

# Energy Efficient Low Complexity I-MRC Detection of SM-OFDM Systems in the Presence of AWGN Channel

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**ABSTRACT** Spatial modulation is a recently proposed and developed technique to exploit the spectrum efficiency of multiple-input multiple-output system, reducing the decoding complexity and increase spectrum efficiency as compared with MIMO system. By using an proper combination of number of transmit antenna ( $N_t$ ) and number of transmit RF chains ( $n_{rf}$ ), SM may achieve superior output and bit error rate (BER). the SM system gains advantages in various aspects such as receiver complexity, hardware implementation, energy efficiency, etc. In this paper, a low complexity detection scheme is projected to lessen the complexity of detection in spatial modulation orthogonal frequency division multiplexing (SM-OFDM) systems. specially, the projected scheme employs a novel maximal ratio combining iterative detector to the SM-OFDM systems with AWGN channels. Simulation results demonstrate that the proposed scheme is capable of effective detection and of providing about considerable system performance with low complexity compared to the conventional parallel interference cancellation (PIC)-aided maximum likelihood (ML) detector and ss detection at a moderate cost.

**KEYWORDS:** Spatial modulation (SM), BER, SNR, OFDM (Orthogonal Frequency Division Multiplexing), MRC (maximal ratio combining).

## I INTRODUCTION

In a typical SM-MIMO system, only one transmit antenna is activated in each symbol slot, and an amplitude-phase modulated (APM) symbol is emitted from the activated transmit antenna. Therefore, the information transmitted through the SM-MIMO system is both conveyed by the APM symbol and the index of the activated TA, which is regarded as the space domain symbols. Compared with the conventional spatial multiplexing and space-time block coding (STBC) MIMO systems, It is more elegant because it is able to work with less number of transmit radio frequency chains compared to old spatial multiplexing. The main challenge faced by wireless communication systems is to provide high-data-rate wireless access at high quality of service and energy efficiency. but the fact is that spectrum is a not enough resource and propagation conditions are uncongenial due to fading (caused by destructive addition of multipath components) and interference from other users, this calls for means to radically increase spectral efficiency and to improve link reliability. MIMO and special modulation are the technology used today to increase the spectrum efficiency and to reduce the complexity of the system special multiplexing is more spectral efficient technology. Multiple-antenna wireless communication systems have turn into accepted due to their advantages of high throughput and improved trustworthiness and the SM system is one of that.

In SM-OFDM antenna activation process is used so no more radio frequency channels are required as in MIMO-OFDM so we can say that SM-OFDM is a special type of MIMO-OFDM system. As in ofdm scheme the digital data is transmitted on multiple carrier frequencies i.e. large number of closely spaced orthogonal subcarrier are used to carry data. OFDM is a symbol technique and it is FFT based. It is fast technique support wideband and MIMO system. But it has some weakness also as power consumption is high, noisy and carrier frequency offsets etc. Carrier frequency offsets is the biggest problem which cannot be eliminated but can be reduce upto some extent

## II. BACKGROUND AND LITERATURE SURVEY

Spatial modulation (SM) is a comparatively recent modulation scheme for multiple antenna wireless communications. It is pretty attractive because of its capability to work with less number of transmit RF chains as compared to usual spatial multiplexing. By using an optimal combination of number of transmit antennas ( $N_t$ ) and number of transmit RF chains ( $N_{rf}$ ), SM can attain better throughput and bit error rate (BER) than spatial multiplexing. The percentage savings in the number of transmit RF chains with the percentage increase in the rate achieved in SM compared to spatial multiplexing is nearly 18.75% savings in number of RF chains and 9.375% increase in rate are possible with 16 transmit antennas and 4-QAM modulation

Abdelhamid Younis Nikola Serafimovski, Raed Mesleh, and Harald Haas In this paper, a generalised procedure for spatial modulation (SM) is offered. Generalised spatial modulation (SM) overcomes in a new fashion the constraint in SM that the number of transmit antennas are in a power of two. In SM, a block of information bits is mapped to a constellation symbol and a spatial symbol. The spatial symbol is a grouping of transmit antennas activated at every instance of time.

Yan zhao Yue Xiao , Binhong Dong , Ping Yang , Lixia Xiao , Wei Xiang [2] perform the work on carrier frequency offset in spatial modulated signal (SM-OFDM). As we know that the main problem in the detection of OFDM signal is carrier frequency offset in this paper symbol by symbol detection method is used and it is compared with PIC and ML detector and in all the method BER and SNR is calculated

Marc Chang-Yi Yan , Yu-Li Chen Hai-Yan Song [3] work on carrier frequency offset (CFO) and channel estimation. Which is very important for multi-input multi- output orthogonal frequency division multiplexing (MIMO- OFDM) wireless communication systems. In this paper, the problems of CFO and channel estimation are considered. An adaptive estimation algorithm is proposed. In this paper CFO and channel parameters estimate at the same time.

N. Serafimovski, A. Younis, R. Mesleh, P. Chambers, M. Di Renzo, C.-X. Wang, P. M. Grant, M. A. Beach, and H. Haas [4] In this paper the practical implementation of spatial modulation is done. Also the comparison between MIMO-OFDM and SM-OFDM is done. In this paper the complexity between two is shown. In this paper is shown that how channel capacity can be increase by spatial multiplexing and how the system can be make more energy efficient . Also the practical implementation of transmitter and receiver is performed

Spatial Modulation for Multiple–Antenna Wireless Systems – A Survey Marco Di Renzo, Member, IEEE, Harald Haas, Member, IEEE, and Peter M. Grant, Fellow, IEEE [2] In this paper the spatial modulation is discussed and it is compared with the SISO system and it is shown that the complexity of SM is less then MIMO system.

Lixia Xiao, Ping Yang Yue Xiao Shiwen Fan Marco Di Renzo, Efficient Compressive Sensing Detectors for Generalized Spatial Modulation Systems is considered in this paper, low-complexity and compressive sensing (CS) based detectors for SM systems are projected. Firstly, an addition of the normalized CS detector (E-NCS) based on the orthogonal matching pursuit (OMP) algorithm is projected, which is shown to be suitable for large- scale SM implementations due to its low complexity. Furthermore, in order to reduce the error floor effect of the E-NCS detector, two efficient CS (ECS) detectors based on the OMP algorithm are considered with the present threshold.

## III System Model

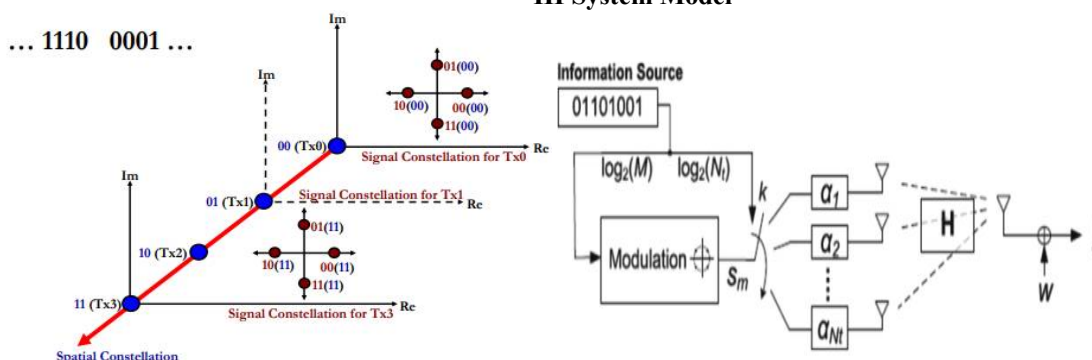


Figure 1

SM predict the activation of a single antenna, at each time instance that transmits a given data symbol (constellation symbol), and the utilization of the spatial position (index) of the active antenna as an added dimension for data

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transmission (spatial symbol). Both the constellation symbol and the spatial symbol depend on the incoming data bits, which is to be transmitted.

The exceptional three dimensional constellation diagram for SM is shown below. The first two bits, in the four bit word term the spatial-constellation point identifies that which antenna is active. The last two bits determine the signal constellation point that is to be transmitted i.e. signal to be transmitted

The information bit stream is divided into vectors containing  $M_{all} = \log_2(M \cdot N_t)$  bits each.

## BLOCK DIAGRAM OF SM TRANSMITER

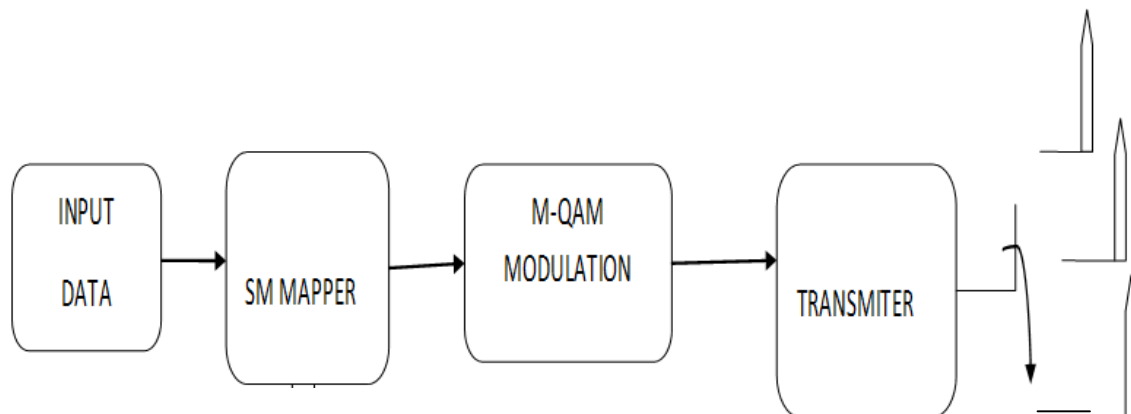


Figure 2

- ❖ Each vector is further split into two sub-vectors of  $\log_2(N_t)$  and  $\log_2(M)$  bits each. The bits in the first sub-vector are used for activating a unique TA for transmission, while the bits in the second sub-vector are mapped to an APM symbol  $s_n^l$ . Note that the TA activation process can be described by the  $N_t$ -dimensional standard basis vector  $e_n$  ( $1 \leq n \leq N_t$ ) (i.e.,  $e_1 = [1, 0, \dots, 0]^T$ )

Finally, the transmitted symbol  $x$  is comprised of the APM symbol  $s_n^l$  emitted from the activated TA  $n$ . The resultant modulated symbol can be formulated as

The corresponding vector-based signal received at the SM-MIMO receiver is given by

$$y = Hx + n = h_n s_n^l + n,$$

where  $H$  is an  $(N_r \times N_t)$ -element channel matrix,  $h_n$  is the  $n$ th column of  $H$  and the elements of the  $N_r$ -dimensional noise vector  $n$  are complex Gaussian random variables obeying  $CN(0, N_0)$ .

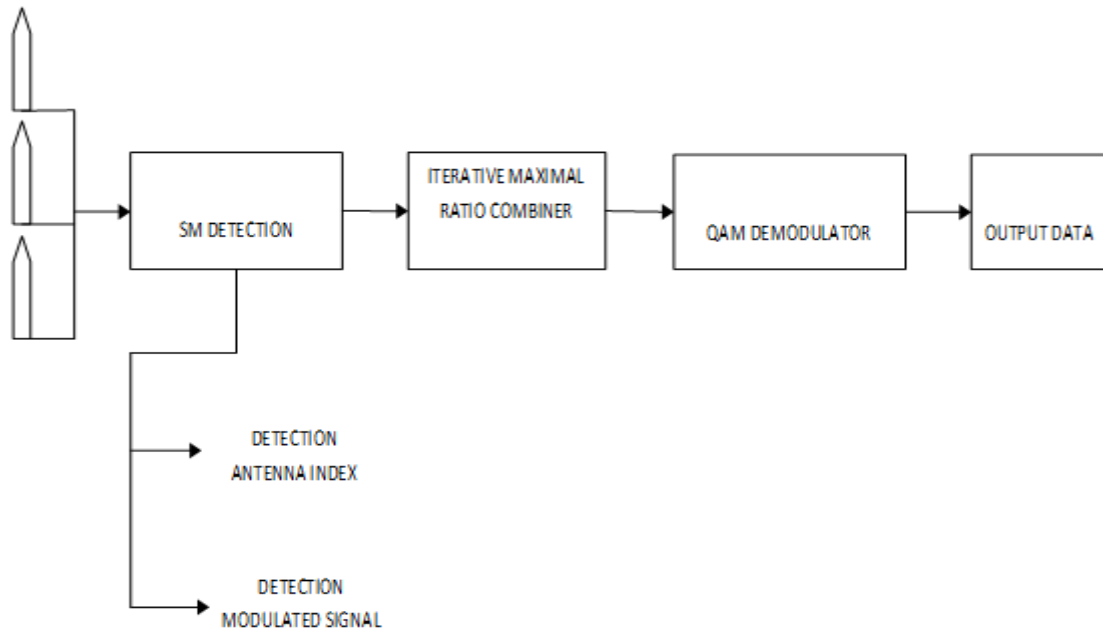
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**BLOCK DIAGRAM OF SM RECEIVER**



**Figure 3**

SM-OFDM maps the incoming bits per subchannel to a grouping of transmit antenna and transmit symbol number. The transmission is only carried out at the particular antenna and no transmission is done at the other antennas for that exacting subchannel and time instant. The receiver guesses the transmit antenna number and the received symbol and uses these two information to de-map the transmitted binary data block back

## IV. PROPOSED DETECTION

For the detection of SM-OFDM signal we have used a low complexity method although this method will not give the best ber and signal to noise ratio but it is useful in the environment where we need less costly low efficient signal. we have taken a rayleigh fading channel in the presence of AWGN channel with zero mean and  $\sigma^2$  variance. The proposed demodulator for SM is based on a two-step approach that is

- ❖ Detection of the antenna index (spatial-constellation diagram)
- ❖ Detection of the modulated symbol (signal constellation diagram)

Stage 1-in the first step the general sm-ofdm model is taken to transmit the M bit QAM symbol. No. of bits transmitted in each time slot is given by.

$$B = \log_2(Mt) + \log_2(M)$$

Stage 2-For detection mainly two steps are applied

- Signal is passed through rayleigh fading channel and AWGN noise is added with zero mean and  $\sigma^2$  variance
  - The weight function is the diagonal matrix which is square of channel matrix.
  - In first phase the information-conveying feature of SM-OFDM is exploited to simplify the design.
- Stage 3
- We have used iterative maximal ratio combiner, for that we have used two cases for demodulation that is signal is passed by two different operators which have different characteristics of weighting.
  - After that the absolute value is calculated.
  - For that value BER is calculated.

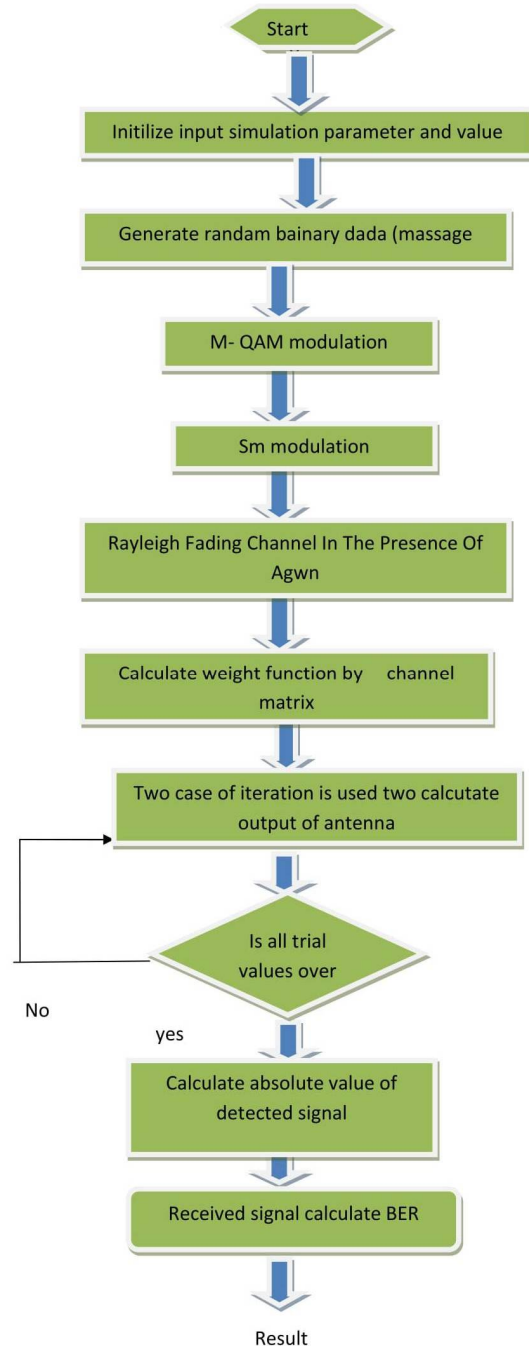
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End  
This is the signal.  
Now calculate the BER and SNR of the detected signal  
Flow diagram of simulation



## V. SIMULATION RESULTS

In this section, we evaluate the performance of the proposed detector. For the simulation process we have used MATLAB simulator where we have  $M_T = 2, 4, 8, 16$  QAM modulation.  $M_R = 2, 4, 8, 16$  QAM modulation. 32 QAM

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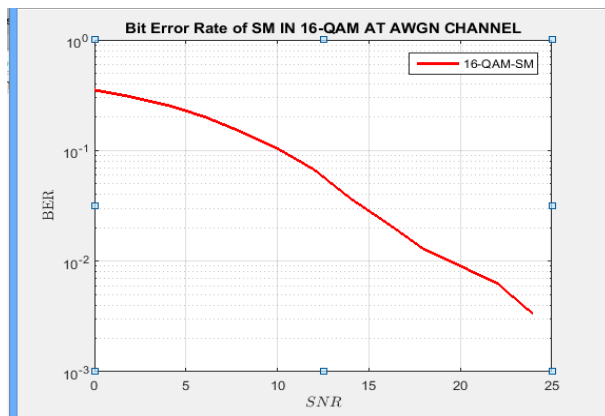
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modulation. All these we have analyse the performance of the I-MRC detector. In our simulation results, the bit error rate (BER) vs signal to noise ratio(SNR) performance of the i-MRC detector with CFOs is denoted. Furthermore, the modulated symbols are transmitted over AWGN channel with zero mean and  $\sigma^2$  variance. signal to noise ratio(SNR) is varried from 1 to 24, 1 to 42, in turns of 1 and 2 to give better result and anylise the results in different valuse.

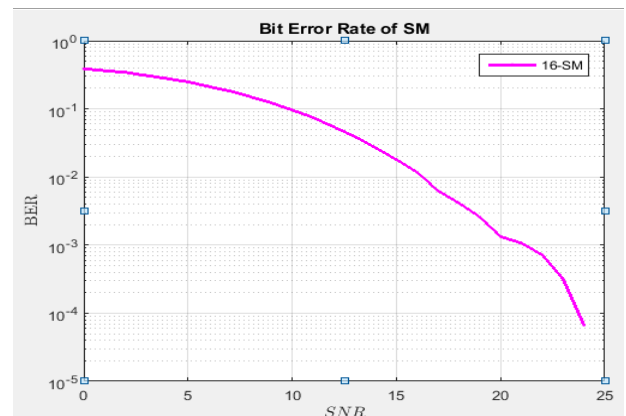
### Performance Analysis

Figs. 4,5,6 and 7 plot the achievable BER of the proposed detection method, which shows that the BER of the simplified design is defferent for different detection scheams.

For the fig.4 we have calculated the ber and snr ratio for 16-QAM with 2 transmit antenna and 2 receiver antennas the graph shows that it has bit error probability = 0.003920



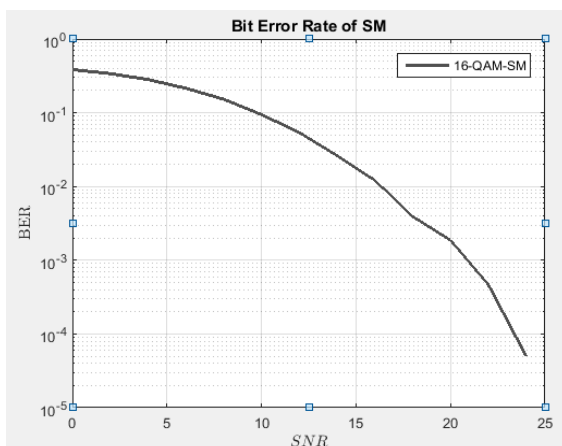
**Figure 4**



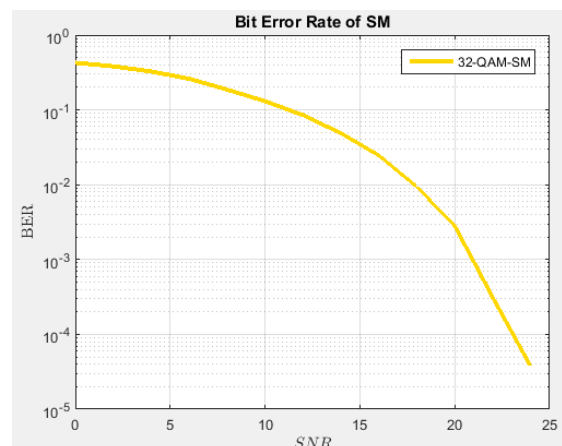
**Figure 5**

For the fig.5 we have calculated the ber and snr ratio for 16-QAM with 4 transmit antenna and 4 receiver antennas the graph shows that it has bit error probability = 0.000067 which is less as compar to fig 1

For the fig.6 we have calculated the ber and snr ratio for 16-QAM with 4 transmit antenna and 4 receiver antennas with the steps of 2 the graph shows that it has bit error probability = 0.000050. which is less so we can use this combinatin which have less complexity and good BER



**Figure 6**



**Figure 7**

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For the fig.7 we have calculated the ber and snr ratio for 32-QAM with 8 transmit antenna and 8 receiver antennas with the steps of 2 the graph shows that it has bit error probability = 0.000037. it is less as compare to other three methods but the complexity of the system increases by increasing the number of nt and nr also by using 32QAM modulation which is not efficient for our detection method so we can use 16-QAM with 4 nt and 4 nr system which will give best result in both ber and complexity

## VI. CONCLUSION AND FUTURE WORK

Spatial modulation is a new modulation technique for multi-antenna wireless communications system. It is more elegant because it is able to work with less number of transmit radio frequency chains compared to old MIMO. By using an proper combination of number of transmit antenna ( $N_t$ ) and number of transmit RF chains ( $n_{rf}$ ), SM may achieve superior output and bit error rate (BER) as compared to MIMO. we know that the savings percentage of number of transmit RF chains as well as the percentage increase in the rate achieved in SM compared to spatial multiplexing just about 19% in number of RF chains and 10% increase in rate are possible with 16 transmit antennas and 4-QAM modulation. A constriction, is the complexity of maximum-likelihood detection of SM signals, specially in large MIMO systems where the number of antennas is huge.

This letter projected an efficient soft iterative detection scheme, where a symbol-by-symbol concept was used by i-MRC idea and the zero constellation point in SM systems has been considered in the design process. Our simulation results explain that the proposed iterative detector is pretty good for SM-OFDM systems. Our future work will focus on the integration of the proposed detector with more complex detector to mitigate the multiple CFO in the system for better result we will use a PSO (particle swarm optimization) for the iteration process to choose best value of iteration for SS detection process.

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