Reconfigurable Design of Hybrid MIMO Detection Scheme for Spatially Multiplexed MIMO System

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Research Article

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Reconfigurable Design of Hybrid MIMO Detection scheme for Spatially Multiplexed MIMO System

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Abstract

In recent years, Multiple Input- Multiple Output (MIMO) has been used to expand data transfer for ensuring consistency. The transmitter and receiver use several antennas and they can achieve high spectral characteristics. However, as the numbers of users and antennas increase rapidly, the complexity of the system increases and it becomes a major problem in many detection systems. It is important to develop sophisticated components to improve compliance with many standards without compromising Bit Error Rate (BER) performance of the components. The proposed work introduces a New Hybrid MIMO Detector (NHMD), which provides the solution for the complicated design procedure. In this proposed method an Optimal Differential Evolution (ODE) algorithm has been designed to select multiple detection detectors. In addition, this method uses a parallel processing to reduce the amount of arithmetic logic. The proposed NHMD method is implemented for cylindrical devices belonging to different FPGA families with different antenna configurations (2 × 2, 4 × 4). The proposed NHMD method provides superior quality by combining multiple detectors. The simulation results confirm that the NHMD method uses low equipment as well as low power consumption and provides high efficiency without affecting BER performance.

Keywords- hybrid detection, zero-force, minimum mean square error, K-best, MIMO, ODE algorithm

1. Introduction

Multiple Input- Multiple Output (MIMO) technology shows high data rates with improved spectral properties [1] & [2]. The performance of a MIMO system is directly related to antenna interference, numerical reference coefficient, signal characteristics, and configuration obtained from multipath channels and some MIMO's receive antennas may provide low SINR for wireless channels. They are often used together, when the main direction of radiation changes. MIMO has several antennas and they can be used for broadcast and reception simultaneously. MIMO has the advantage of having many antennas and advanced signal processing technologies [3]. Using this technology, a large number of data streams can be transmitted or received independently via MIMO antennas [4]. The main problem with MIMO technology is interference from neighboring antennas. Most MIMO programs are designed to achieve advantages of using systems such as spatial multiplexing and spatial diversity [5]. With MIMO, the balance between the spectrum benefits and the diversity benefits can be trusted. However, none of them supports the practical basis for achieving the optimal compromise between the spatial multiplexing and the differential amplification [6]. The combined advantage of spatial multiplexing and differentiation has long been recognized as hybrid sound. As for the Bit Error Rate (BER) or the Symbol Error Index (SER), the data transfer rate can be significantly increased while maintaining a satisfactory connection [8].

Low complexity, low power consumption, high performance, high-performance hardware and operating systems are the main problems of MIMO hybrid sound [9] - [12]. Recently, several structures have been proposed to solve the problem of introducing various transactions between complexity and efficiency. Of these, Maximum Likelihood detection (ML) [13] is the most suitable detection method, and as the number of antennas increases and complexity increases, BER decreases in the overall search. On the other hand, nonlinear detectors do not have serious problems without the classification of Minimum Mean Square Error (MINIMUM MEAN SQUARED ERROR (MMSE)) [13] - [15]. When searching for advanced priority methods, the previous decoder prioritizes the nodes and node paths in the original stream [16]. On the other hand, a first scheme, such as the K-Best Detector [17], suggests that a certain number of candidates should move on to the next step. The initial method of preventing node expansion uses a detection mechanism in Q-Best cluster based decoder to maintain maximum probabilistic performance [18]. For example, secondary amplitude modulation has been selected for 64-QAM. That is, the value of the k-star is about 4 times higher and as a result, the linear increase is less [19]. This includes significant delays in start, antenna values and sizes. In the proposed system, Structural placement that is distributed K best and Subsequent Interference Compression (SIC) technique has been used to reduce the computational problems and for further enhancement, Novel Hybrid MIMO detection (NHMD) has been introduced to compromise both the system complexity and hardware design challenges. The main aim of NHMD method is to implement efficient hardware design in terms of complex-less hybrid MIMO detection with less hardware and better BER performance. Edward et al. [31] have presented a tree-search based modified K-best algorithm and hardware structure for spatially multiplexed wireless MIMO system. An updated method corrects the current method to determine the best queue with root size distribution problems. The addition of wood at all levels reduces equipment problems and improves structural performance in accordance with LTE-A standards. The revised Q-Best algorithm reduces the path metric calculations of various antenna configurations. It can be added multiple times to change the number of amplifiers in order to improve area and power which increases the device performance by 24%. Currently, polyamide (NP: Non-deterministic Polynomial) is a non-NP polynomial problem that can be accurately detected in MIMO systems whereas, it is difficult to detect because, MIMO is not compatible with many antennas.

The MIMO system evolved into the new Horizons like Massive MIMO system, where the requirements of individual user experience is improved in many fold [34-35]. The MIMO system uses various multiplexing techniques such as special multiplexing and many decoder methodologies are employed which are complex in nature [36-37]. The spectrum need per user is increases exponentially along with MIMO environment of multiple Transmitting Antennas and Receiving antennas and it become tough task to toggle between maintaining system parameters [Example BER (Bit Error Rate)] and improving performance [38]. The complete analysis and the set properties of the Zero Forcing Detractor is completely analyzed and portrait in [42]. It is evidence that the ZF is best suit in eliminating inter symbol interference completely due the symbol present in the other channel and with this Zero Forcing property ZF detector is best suits in MIMO Environment to eliminate ISI. It is evident that the conventional Zero Forcing Algorithm is very much effective in reducing or nullifying the ISI effect. [33], [42].

To achieve high performance rate without compromising BER numbers, this paper proposes a NHMD (New Hybrid MIMO Detector) detector for multiple antenna MIMO system Environment. The proposed Hybrid MIMO Detection (NHMD) system combines K-optimized detection for existing Zero Forcing (ZF) technique, Minimum Mean Squared Error (MMSE) and imminent communications systems. The proposed work improves the performance of the MIMO system by the way of minimizing the Energy consumption as well this proposed schema not compromised on the BER rate hence the overall system performance is improved. From this analysis, the proposed method produces better numbers and improved the performance of the system. The organization of this paper is as follows. The recent K-best algorithm is reviewed in Section 2. In Section 3, the problem methodology and system model of NHMD method are described. The proposed NHMD detector, the hardware architecture and detailed circuit design are presented in Section 4. Section 5 presents the simulation result and its comparison with other methods. Finally, the conclusion is provided in Section 6.

2. Related works

The recent innovations in wireless technology open the doors for many innovations like LTE, MIMO and Massive MIMO (5G). The MIMO uses multiple antennas at the transmission and receiving stages in order to improve the gain of the antenna [39]. Huang et al. [21] have provided a hardware-efficient structure for high-performance MIMO innovations. Unlike the existing K-Best algorithms, the K-Best algorithm search tree group has high survivability and low computational complexity. The K-Best MIMO detector algorithm and the error distribution method based on the integrated distribution of channel noise and associated errors are presented. This method is based on a strategy of calculating internal links during a tree search which significantly reduces the search space [22]. The channel preprocessing is defined using the MINIMUM MEAN SQUARED ERROR (MMSE) -SQRD QMS decomposition (MINIMUM MEAN SQUARED ERROR (MMSE) module), which models arrays of spatial and simulated modeling [23]. An effective MINIMUM MEAN SQUARED ERROR (MMSE) MIMO fixed point detection is done by launching interpolation software for LTE-A wireless sharing. Detection algorithms and dynamic scaling schemes improve the dynamic range of intermediate values some Intelligent surfaces beyond the scope of MIMO system also proposed by Ertugrual [24], [41] which is still depends on shift keying techniques

Spatial Multiplexing, Signal to Noise Ratio (S/N), QoP (Quality of Performance), Power Utilization, Capacity and Bit Error Rate (BER) are the important parameters one need to concentrate when dealing with MIMO system. Depending on the target BER performance and or SNR reduction in channels, 10% to 51% improvement in system efficiency is achieved by the system. Customizable MIMO detection and scalable MIMO detection systems are available on multi-core platforms, and the system nodes are integrated with the Network on Chip (NOC) model. The tree-based MIMO detection algorithm is optimized for NOC systems and it includes processing elements for implementing the algorithm [26]. Chebyshev parallel iteration is used to reduce the computational load and to study the parallelism of inverse and matrix multiplication. Chebyshev iteration which is based on Eigen values method is the key process used to obtain the following (i) the initial values for the inverse matrix, (ii) Values for matrix multiplication. The high-performance K-optimal detection used in MIMO systems employs a two-dimensional (2D) parallel classification algorithm [28]. Custom algorithms classify data in parallel to improve the performance and to avoid delays associated with the existing algorithms. Minimum Mean Squared Error (MMSE) detection is recommended for large 128 × 8 64-QAM MIMO systems with parallel full-tube configurations [29]. This design uses diagonal tuning based on diagonals and hence, there are no performance limits. It is a high-performance multimode preprocessor designed for MIMO 4x4 detectors with many preprocessing programs, including QRRD, SQRD and MINIMUM MEAN SQUARED ERROR (MMSE) -SQRD [30].

Susnata and Jeyanandh [40] have proposed a reconfigurable design for 28/34 Gigha Hertz MMSE system. They have implemented the beam forming receiver with adoptive approach. The Hybrid Beam forming Receiver used for the Aggregation of carrier signal used in MIMO system.

And they have adopted a multi standard MIMO system which makes the total implementation become complex

When multiple user are simultaneously using the system, the number of transmitting antennas and Receiving antennas count reaches a threshold as well the overall operational complexity of the system drastically increases. The parameters like Bit Error Rate is greatly influenced by the system complexity which get diluted when number of users and number of transmitter and receiver antenna increases results in performance degrade. As well this scenario become worsen in the LTE-A category

In the recent innovations and implementation procedures of 5G uses the advantage of MIMO system in the name of Massive MIMO. This massive MIMO system uses very large capacity transmission and receiving antennas uses to achieve higher gain for the individual user to give better technical advantage to the End user. As per IMT-2020, the 100x in terms of data download and upload improvement over the existing network capacities and 1000x times the user accommodation expansion in comparisons with current network structure are the expected target of the 5G system which through a big battle ground for the researchers to achieve such a goal. This practical implementation increases large technical advancement as well increases the complexity of the system. This leads to use countless number of antennas at any specific time interval. This complexity technically improved at a significant level by Edward et al. [31] even though the author missed to provide solution to the best queue with root size distribution problem in the spatially multiplexed wireless MIMO system which is addressed by this proposed system

3. Problem methodology and system model

3.1 Problem methodology

Edward et al. [31] have presented a tree-search based modified K-best algorithm and hardware structure for spatially multiplexed wireless MIMO system. An updated method corrects the current method to determine the best queue with root size distribution problems. The addition of wood at all levels reduces equipment problems and improves structural performance in accordance with LTE-A standards. The revised Q-Best algorithm reduces the path metric calculations of various antenna and galaxy configurations and reduces device performance by 24%. It can be added multiple times to change the number of amplifiers in order to improve area and power. Poor detection capabilities are displayed by MIMO system when used with polyamide (NP) system, since, it is a non-NP polynomial problem hence MIMO is not compatible with many antennas of the system.

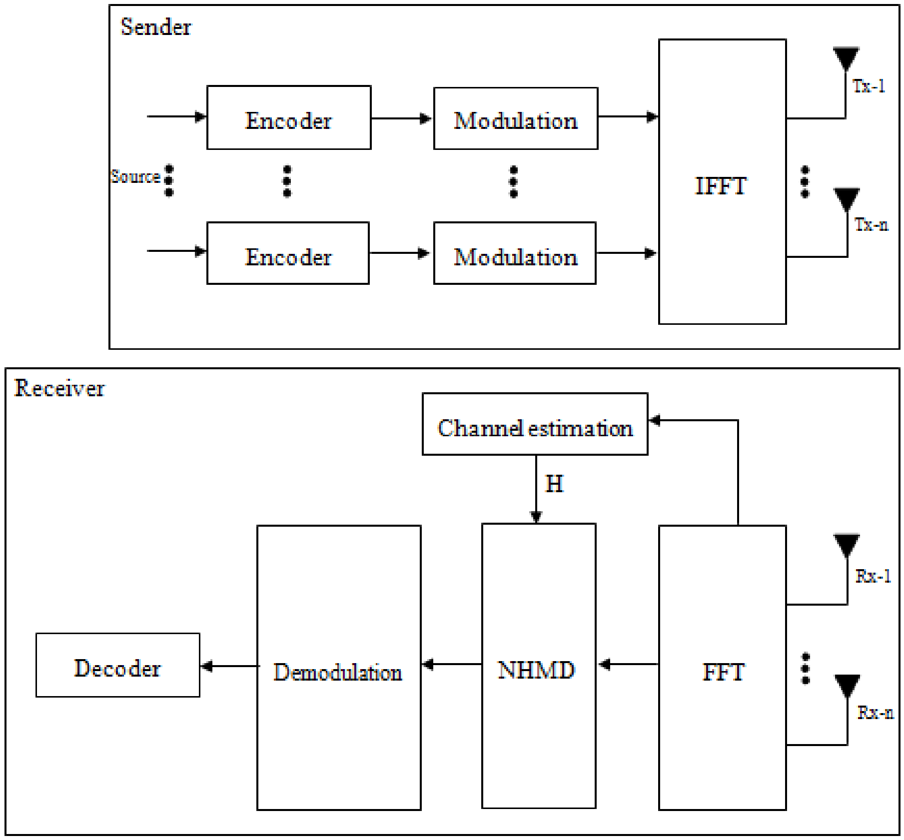


Figure 1 MIMO system with the proposed Novel Hybrid MIMO detector (NHMD)

This makes it a great candidate. Here, a new Hybrid MIMO Detection (NHMD), which combines K-optimized detection for existing ZF, MINIMUM MEAN SQUARED ERROR (MMSE) and future communications systems, has been proposed. The main contributions of the proposed NHMD system are:

- NHMD method improves BER performance by combining traditional NF and MINIMUM MEAN SQUARED ERROR (MMSE) with K-gain detection.
- The Optimal Differential Evolution (ODE) algorithm is used to select the correct detector as Z-F + Q-best detector and MINIMUM MEAN SQUARED ERROR (MMSE) + K-best detector.
- The Proposed Detection system (K-Best) replaces the conventional K-Best detection algorithm by dividing it into NHMD mode.
- The NHMD method uses a parallel process to reduce the arithmetic logic.

3.2 System model

Figure 1 shows a computer model of the MIMO system proposed by NHMD. On the transmitter side, the encrypted data stream can be moved to another by using QAM symbols. Fourier Transform (FFT) is used to encrypt data at several carrier frequencies. When the receiver receives a signal, it is converted to an FFT. The channel transfer function is calculated to detect the H signal and some transmission characteristics are provided. MIMO systems with multiple transmission channels can use higher speed and transmit data over a limited spectrum. The MIMO detector combines additional processing with a channel decoder before receiving each signal. Finally, the channel decoder rejects the source of the transmitted bit information. The numbers of Transmitting antennas and Receiving antenna in the MIMO multiplex system is expressed as follow in Equation (1)

$$y = Hx + N \tag{1}$$

Where,

x is a complex vector of exchange symbols i.e. $x = (x_1, x_2, \ldots x_T)^T$ and each component is drawn independently of a complex galaxy in the M-QAM array. The complex output symbol H is $y = (y_1, y_2, \ldots y_R)^T$ and the main band of the potential channel of the repeater between the transmitter and the receiver, defines the matrix of the complex channel R x T as well as processes the scan with zero median White Gaussian scanning (AWGN) as a vector of the scanning process.

Channel Estimations: A multipath fading occurs, due to the influence of the phase difference of the received signal on the receiver side. This is due to the fact that the received signal moves at different distances and routes. Rail transport can reach many customers. Power relays are commonly used for speed signals. The probability density function of the class of the relay channel of distribution is multipath fading, due to the phase difference of the received signal on the receiver side.

$$F_{Ray} = \frac{r}{\sigma^2} e^{-r^2/\sigma^2}; \qquad r \geq 0 \tag{2}$$

Where,

r is the random variable and

σ^2 is the variance.

AWGN channel is common channel representation for verifying all modulation techniques.

MIMO Detector: Before minimizing the signal received from the receiver, the detection process should be shortened, due to spatial variation and Inter Symbol Interference (ISI). The linear detection method is the most widely used method in the receiver. The amplitude of the received signal is linearly converted by the amplifier through a matrix of directional changes, and the received signal is measured to the nearest point in the open atmosphere. From here, the complex signal vectors $\tilde{y}$ are obtained

$$\tilde{y} = [\tilde{h}_1 \ \tilde{h}_2 \ \ldots \tilde{h}_T] \begin{bmatrix} \tilde{x}_1 \\ \vdots \\ \tilde{x}_T \end{bmatrix} + \tilde{N} \tag{3}$$

Then,

$$\tilde{y} = \tilde{h}_1 \tilde{x}_1 + \tilde{h}_2 \tilde{x}_2 + \cdots + \tilde{h}_T \tilde{x}_T + \tilde{N} \tag{4}$$

Zero Forcing Detectors: The main idea of Zero Forcing is to improve $\tilde{y}$ the channel-based compatibility matrix and to reduce Inter Symbol Interference to zero. There is no sound in the calculation $\tilde{y}$. The ZF algorithm consists of two stages [33]. It is clear that the Zero forcing detector employed in a MIMO environment completely eliminates the symbol interferences from other symbol layers traditionally [42].

$$\tilde{Z} = \begin{bmatrix} \tilde{z}_1 \\ \vdots \\ \tilde{z}_T \end{bmatrix} = \tilde{C}_{ZF} \ \tilde{y} = \begin{bmatrix} \tilde{g}_1 \\ \vdots \\ \tilde{g}_T \end{bmatrix} \tilde{y} \tag{5}$$

Where, $\tilde{y}$ is used to indicate the complex signal vector and $\tilde{C}$ is the channel noise in the Multi transmit and receive antenna, all in the MIMO environment.
MINIMUM MEAN SQUARED ERROR (MMSE) Detector: The main strategy of the Minimum Mean Squared Error (MMSE) detector is Zero Forcing. The difference is that a new inverse matrix $\tilde{C}_{MMSE}$ is calculated to reduce signal distortion, due to channel and expected noise.

$$\tilde{C}_{MMSE} = \left(\tilde{H}^{H} \tilde{H} + \frac{1}{\rho} In \right)^{-1} \tilde{H}^{H} \tag{6}$$

Where, $\tilde{C}_{MMSE}$ is the representation for channel noise due to symbol interference in multiple transmit antenna and multiple receiving antenna environment where inter symbol interference is quite high. Where, the Zero Forcing applied to the MMSE which yield better elimination of ISI in the received signal.
SSNR is the n × n identity matrix. MINIMUM MEAN SQUARED ERROR (MMSE) ZF for AWGN is canceled. This is due to the fact that the average effect of Gaussian noise is calculated, when the ISI effect is reduced.
K-Best Detector: As the number of MIMO antennas increases and the modulation method is adjusted, even the most suitable algorithm is difficult to evaluate and it cannot be implemented at the hardware level. The channel matrix is defined as follows:

$$y = IJx + N \tag{7}$$

Therefore,

$$I^{-1} y = J_x + I^{-1} N \tag{8}$$

Simplified as $Z = I^{-1}\, y$ and $w = I^{-1}\, N$

$$Z = J_x + w \tag{9}$$

The proposed system with k-best modifications are now finalized and obtained through equation 10 as follows:

$$\tilde{C}_{Kbest} = \arg\min_{xe\phi} \left\| Z - J_x \right\|^2 \tag{10}$$

Where, the Z is the Zero Forcing which augmented with Channel ISI in order to get best rates (No inference or minimal inference). 'J' is the matrix of parent triangles and hence, searching through the Jx tree is complicated. Partial Euclidean Distance (PED) is the distance between a received and a given signal. The PED of each column is calculated as follows.

$$P_i(x_i) = P_i(x_{i+1}) + \left| R_i(x_i) \right|^2 \tag{11}$$

$$P_i(x_i) = Z_i - \sum_{j-1}^{4} J_{ij} x_j \tag{12}$$

Each K-best detector Tree stack focuses on choosing the best K game and choosing the best hint. The choice of the optimal value for the cable depends on the current location of the tree, such as the antenna, modulation system and system parameters. Where the received signal notified as K-Best, then its values are obtained through equation 13
The value of 'K' may be deduced with the following bounds:

$$K=\sqrt{M}\times\frac{B}{4};L=B \tag{13}$$

$$K_L=ceil\left[K_{L+1}/P_L\right];L<B,whereP_L=B-(C_L-1) \tag{14}$$

Where, 'L' is the summation of all the branches in the tree, 'M' indicates total count of branches present in the tree. The order of the Matrix set in the above equation indicated through 'B'. And the capacity of the channel is indicated through 'C'. The P indicates the point Set of the total constellation. The calculated data vector is used to determine the best mobile node. The same number of transmitter and receiver antennas facilitates the inverse calculation of the channel matrix. The expected data depend on the size of the vector channel and it can be specified.

$$\tilde{C}_{Kbest_{est}}=H^{-1}y \tag{15}$$

The processing steps for determining the K-best detection are summarized in Algorithm 1.

4. Reconfigurable design of novel hybrid MIMO detector (NHMD)

In this section, initially the operational structure of the proposed NHMD is discussed. The reconstructed design of the K-Best special method and the optimal differential evolution method are focused. The functional structure of the proposed NHMD method is shown in Figure 2. The purpose of NHMD system is to open the receiver to obtain a transmission code with minimal error by using other methods. This is due to the number of bit representations that the MIMO should focus on reducing hardware implementation and power requirements. The number of features required by these innovators is huge, and computational problems can be very expensive, if they are implemented in double or single precision representations.

4.1Isolated K-best detector

There are two main functions for measuring and placing PEDs in FPGAs to activate the Q-Ideal Insulation detector. These two functions require more complex functions, such as complex multiplication, complex addition, and regular operations. Hence, these functions require a large amount of memory in the FPGA. To calculate the PED, the condition has to be evaluated. To evaluate the criteria of rule 2 or L2, a square root function with two main functions is needed to calculate the PED in the FPGA in order to initialize the detector using K-Best isolation.

$$\|P\|=\sqrt{p_1^2+p_2^2+\dots p_m^2} \tag{16}$$

Both of these functions require significant resources and hence, the L2 standard and the L2 algorithm have changed a lot. L1 basically reduces the absolute difference. The linear characteristics that a device can detect without using an amplifier significantly reduce the existing design problems and the PED is mentioned through 'P'.

$$\|P\|=\sum_{i=1}^{n}P_i \tag{17}$$

Testing performance for errors according to the L1 standard, the difference in performance between the two types of words is checked in accordance with the L1 standard. The input variable depends on the layer that calculates the PED. PED calculations are performed as follows:

$$S_1=\left|x_1-r_{11}y_1-r_{12}y_2-r_{13}y_3-r_{14}y_4\right| \tag{18}$$

$$S_2 = |x_2 - r_{22} y_3 - r_{23} y_3 - r_{24} y_4| \tag{19}$$

$$S_3 = |x_3 - r_{33} y_3 - r_{34} y_4| \tag{20}$$

$$S_4 = |x_4 - r_{44} y_4| \tag{21}$$

Where, S_1, S_2, S_3 and S_4 indicate the symbols in the calculation of PED's for the proposed NHMD system. 'x' and 'y' are independent variable. For each PED calculation module, three types of function blocks are added, multiplied and completed. Actual results can only be used to evaluate the verdict after the entire decision. Memory requirements are reduced during classification according to the asynchronous array created by the inventor and the continuous linear array method is recommended. Two types of modifications are made during sorting. If the queue is halfway, it moves left and right. T lists all candidates for TT.

Algorithm : 1 Isolated K-Best Detection	
Layer N	
1	Calculate PEDs Pi for all Symbols Zi
2	Select the value of K_N from Equation 28
3	Shortlist the value of K symbols with minimum PEDs Pi and their corresponding Zi
Layer N-1 to 2	
1	Calculate PEDs for all favorable children of the K parents of Previous layer
2	Update the value of $K_{N-1 \text{ to } 2}$ using Equation 29
3	Shortlist $K_{N-1 \text{ to } 2}$ symbols with minimum PEDs Pi and their symbols Zi
Layer 1	
1	Calculate PEDs for all children of the $K_{N-1 \text{ to } 2}$ parents of the previous layer
2	Select symbol with minimum PED and consider its hierarchy as solution

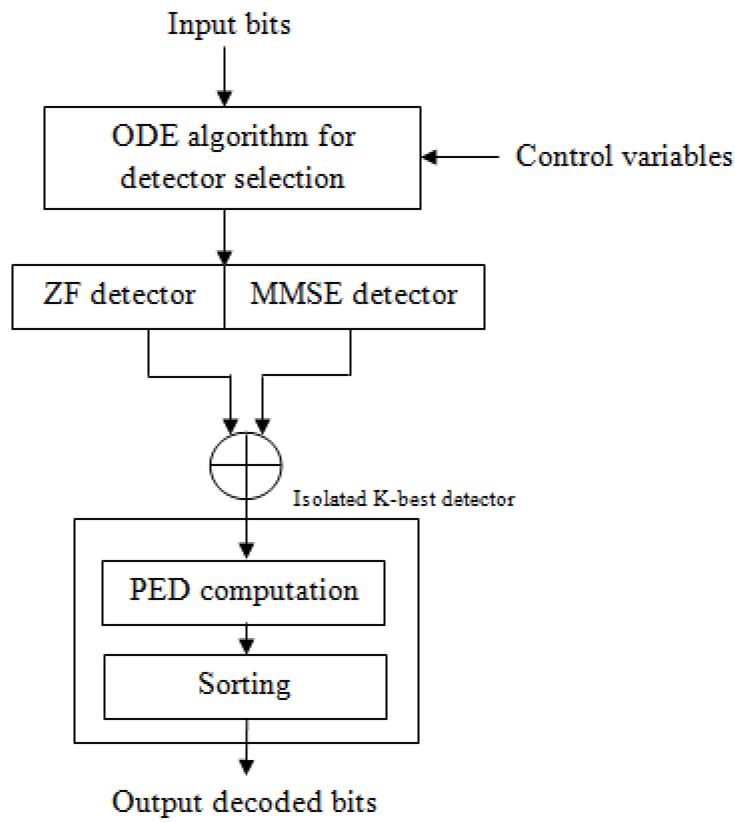


Fig. 2 Functional structure of the proposed Novel Hybrid MIMO detector (NHMD)

4.2 Optimal differential evolution (ODE) algorithm for Detector selection

A subset of hardware modules includes ODM (optimal differential evolution) algorithm. The general configuration of the control module is shown in Figure 3. The addresses of the PM and FM modules, 3 registers for storing the code, 3 64-bit registers for storing attributes and log files are displayed. The 64-bit version is written down and each subsequent character is saved.

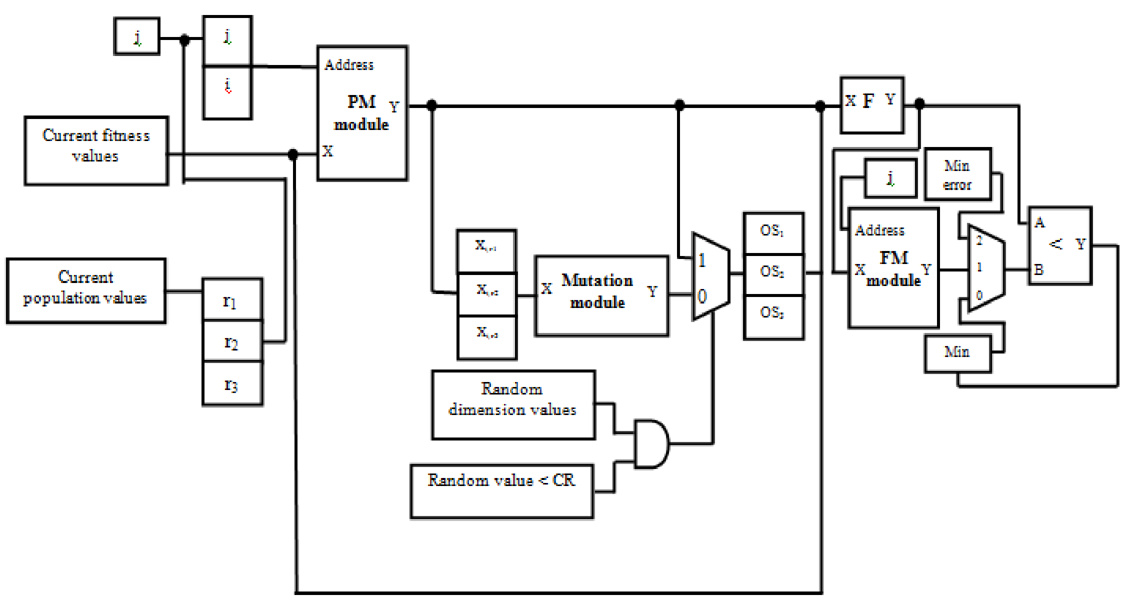


Fig. 3 Hardware architecture of the proposed ODE algorithm

4.2.1 PM module

The primary module consists of memory unit and the protection part of memory unit. The memory size of the proposed ODE algorithm is maintained by the PM module and the memory size is defined as follows:

$$PM = NP \times Dwords \tag{22}$$

If each word is specified by 8 bytes (64 bits), then the PM size expressed in bytes is specified as follows:

$$PM = NP \times D \times 8bytes \tag{23}$$

4.2.2 FM module

This module is implemented similar to PM. Here, the FM size is determined by the fill parameter, since only one value is stored. FM exposure can be expressed as:

$$FM = NPwords \tag{24}$$

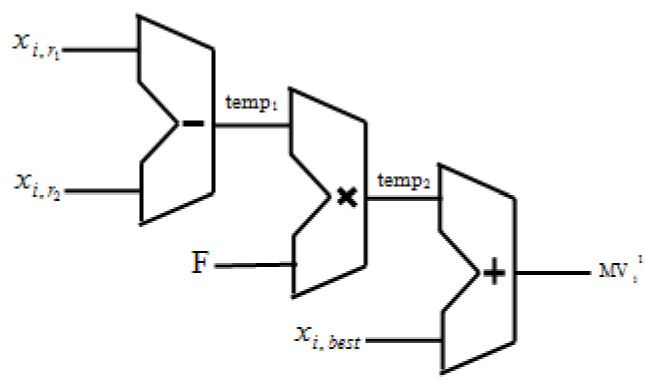


Fig. 4 Mutation module

If each word is specified by 8 bytes (64 bits), then the FM size expressed in bytes is specified as follows:

$$FM = NP \times 8bytes \tag{25}$$

4.2.3 Mutation and crossover module

The equations (3) and (4) illustrate mathematically generated mutation and crossover functions. This section describes the detailed hardware architecture. The configuration contains 3 floating point values and the binary floating point function generates an odd set.

$$temp_1 = x_{i,r1}^0 - x_{i,r2}^0 \tag{26}$$

$$temp_2 = F \times temp_1 \tag{27}$$

$$MV_{i,best}^1 = x_{i,best}^0 - x_{i,r2}^0 \tag{28}$$

Figure 4 shows the vector of complete and genetic mutation tests for the next project.

Random numbers for all reduced process sizes (for example, find the values and locations of several sizes and go to the next multiplexing tool) are recorded.

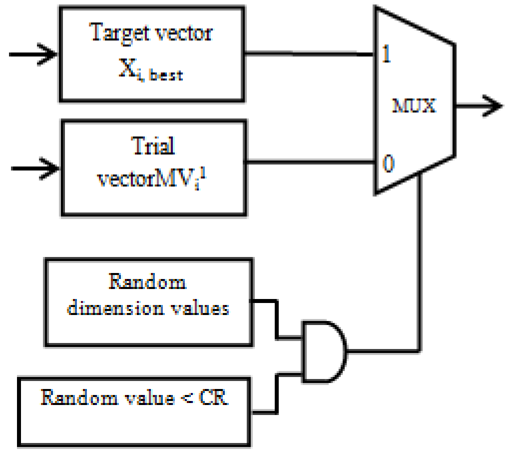


Fig. 5 Crossover module

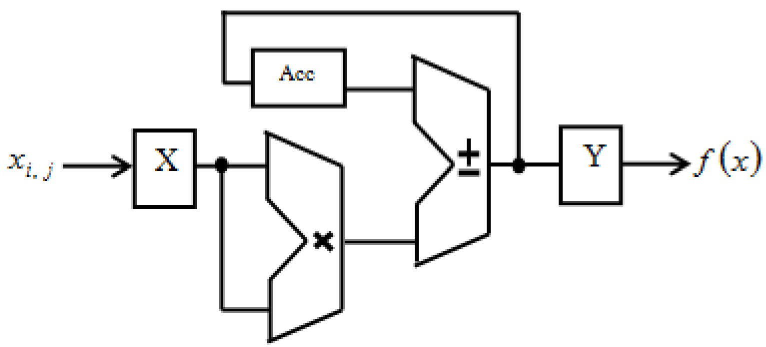


Fig. 6 Fitness computation modules based on Sphere function

Depending on the value and size of CR shown in Figure 5, the best (target) or experimental multiplexer vector follows. A cell automation program is used to generate random numbers for each 3D value. ,

4.2.4 Fitness function module

The actual calculation depends on the use of the module and so, this module only switches between applications. A set of six reference mathematical functions is used to evaluate the applicability of the ODE algorithm. The performance of the existing systems is:

$$f(x) = \sum_{i-1}^{D} x_i^2 \tag{29}$$

Figure 6 shows the module of fitness computation with Sphere function.

5. Simulation Setup and Discussion of Results

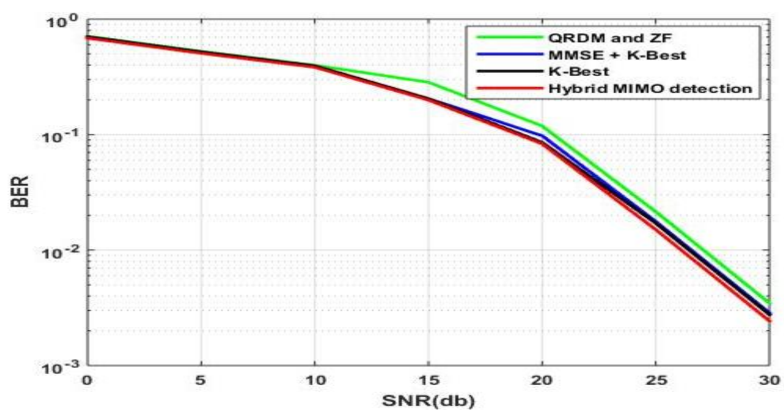
The Hardware proto types are easily designed with the help of Xilinx platform and to attain the possible results those proto models are run through simulink and MATLAB tool. The result out analysis matches with the real world working environment outcomes. This proposed system is designed with the help of Xilinx platform which eliminates the programming of Hardware coding since the job done by MATLAB and Simulink tool. The proposed new NHMT system is implemented using the above said methodology that is Xilinx system model is used to develop the Hardware proto type then the MATLAB and Simulink tool is used to generate the necessary outcomes and testing.

The following hardware structures are involved in the proposed simulation process. The proposed simulation work is performed using various FPGAs from the Xilinx series Vertex-4 (XC4 VFX12), Vertex-5 (XC5 VSX 240D) and Vertex-6 (XC6 VCX 75D). the simulation outcomes are analyzed for effectiveness on the hardware and complexity involved in the proposed NHMT method. These outcomes of the simulation then compared with the results of drilling mechanisms namely the QRTM-Z hybrid, MINIMUM MEAN SQUARED ERROR (MMSE) -K best and the K-best hybrid [33],[34][19].

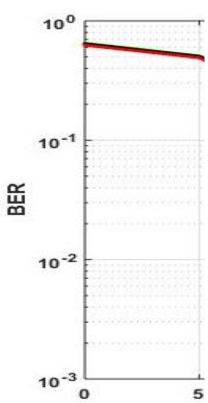
5.1 BER analysis

MIMO BER 2x2 and 4x4 are used to analyze all the detectors and to transmit 100,000 antennas and 96 bits in a single volume configuration. Antenna configuration is compared with 2 × 2 and different QAMs and it is shown in Figure 7a-7c . The proposed MIMO hybrid detector provides 4 dB higher efficiency than K-compatible products with BER = 10^{-1}. This suggests that the proposed BR NHMD method has a low NAB SNNR. Similarly, Figures 8a-8c shows the comparison of 4x4 antenna configurations with different QAM sizes, respectively. The proposed hybrid MIMO detection is larger than the K-Best, and the proposed 10 dB SNR is much smaller than the NHMD.

(a)



(b)



(c)

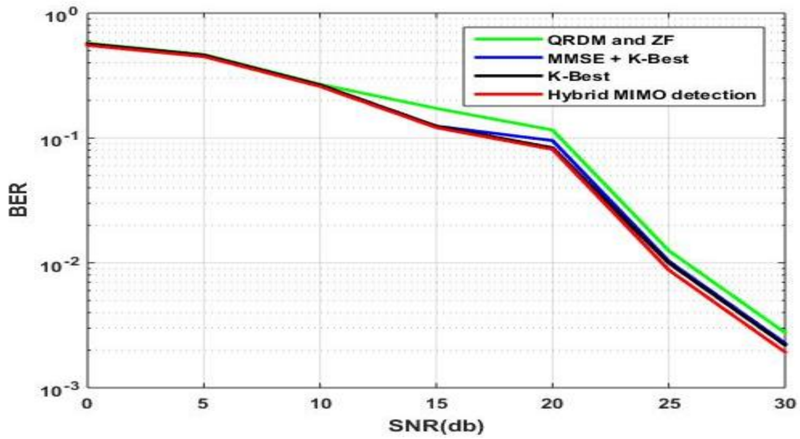
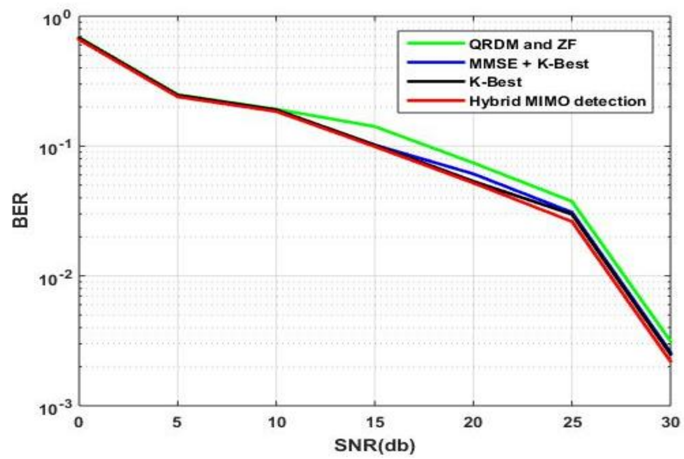
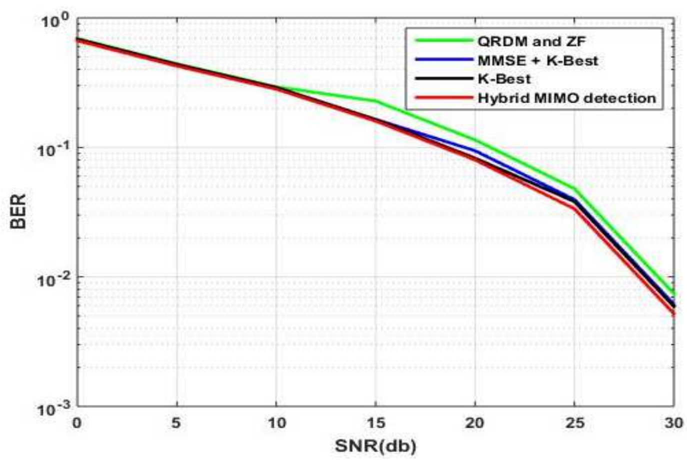


Fig. 7 Comparison of BER with 2 × 2 antenna configuration and (a) 16 (b) 64 (c) 256 QAM
(a)



(b)



(c)

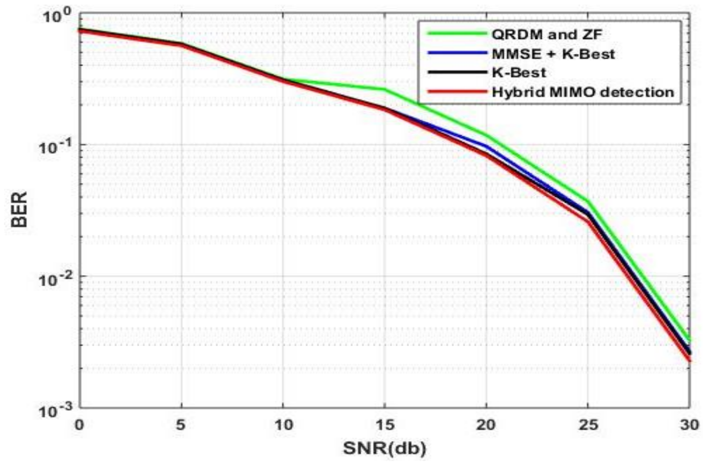
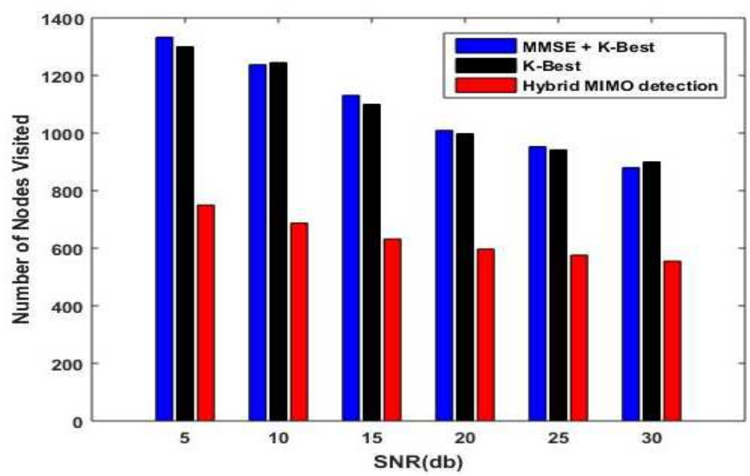
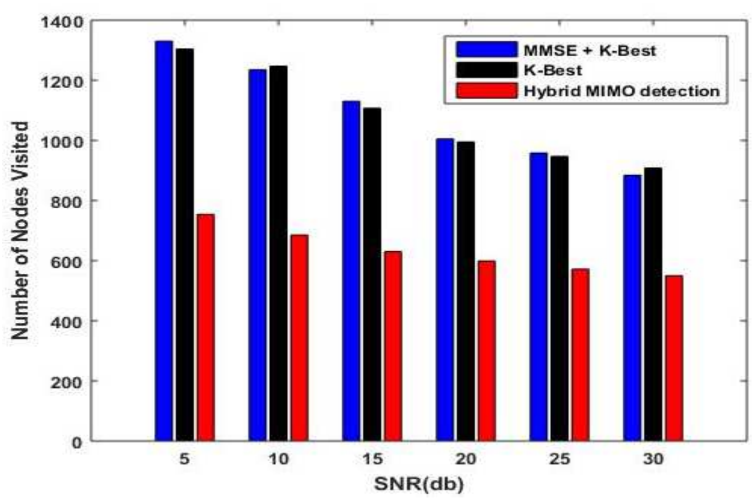


Fig. 8 Comparison of BER with 4 × 4 antenna configuration and (a) 16 (b) 64 (c) 256 QAM
(a)



(b)



(c)

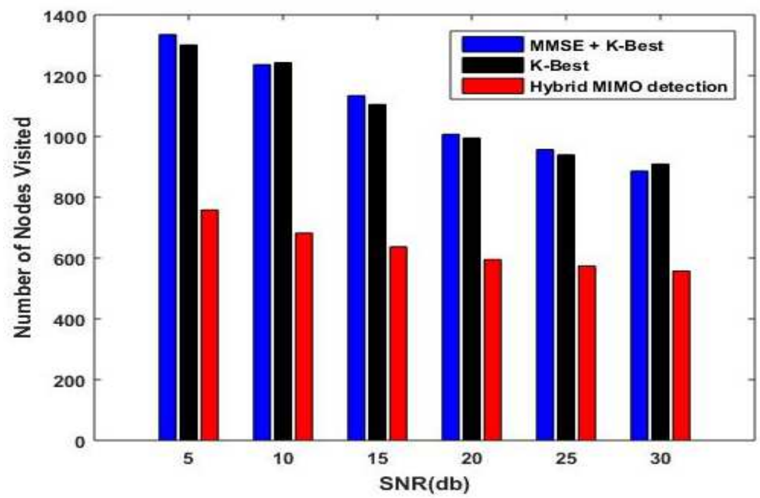
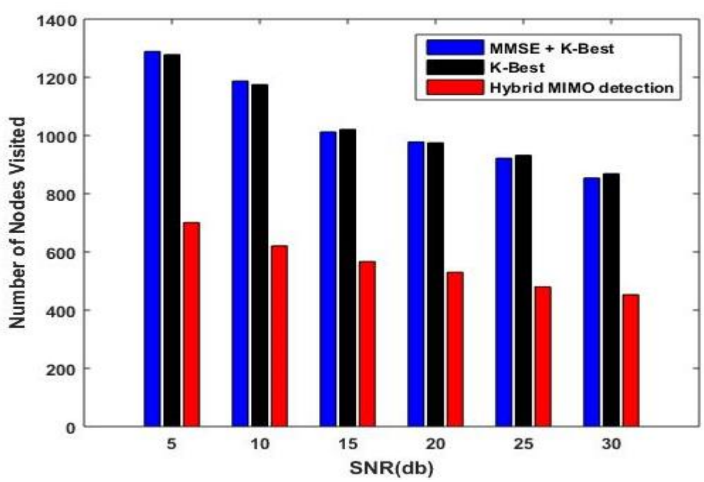


Fig. 9 Comparison of number of nodes visited with 2 ×2 antenna configuration and (a) 16 (b) 64 (c) 256 QAM

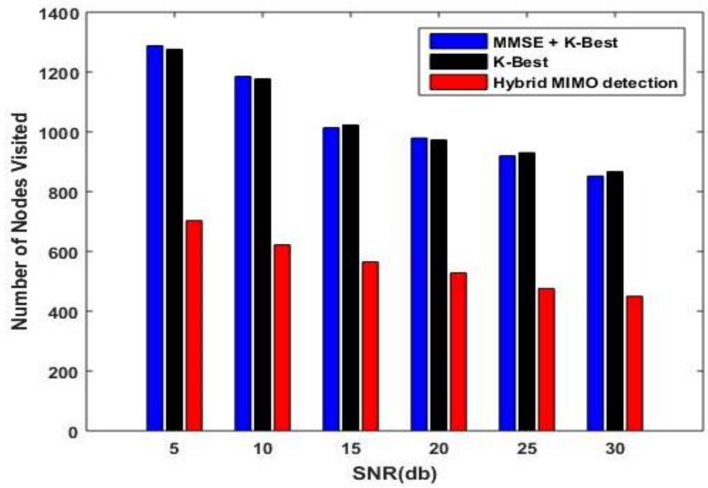
5.2 Complexity analysis

Comprehensive analysis is performed on all detectors based on the number of nodes observed and floating point calculations using 2 × 2 and 4 × 4 antenna configurations. Figure 9a-9c shows the configuration of antennas 2 and 2 and the number of review nodes is compared with different QAMs, respectively. The NHMD method and the hybrid MINIMUM MEAN SQUARED ERROR (MMSE) -K are the best [34] and K-Best [19]. The proposed MIMO hybrid detector is superior to K-Best for all SNR values. This shows that the number of observed nodes can be neglected in comparison with the current detector. Similarly, Figures 10a-10c show antenna configurations 4 x 4 and the number of nodes observed compared to different QAMs, respectively. The NHMD method and the hybrid MINIMUM MEAN SQUARED ERROR (MMSE) -K are the best [34] and K-Best [19].

(a)



(b)



(c)

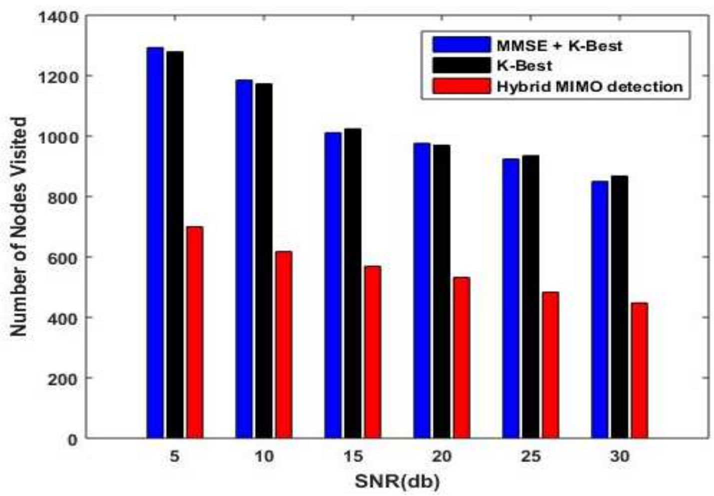
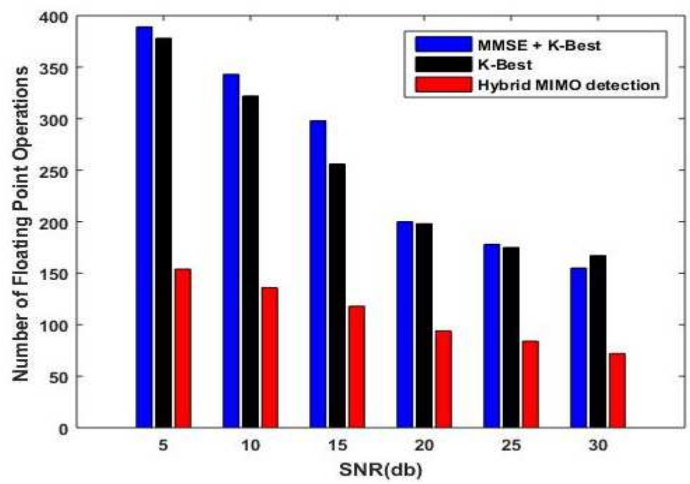


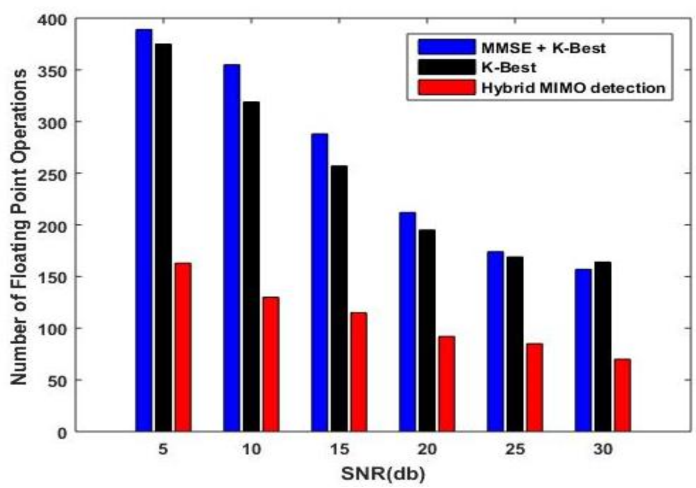
Fig. 10 Comparison of number of nodes visited with 4 × 4 antenna configuration and (a) 16 (b) 64 (c) 256 QAM

The proposed detector redefines K-Best and shows that the number of nodes visited by the proposed NHMD method is negligible for all SNR values. The NHMD method compares hybrid MINIMUM MEAN SQUARED ERROR (MMSE) -K best [34] and Q-best [19] with Figure 11a-11c 2 x 2 antenna configurations and different QAMs floating point numbers, respectively. The proposed MIMO hybrid detector is superior to the K-Best for all SNR values. This shows that the observed floating point performance is negligible compared to the present invention. Similarly, Figure 12a shows A and C floating-point operating systems with 4× 4, different QAMs antenna configurations (NHMD mode, hybrid MINIMUM MEAN SQUARED ERROR (MMSE) -K best [34] and K-best [19]), respectively. The proposed update overrides the K-Best and shows that the floating point performance of the proposed NHMT method is negligible for all SNR values.

(a)



(b)



(c)

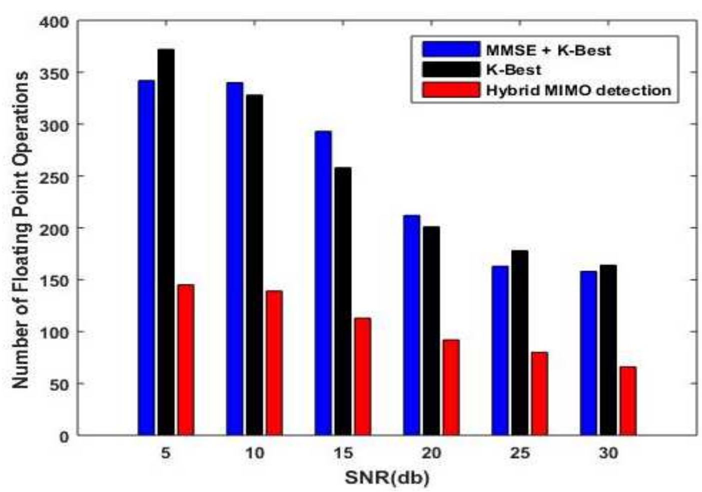
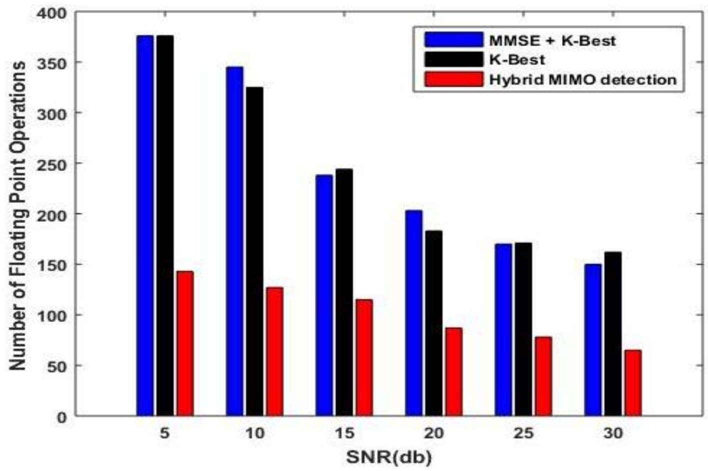
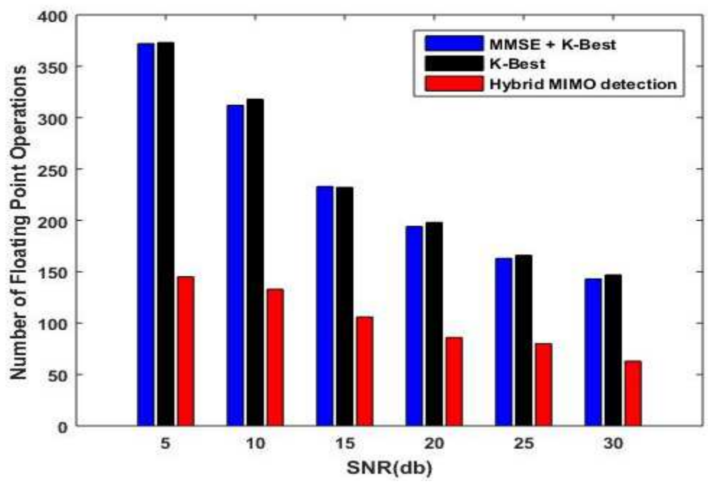


Fig. 11 Comparison of number of floating point operations with 2×2 antenna configuration and (a) 16 (b) 64 (c) 256 QAM

(a)



(b)



(c)

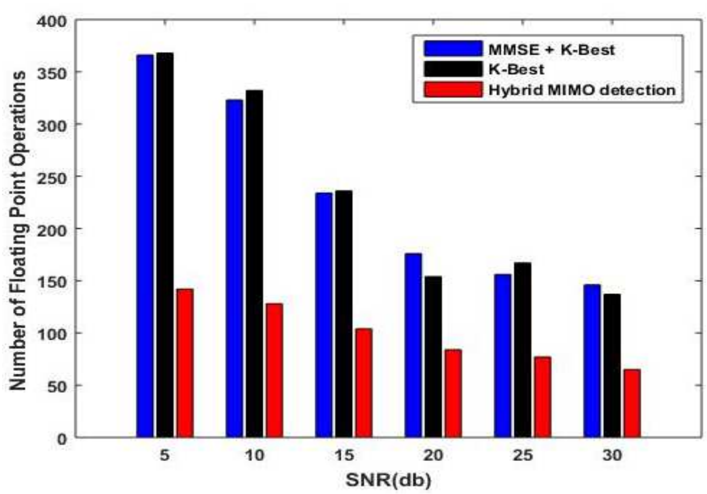
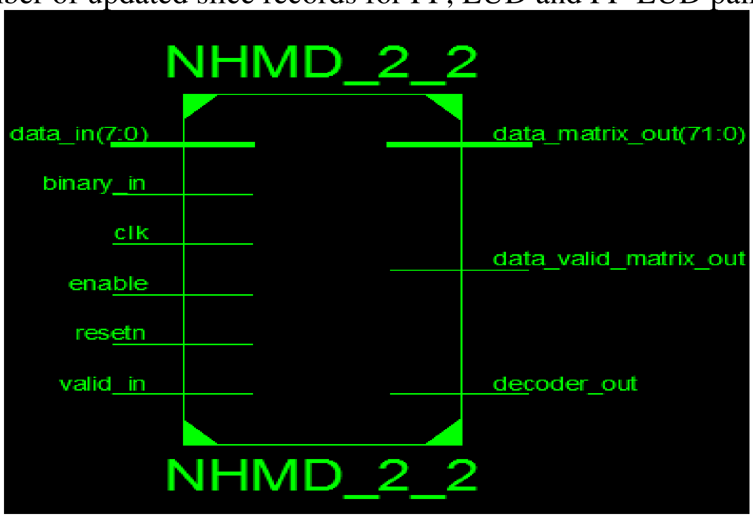


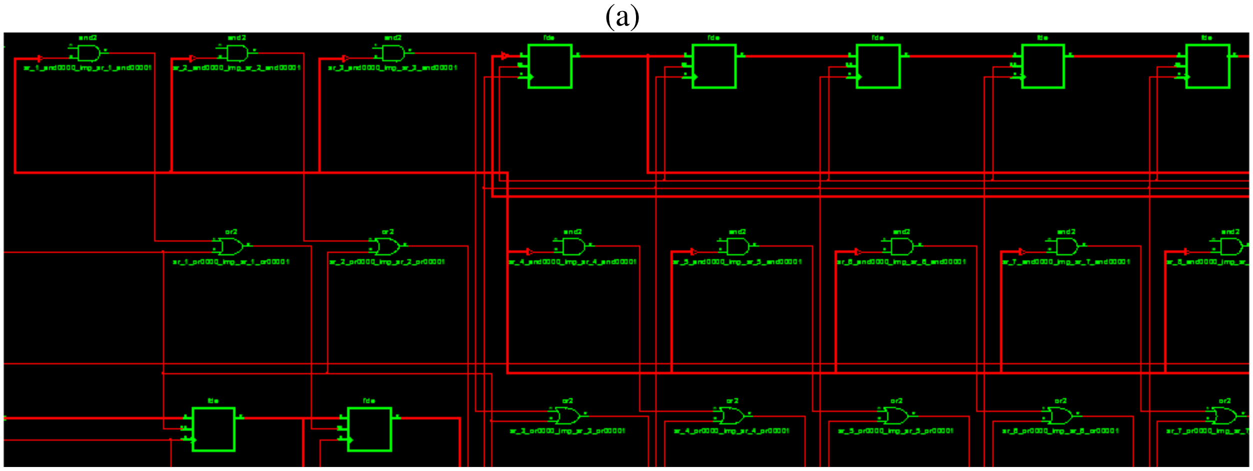
Fig. 12 Comparison of number of floating point operations with 4×4 antenna configuration and (a) 16 (b) 64 (c) 256 QAM

5.3 Hardware utilization analysis

The performance section of the proposed NHMT FPGA system is analyzed, including several product families, Wireless 4 (XC4VLX200D), Vertex 5 (XC5VLX20D) and Xilinx version 14.5. Extension Silicon is a tool that integrates design and graphics into target devices. The design process is checked with the built-in ISIM Simulator. External and detailed images of RTL NHMD (2 × 2 antenna configuration) are shown in Figures 13a and 13b, respectively. The use of tools and materials is analyzed in the design process. Table 1 shows the hardware usage of some NHMD systems: Vertex 4 (XC4 VLX 200D), Vertex 5 (XC5 VLX 20D), and Vertex 7 (XC7VLX30T). Antenna configurations 64 2 ×2 and 4 × 4 QAM are implemented in two configurations. The recommended NHMMT method in this list uses at least 6 FPGAs based on FF and LUT. The performance of the proposed NHMD method is compared with the existing hardware designs [21]-[31]. Table 2 compares the hardware usage of specific inventors with the existing inventors. This indicates that the hardware application of the proposed NHMD method is less than the number of updated slice records for FF, LUD and FF-LUD pairs.



(a)



(b)

Fig. 13 RTL screenshot of NHMD method with 2×2 antenna configuration (a) Outline (b) Deep architecture

Table 1 Hardware utilization of proposed NHMD method

Metrics	2×2 and 64 QAM			4×4 and 64 QAM		
	Virtex4	Virtex5	Virtex6	Virtex4	Virtex5	Virtex6
Number of slice Registers	1561	1116	1113	1626	1117	1122
Number of slice FFs	1116	-	-	1116	-	-
Number of LUTs	2949	1236	704	3068	1236	704
Number of FF-LUT pairs	-	1795	1444	-	1796	1456

5.4 Throughput analysis

Typically, after a detector is implemented in FPGA, the performance is measured using the maximum clock frequency (Fmax), sprocket size (M), number of antennas (N), and clock rotation required for design. The throughput of the proposed NHMD method is compared with the existing hardware designs [21]-[31]. The performance comparisons of the existing innovators and current innovators are described in Table 3. This clearly illustrates the effectiveness of the proposed NHMD method.

5.5Power analysis

NMMD method is provided by an isolator detector known as K-Best. The power consumption of the proposed NHMD method is compared with the existing hardware designs [21]-[31]. Table 4 illustrates the comparison of energy costs of the proposed inventor and the existing inventor. It shows that the energy consumption of the proposed NHMT system is negligible compared to the actual results.

Table 2 Comparison of hardware utilization

Ref.	Detector	Target device	Antennas	QAM	K	Hardware utilization			
						Registers	LUTs	FFs	FF-LUT pairs
[21]	K-Best	90nm	4×4	64	8	321 KG gates			
[22]	K-Best	65nm	NA	64	10	177 KG gates			
[23]	K-Best	65nm	4×4	64	10	586 KG gates			
[24]	MINIMUM MEAN SQUARED ERROR (MMSE)	Virtex 7	NA	64	NA	9145	136	NA	NA
[25]	K-Best	22nm	4×4	16	5	425 KG gates			
[26]	K-Best	Virtex	4×4	64	NA	303372	847459	2768	NA
[27]	MINIMUM MEAN	Virtex 7	128×16	64	NA	NA	70288	70452	NA

	SQUARED ERROR (MMSE)								
[28]	K-Best	90nm	4×4	64	16		182 KG gates		
[29]	MINIMUM MEAN SQUARED ERROR (MMSE)	Virtex 7	128×8	64	NA	NA	20454	25103	NA
[30]	MINIMUM MEAN SQUARED ERROR (MMSE) - SQRD	90nm	4×4	64	NA	NA			
[31]	K-Best	Virtex 5	4×4	16	NA	3458	6587	NA	NA
*	NHMD	Virtex 4	2×2	64	10	1561	1116	2949	NA
			4×4	64	10	1626	1116	3068	NA
		Virtex 5	2×2	64	10	1116	1236	NA	1795
			4×4	64	10	1117	1236	NA	1796
		Virtex 6	2×2	64	10	1113	704	NA	1444
			4×4	64	10	1122	704	NA	1456

Table 3 Comparison of maximum clock frequency and throughput

Ref.	Detector	Target device	Antennas	QAM	K	Metrics	
						Max. clock frequency (MHz)	Throughput (Mbps)
[21]	K-Best	90nm	4×4	64	8	170	4080
[22]	K-Best	65nm	NA	64	10	499	1198
[23]	K-Best	65nm	4×4	64	10	550	2640
[24]	MINIMUM MEAN SQUARED ERROR (MMSE)	Virtex 7	NA	64	NA	422	1146
[25]	K-Best	22nm	4×4	16	5	NA	3200
[26]	K-Best	Virtex	4×4	64	NA	148.7	281.3
[27]	MINIMUM MEAN SQUARED	Virtex 7	128×16	64	NA	205	1230

	ERROR (MMSE)						
[28]	K-Best	90nm	4×4	64	16	200	1200
[29]	MINIMUM MEAN SQUARED ERROR (MMSE)	Virtex 7	128×8	64	NA	205	308
[30]	MINIMUM MEAN SQUARED ERROR (MMSE) - SQRD	90nm	4×4	64	NA	220	44
[31]	K-Best	Virtex 5	4×4	16	NA	52	27.7
*	NHMD	Virtex 4	2×2	64	10	165.079	495.237
			4×4	64	10	217.794	1306.764
		Virtex 5	2×2	64	10	410.627	1231.881
			4×4	64	10	382.387	2294.322
		Virtex 6	2×2	64	10	518.483	1555.449
			4×4	64	10	454.143	2724.858

NA-not applicable, *this paper

Table 4 Comparison of Power consumption

Ref.	Detector	Target device	Antennas	QAM	K	Power consumption (mW)
[21]	K-Best	90nm	4×4	64	8	234
[22]	K-Best	65nm	NA	64	10	20.77
[23]	K-Best	65nm	4×4	64	10	245
[24]	MINIMUM MEAN SQUARED ERROR (MMSE)	Virtex7	NA	64	NA	NA
[25]	K-Best	22nm	4×4	16	5	NA
[26]	K-Best	Virtex	4×4	64	NA	NA
[27]	MINIMUM MEAN SQUARED ERROR (MMSE)	Virtex7	128×16	64	NA	1660

[28]	K-Best	90nm	4×4	64	16	NA
[29]	MINIMUM MEAN SQUARED ERROR (MMSE)	Virtex7	128×8	64	NA	NA
[30]	MINIMUM MEAN SQUARED ERROR (MMSE) - SQRD	90nm	4×4	64	NA	167
[31]	K-Best	Virtex5	4×4	16	NA	NA
*	NHMD	Virtex4	2×2	64	10	197
			4×4	64	10	198
		Virtex5	2×2	64	10	209
			4×4	64	10	333
		Virtex6	2×2	64	10	575
			4×4	64	10	1293

NA-not applicable, *this paper

6. Conclusion

The BER is a key factor which determines the performance of the MIMO system. This paper successfully implemented NHMT Detector for MIMO system. The presented system improved the performance of MIMO system. This proposed system suitable for the design and development of devices used for future communications like Massive MIMO, 5G and 6G. The NHMT method combines ZF and MINIMUM MEAN SQUARED ERROR (MMSE) to extract maximum gain for the Antenna used in MIMO system which directly improves the performance of the MIMO. The proposed system uses optimal detection schema from the optimal locations of the Antennas and the values are estimated using the Optimum Differential Evolution (ODE) algorithm. The proposed hardware design is used to reduce design logic and energy consumption. BER and complex analysis show the effectiveness of the proposed NHMD compared to the conventional hybrid detectors. The analyses of hardware usage, efficiency and profitability depict the progress of the proposed NHMD design compared to the existing technologies.

Future Direction:

(1) The MIMO system in moved from Multi MIMO into Massive MIMO system, this presented work possible implemented in the 5G Environment (Massive MIMO)
(2) 6G adoptability may tested in the sophisticated laboratory environment
(3) Integration of IOT-with 5G and IOT-6G possibilities open door for many research possibilities

CONFLICT OF INTEREST:

The Authors of this paper state that there no conflict of interest with any one in all means.

Thanking You
Corresponding Author

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Figures

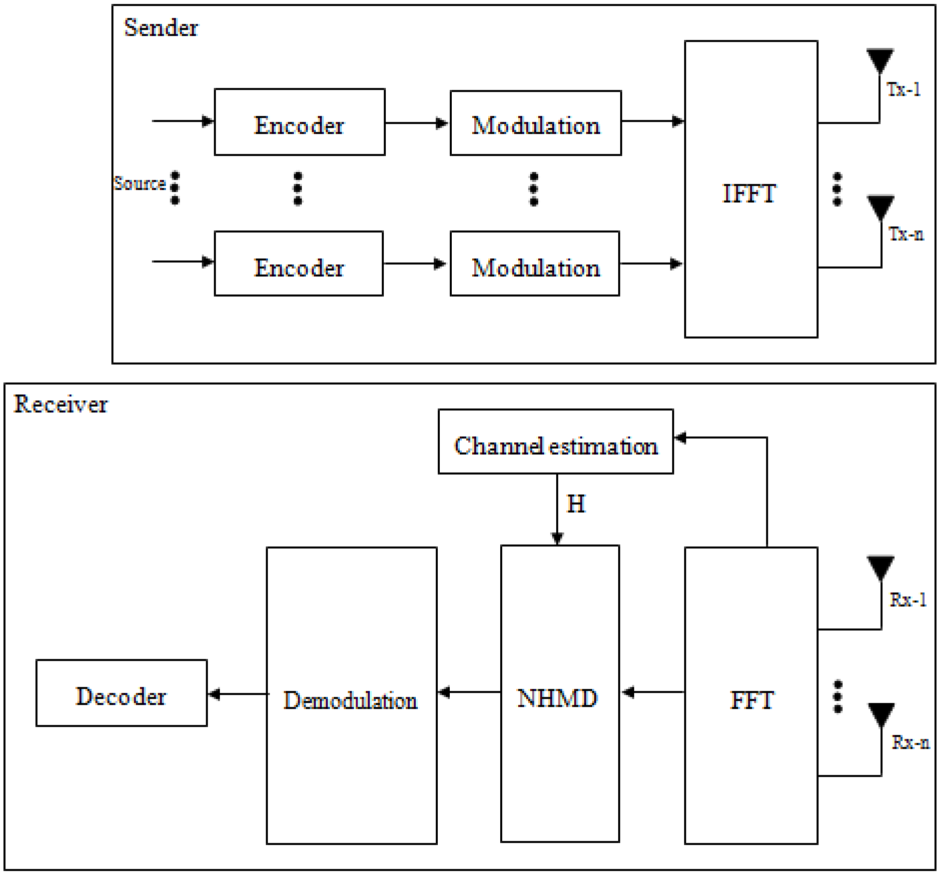


Figure 1

MIMO system with the proposed Novel Hybrid MIMO detector (NHMD)

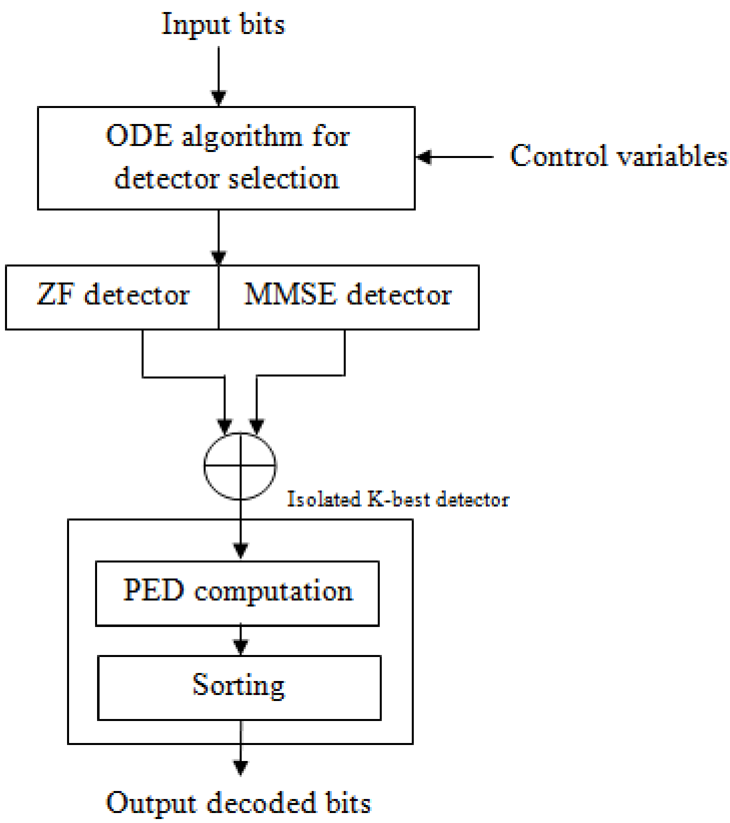


Figure 2

Functional structure of the proposed Novel Hybrid MIMO detector (NHMD)

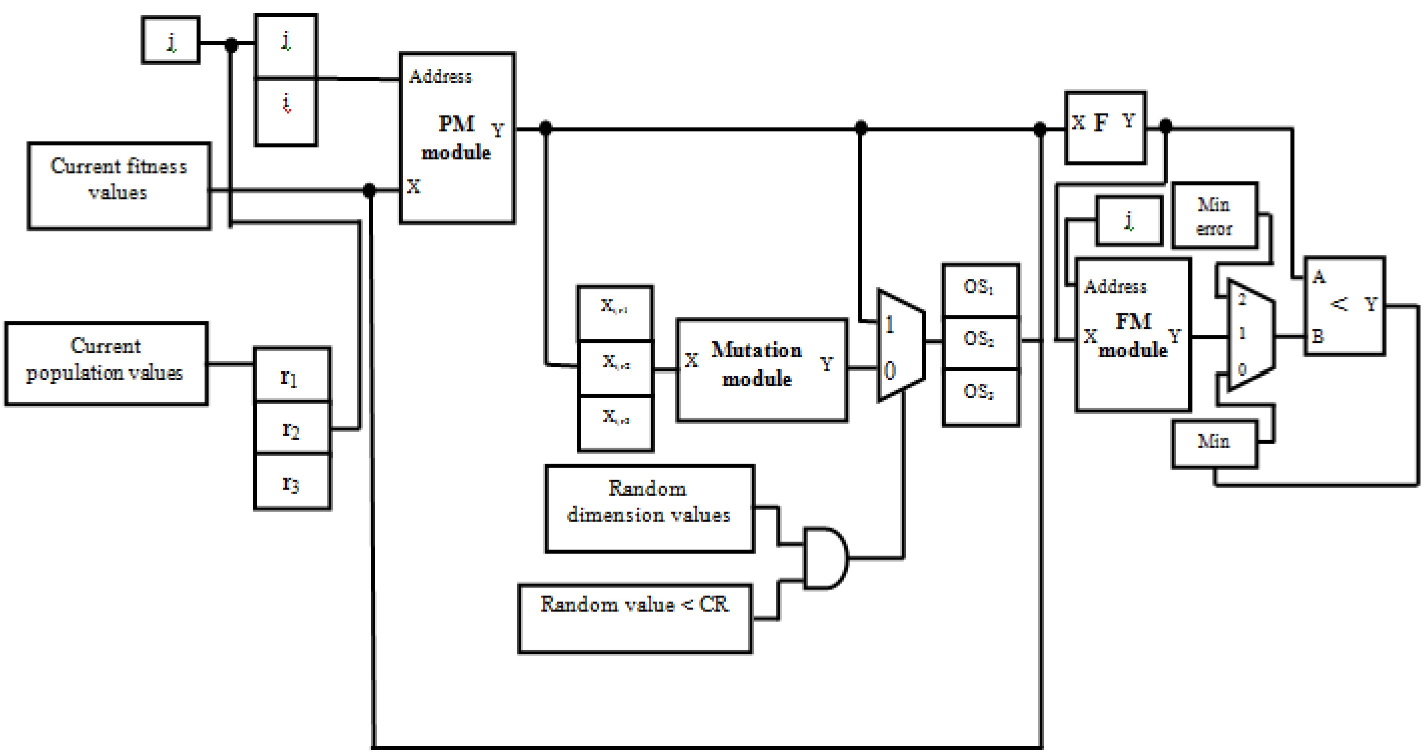


Figure 3

Hardware architecture of the proposed ODE algorithm

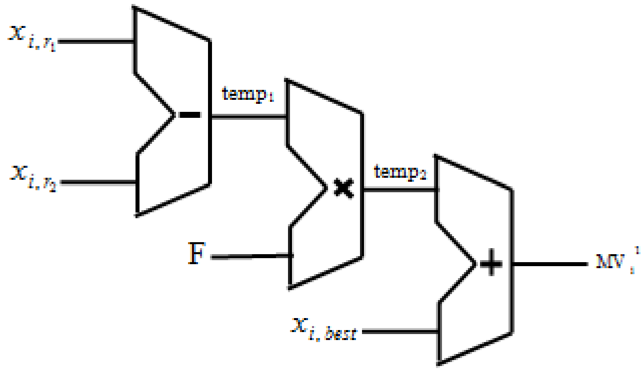


Figure 4

Mutation module

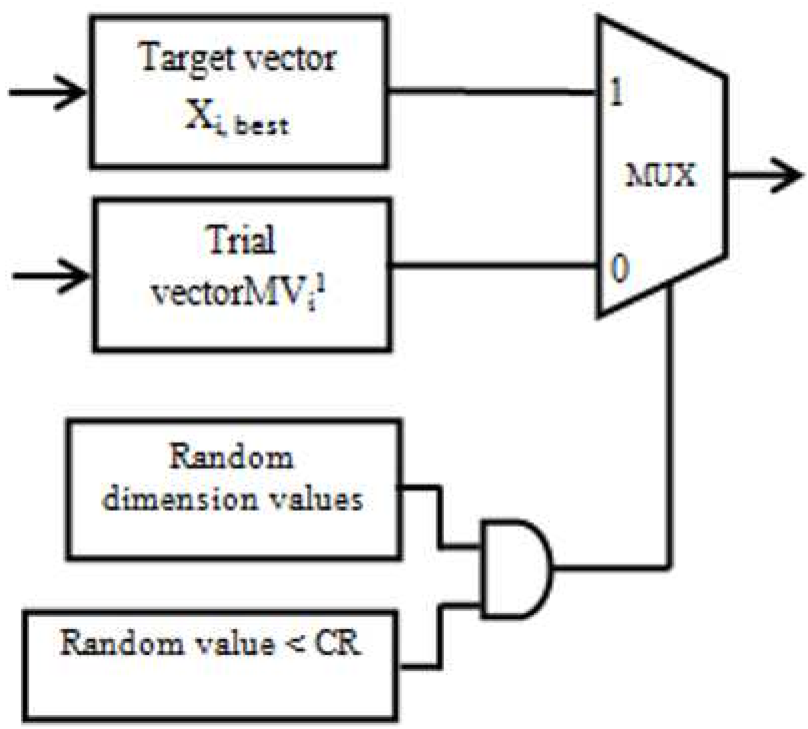


Figure 5

Crossover module

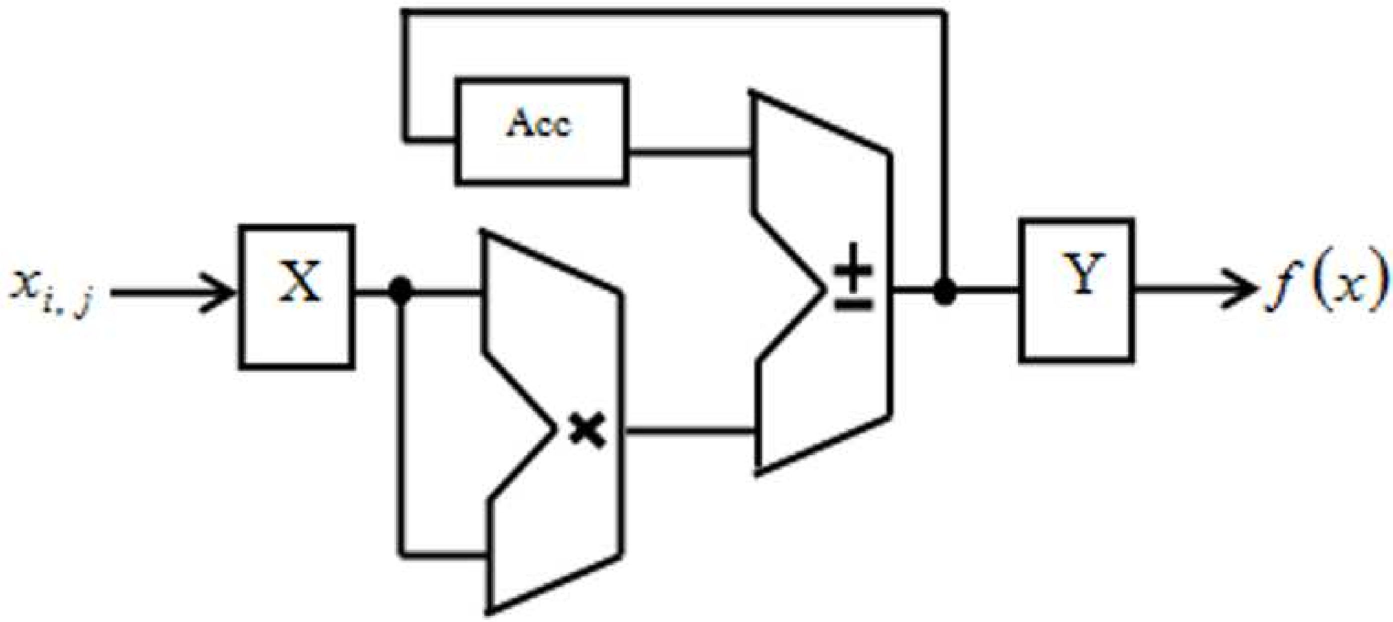


Figure 6

Fitness computation modules based on Sphere function

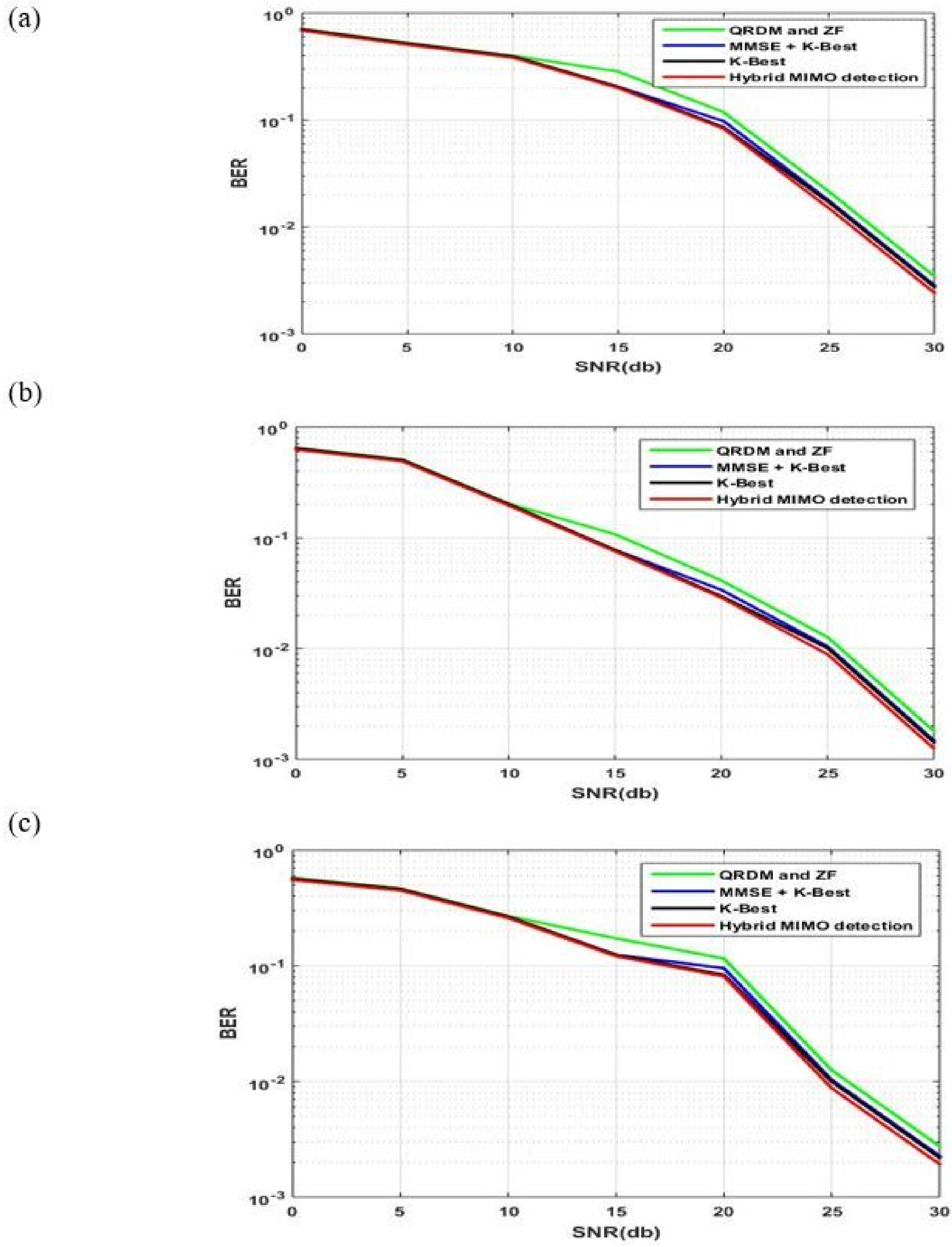


Figure 7

Comparison of BER with 2 × 2 antenna configuration and (a) 16 (b) 64 (c) 256 QAM

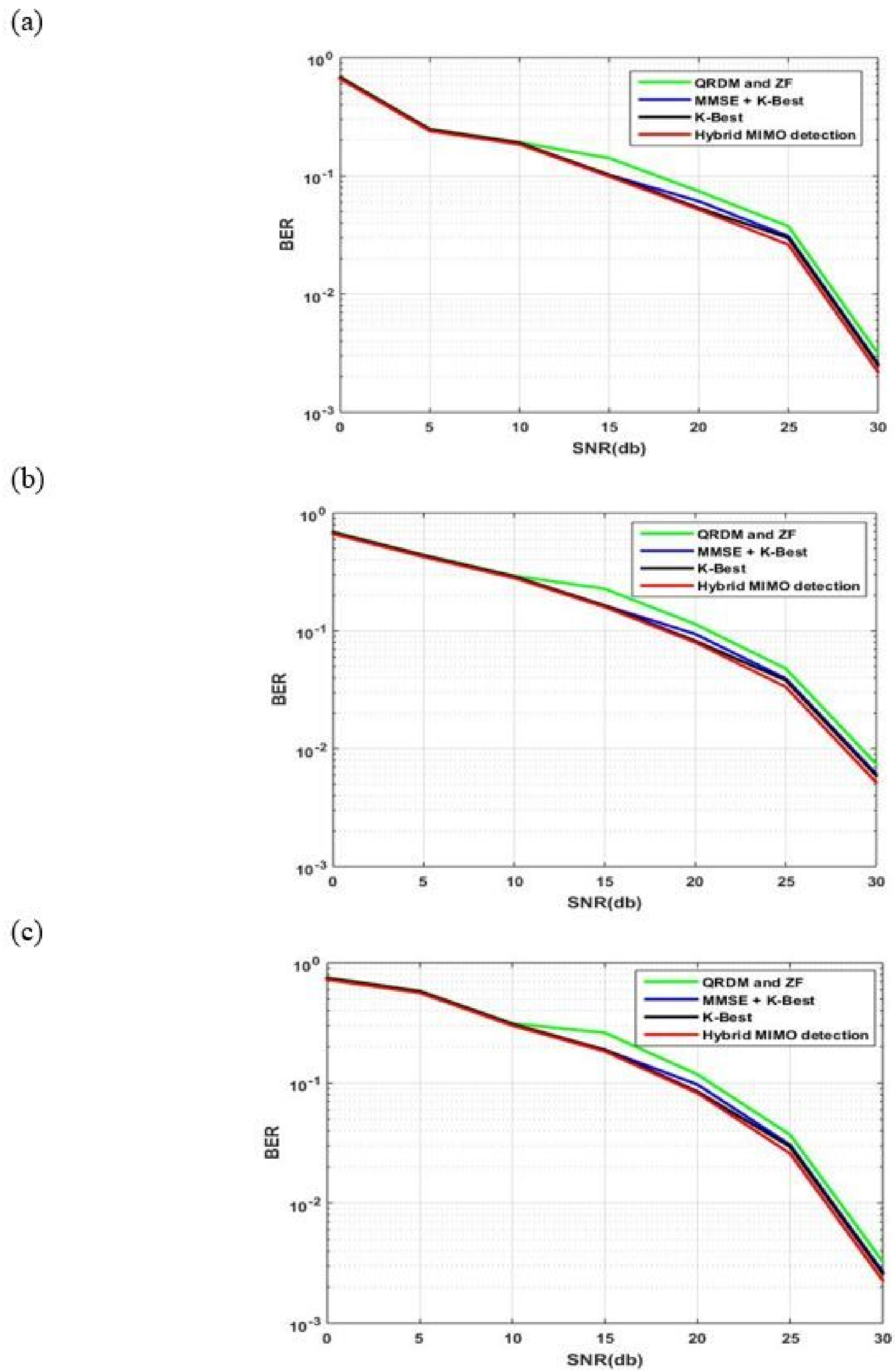
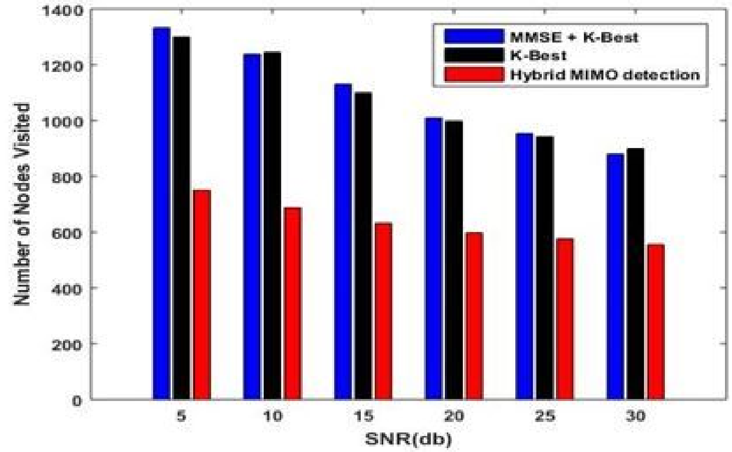


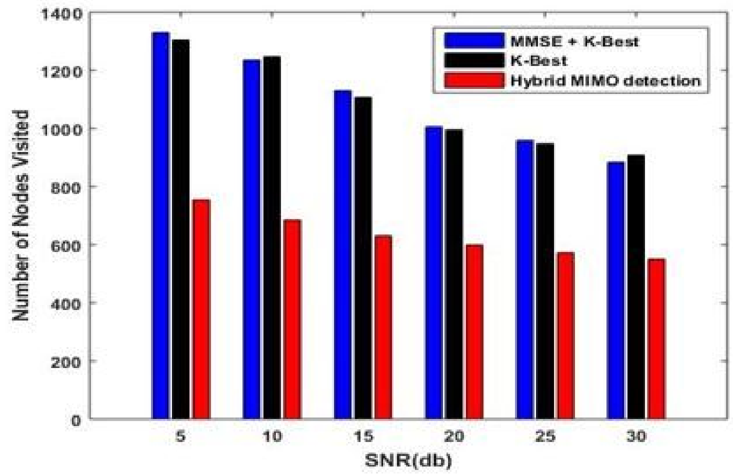
Figure 8

Comparison of BER with 4 × 4 antenna configuration and (a) 16 (b) 64 (c) 256 QAM

(a)



(b)



(c)

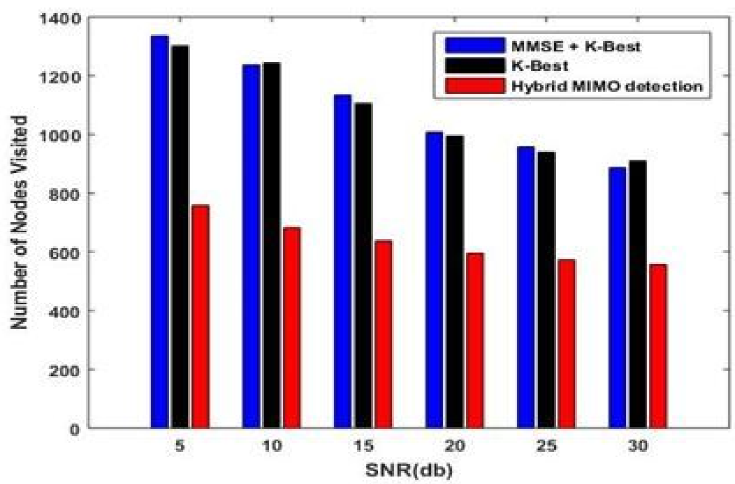


Figure 9

Comparison of number of nodes visited with 2 ×2 antenna configuration and (a) 16 (b) 64 (c) 256 QAM

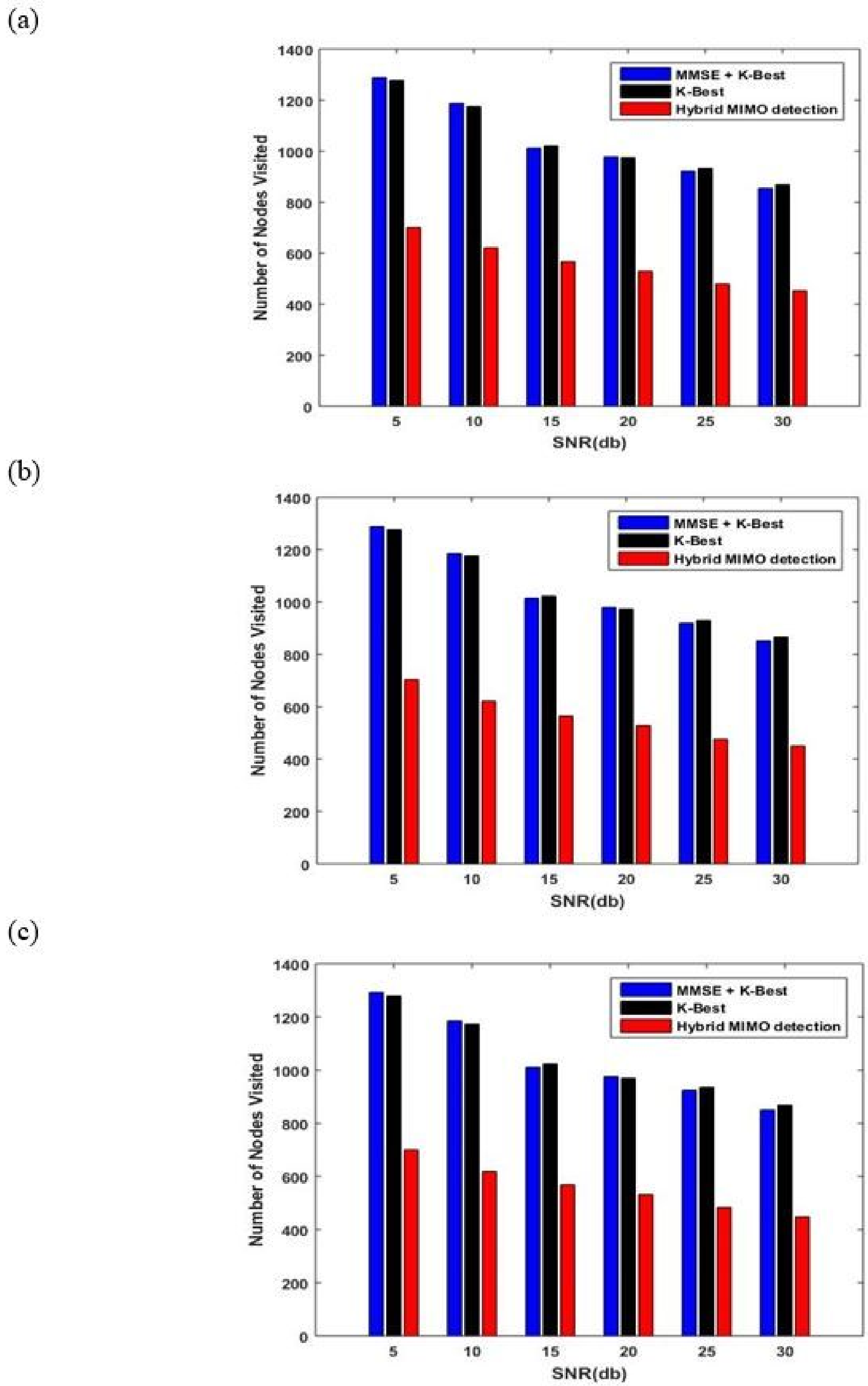


Figure 10

Comparison of number of nodes visited with 4 × 4 antenna configuration and (a) 16 (b) 64 (c) 256 QAM

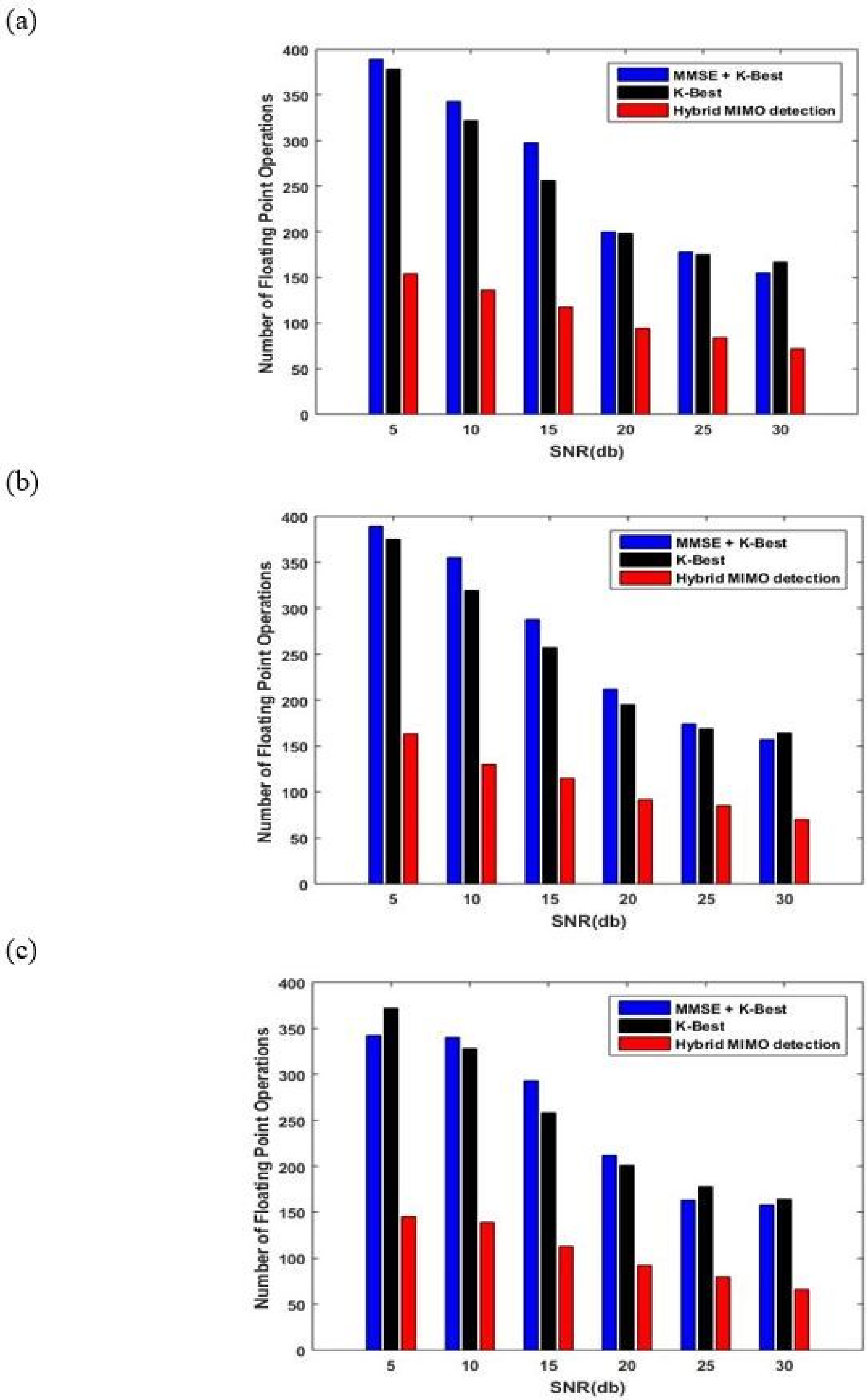


Figure 11

Comparison of number of floating point operations with 2 × 2 antenna configuration and (a) 16 (b) 64 (c) 256 QAM

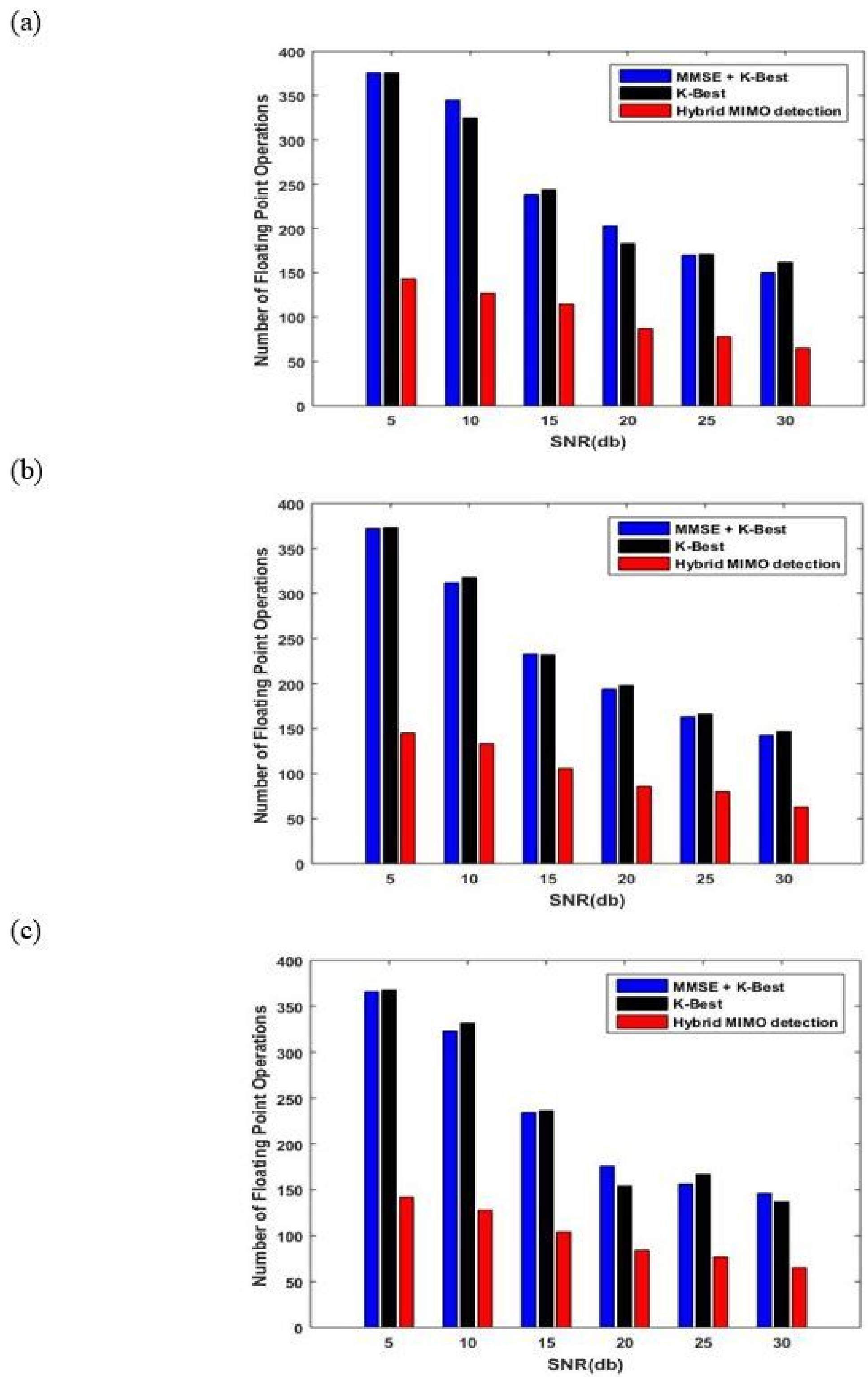


Figure 12

Comparison of number of floating point operations with 4 × 4 antenna configuration and (a) 16 (b) 64 (c) 256 QAM

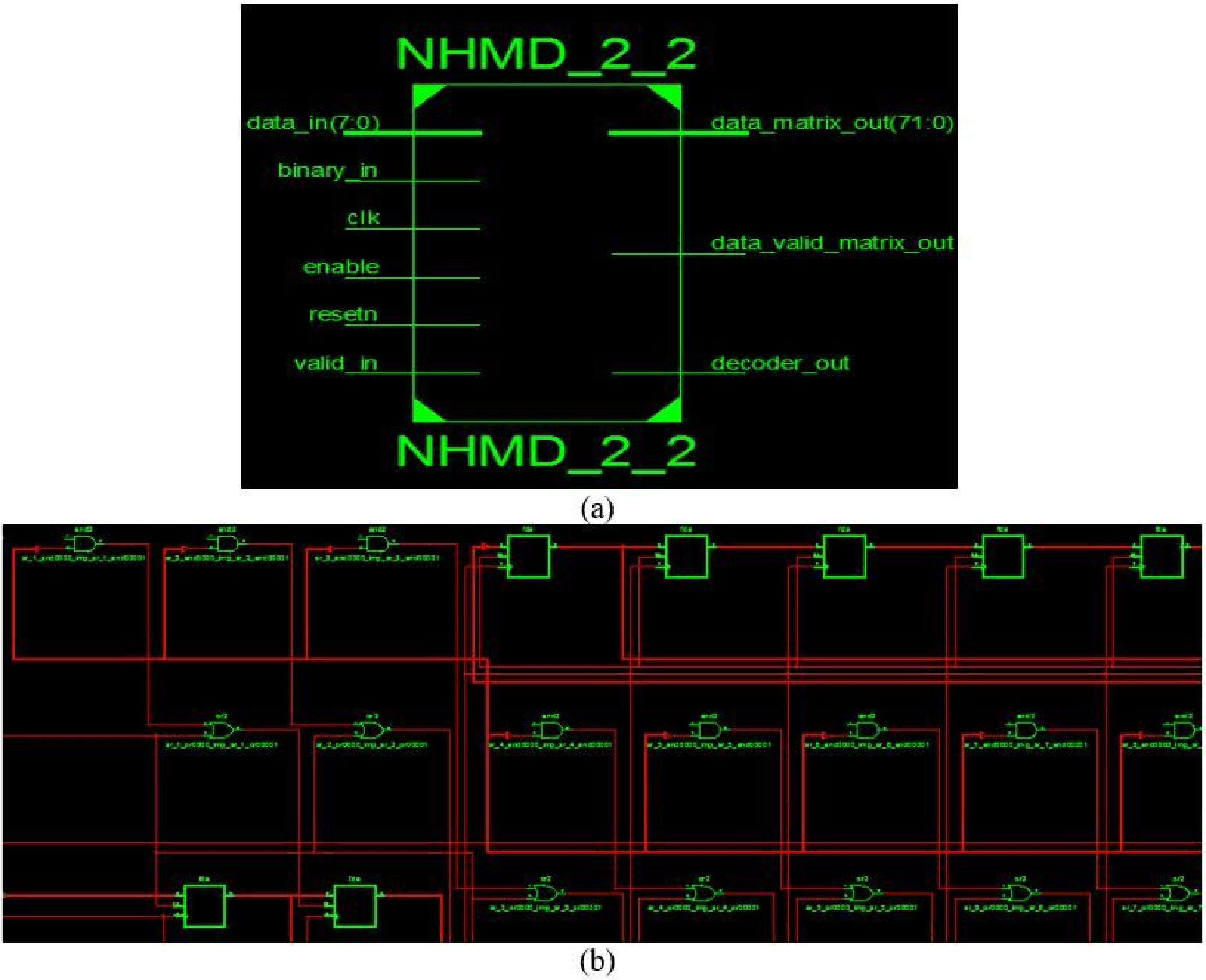


Figure 13

RTL screenshot of NHMD method with 2×2 antenna configuration (a) Outline (b) Deep architecture