of efficient and short decoding delay in AOS, and could obtain the smaller random error, thus improve measurement accuracy.

A. Error Pattern and Statistics

Error patterns of turbo codes have been theoretically and pragmatically studied. Based on our simulation results, it can be further concluded that when a larger number of errors occur in one turbo block (or turbo frame, which makes no difference in this paper), the error positions are roughly uniformly distributed in the block.

Fortunately, it seems that this error probability decreases with the increase of SNR. In conclusion,the error pattern

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of turbo code at some SNR can be roughlymodelled as follows:

- The frame error distribution can be modelled as Bernoulli distributed with simulated frame error rate (FER).
- Inside an erroneous frame, bit error number follows a distribution while erroneous bits are uniformly distributed in the frame.

The analytical expression for the BER for BPSK modulated data in a Rayleigh fading channel is

$$P_b = 0.5\left(1 - \sqrt{\frac{E_b/N_0}{(E_b/N_0)+1}}\right)$$

And for the AWGN channel $P_b$is defined as:

$$P_b = 0.5\, erfc\left(\sqrt{\frac{E_b}{N_0}}\right)$$

B. *Numerical and Graphical Validation*

This section will provide BER analysis for proposed system over slow fading channels.

The BER curve is shown in Figure below. From Figure we can see that the BER gradually decreases with the increasing of interleave length. But the increasing of interleave length will make the decoding complexity and decoding delay increase. So the interleave length should be appropriate.

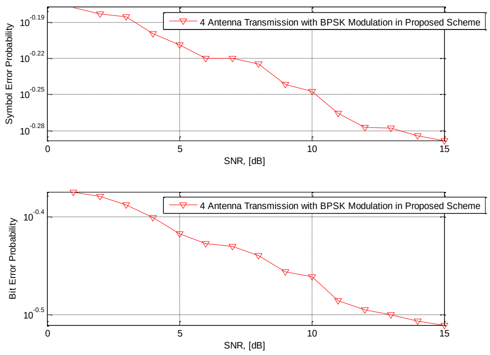

Figure 10. Shows the bit error probability and symbol error probability with respect to signal to noise ratio for the proposed scheme under BPSK modulation and Rayleigh fading environment.

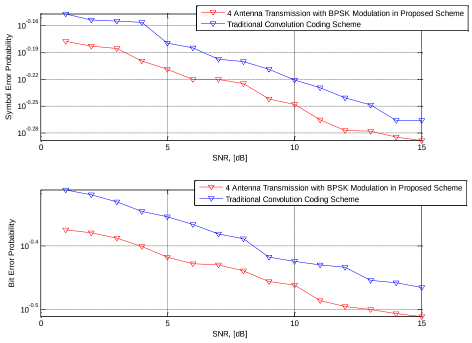

Figure 11. Shows the bit error probability and symbol error probability with respect to signal to noise ratio for the proposed scheme and traditional scheme proposed by [25] under BPSK modulation and Rayleigh fading environment.

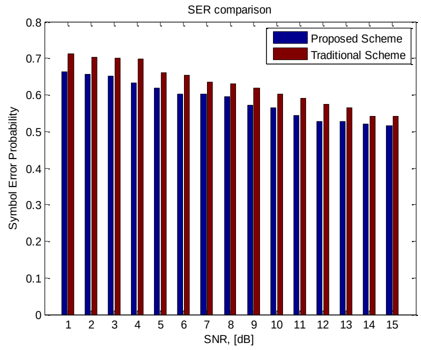

Figure 12. Shows the bar plot for symbol error probability (errors in received decimal data) with respect to signal to noise ratio for the proposed scheme and traditional scheme proposed by [25] under BPSK modulation and Rayleigh fading environment.

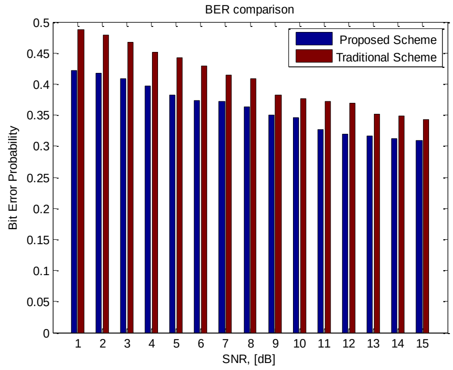

Figure 13. Shows the bar plot forbit error probability (errors in received digital/binary data) with respect to signal to noise ratio for the proposed scheme and traditional scheme proposed by [25] under BPSK modulation and Rayleigh fading environment.

TABLE I: SER COMPARISON OF PROPOSED SCHEME AND SCHEME PROPOSED BY [25]

SNR	SER (traditional) [25]	SER (Proposed)
1	0.713200000000000	0.664200000000000
2	0.702100000000000	0.656100000000000
3	0.699800000000000	0.652100000000000
4	0.697600000000000	0.631800000000000
5	0.661500000000000	0.617800000000000
6	0.653300000000000	0.602700000000000
7	0.634200000000000	0.602100000000000
8	0.630600000000000	0.596000000000000
9	0.618700000000000	0.573000000000000
10	0.601300000000000	0.565300000000000

TABLE II: BER COMPARISON OF PROPOSED SCHEME AND SCHEME PROPOSED BY [25]

SNR	BER (traditional) [25]	BER (Proposed)
1	0.487510000000000	0.421900000000000
2	0.479150000000000	0.417200000000000

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3	0.466870000000000	0.409200000000000
4	0.451020000000000	0.397400000000000
5	0.442350000000000	0.382300000000000
6	0.429740000000000	0.373400000000000
7	0.415170000000000	0.371350000000000
8	0.408820000000000	0.363550000000000
9	0.381890000000000	0.349850000000000
10	0.376790000000000	0.345950000000000

V. CONCLUSION& DISCUSSION

In this paper, we have throughsupplementary research on the RS-Turbo code in AOS under Spatial modulation and spatial division multiplexed channel path in which signal is divided into space and time, and profoundly analysed the structure and performance of the RS-Turbo code under fading environment, eventually we sent it into space transmission channel for simulation and experiment. The software simulation and experiment results unswervingly showed that the proposed code has the sophisticated coding gain, more stable iterative decoding andsmaller complexity costs than convolutional code and Turbo code. Furthermore, the shorter encoding and decoding processing delay is possible to diminish the random errors in ranging process, and further to mend the measurement accuracy.

It can be perceived from the simulation that the error correcting enactment of Turbo code is value-addedcongruently with the increasing of connection vector length, interleave length and iteration times. But at the same time, the complexity and time delay of decoding upsurge, consequently parameters must be selected appropriately. Compared with convolutional code, the BER and FER are lower. So anticipatedcode is a better channel coding scheme than convolutional code in AOS.Following the development of a system conceptfor future wide-area macrocellular wireless and satellite networks,a prototype has been built to evaluate itsfeasibility and investigate the implementation ofthis technologies. This prototypehas been used to evaluate performance in differentconditions typical of macro-cellular wirelessand satellite networks.

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