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# Improving Computation Complexity in DDSTBC using Coefficient Vectors for Fading Channels

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***Abstract:*** *A coefficient vector technique implemented on a differential distributed space time block coding (DDSTBC) scheme is presented in this paper to improve on the computation complexity of existing DDSTBC schemes. The full mapping scheme and differential technique for utilizing the co- efficient vectors in a two-relay cooperative network is presented and comparison is made between the proposed technique and the traditional unitary matrices based technique. Results obtained from the numerical and simulation analysis conducted, showed that the proposed method presents an improvement in terms of computation complexity and BER performance. The proposed scheme was extended to accommodate networks with four and eight relay nodes utilizing square-real orthogonal codes.*
***Keywords:*** *Differential Distributed Space Time Block Coding, Co-efficient Vectors, Unitary Matrices*

## I. Introduction

In the research carried out in [1, 2], the differential implementation of the Alamouti and generalized square-real orthogonal schemes are designed for cooperative networks where the destination node is unable to acquire full CSI. Similarly, the research in [3-5] was carried out with proper consideration of differential DSTBC from orthogonal designs where it is impossible for either the relay or the destination node to acquire CSI. As opposed to other research works in the literature [6-9], which are based on the implementation of differential techniques on cooperative networks using the traditional unitary matrices based system, a coefficient vector technique is applied in place of the unitary based technique. Based on this, DDSTBC schemes for cooperative networks based on co-efficient vectors are designed. In addition, the mapping scheme and differential technique for utilizing co-efficient vectors in two-relay cooperative networks is presented. In the numerical and simulation results, the co-efficient vector and the unitary matrices schemes are compared in relation to the BER performance and computation complexity. Furthermore, the co-efficient vector scheme is extended to allow for networks with four and eight relay nodes. The major contributions in this letter are as follows:

(1) Different from other existing works in the literature, this letter proposes the co-efficient vector technique and adapts it for differential encoding and decoding. It is noteworthy that the co-efficient vector technique has only been used in [10-15] for multiple antenna networks. This is therefore the first work that explores the use of the co-efficient vector technique for single-antenna cooperative networks.
(2) This paper provides the generalized mapping scheme and differential recipe for utilizing co-efficient vectors in cooperative networks with any number of relay nodes.
(3) Finally, this paper compares and contrasts the traditional unitary matrices design with the co-efficient vector designs in terms of computational complexity and BER performance. From the simulation results, significant findings and deductions are made.

## II. Differential Orthogonal Designs In Cooperative Networks

***(A)*** *Differential DSTBC Using Unitary Matrices:*

*System Model:* Figure 1 shows a cooperative network where the source node transmits the signal in the transmit phase while the two relay nodes and , generate the orthogonal DSTBC matrix signal at the destination node . Each stage contains symbol transmissions where the information signals are in groups of symbols , , = 1, … , , ∈ , + 1 . The power allocation strategy at the source and the cooperating nodes is included in this set-up and it is assumed that the cooperating nodes simply forward their received signals to the destination node without decoding. This design makes use of the maximum likelihood (ML) decoding at the destination node to recover the signals.

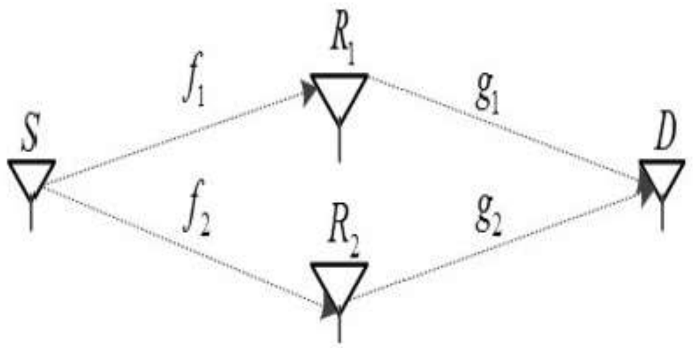


Fig 1: Two-Relay Cooperative Network

## III. Ddstbc Using Coefficient Vectors

Consider the same cooperative network illustrated in Figure 1.The signals $x_{k+1,t}$ , ,t =1,…..T , transmitted in the (k+1)th block are generated from the signals $x_{k,t}$ , t=1,…..T, transmitted in the kth block [11, 16].

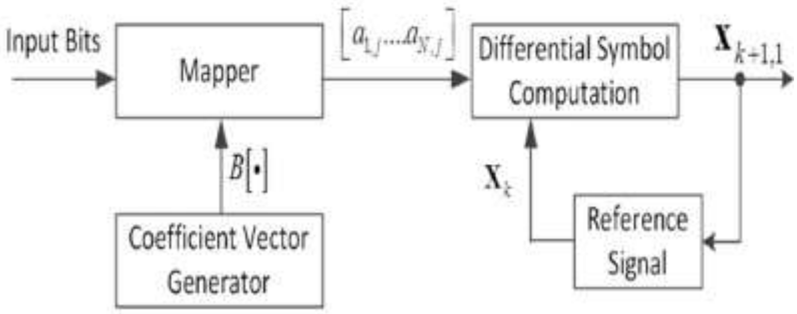


Fig 2: Coefficient Vector based Differential Encoder

Firstly, the modes through which the information signals in the (k+1)th block are generated using the co-efficient vector set. The source node constructs a length $2^{2m}$ co-efficient vector set

$$B = \left\{ [a_{1,1}, a_{2,1}]^{\mathrm{T}}, [a_{1,2}, a_{2,2}]^{\mathrm{T}}, \dots, [a_{1,2^{2m}}, a_{2,2^{2m}}]^{\mathrm{T}} \right\}$$

Which consists of unit-length vectors, where [.]T represents the transpose of the vector. Also, pseudo-random numbers are generated to implement the one-to-one mapping scheme N(.) . These are then defined for the m = log2M signal constellation then 2m information bits are mapped onto B. Differential encoding begins at the source node by transmitting the reference information signal TXN reference orthogonal matrix $X_k$ . Let

$\boldsymbol{X}_k = [\boldsymbol{x}_{k(1),t}, \dots, \boldsymbol{x}_{k(N),t}]$ where $\boldsymbol{x}_{k(n),t} = [x_{k(n),1}, \dots, x_{k(n),T}]^T$ is the nth column of $X_k$.

At the (k+1)th block the 2m information bits are received at the encoder and then the corresponding vectors are selected from the co-efficient vector set B. The selected corresponding vectors:

$[a_{1,n}, a_{2,n}]^{\mathrm{T}},\ n \in \{1,2,\dots,2^{2m}\}$ depends on the 2m information bits and the pseudo-random one-to-one mapping scheme. N(.)described earlier. Assuming $x_{k+1} = [x_{k,1(1)}, x_{k,(1,2)}]$ is transmitted by the source node in the kth block. The source node then computes the signals for the (k+1)th block using the transmitted signals in the kth block and the selected co-efficient vector as follows:

$$\boldsymbol{x}_{k+1,1} = [a_{1,j}, \dots, a_{N,j}]^{1} \boldsymbol{X}_k,\ \ j \in \{1,2,\dots,2^{2m}\}, N = \{2,4,8,\dots\} \qquad (1)$$

By taking the conjugate-transpose of both sides of (1), the following equation is obtained:

$$[a_{1,j}, \dots, a_{N,j}] = \boldsymbol{x}_{k+1,1} \boldsymbol{X}_k^{\ H} \qquad (2)$$

The relay nodes simply recover the elements of the co-efficient vector set and use (2) for differential encoding. This reduces the computational complexity of the encoder such that the relay nodes avoid the first two sub-blocks, the Mapper and theCoefficient Vector Generator, shown in Figure 2.

*B. Implementing Differential Encoding Using Coefficient Vectors (BPSK):* Consider a BPSK modulation scheme with two normalized signal points -1/⌈2 and +1/⌈2. the co-efficient vector set is computed as B = {[1,0],[0,1],[0,-1],[-1,0]} as employed in multiple antenna systems [7]. Thus the mapping scheme N(.)for each set of the information bits to a co-efficient vector set is defined by:

$$N\{(00),(10),(01),(11)\} = \{[1,0]^{\mathrm{T}},[0,1]^{\mathrm{T}},[0,-1]^{\mathrm{T}},[-1,0]^{\mathrm{T}}\} \tag{3}$$

Let the information signal generated at the relay nodes in the kth block be denoted by $\tilde{x}_k(a) = [\tilde{x}_{k,1}, \tilde{x}_{k,2}]$, Therefore The information signals $\tilde{x}_{k+1,1} = [\tilde{x}_{k+1,1}, \tilde{x}_{k+1,2}]$ to be transmitted in the (k+1)th block is generated using (3) in each realy node as:

$$\tilde{x}_{k+1,1} = 1.\left[+1/\sqrt{2},+1/\sqrt{2}\right]^{\mathrm{T}} + 0.\left[+1/\sqrt{2},-1/\sqrt{2}\right]^{\mathrm{T}} = \left[+1/\sqrt{2},+1/\sqrt{2}\right]^{\mathrm{T}} \tag{4}$$

This implies that, the signals to be transmitted in the (k+1)th block are represented in terms of a linear combination of the signals in the kth block and the co-efficient vector. The coefficient vector [1,0]T is determined by the recovered information bits (0,0) .Thus, at the first transmission interval of the (k+1)th block, the first relay R1 transmits $\tilde{x}_{k+1,1} = +1/\sqrt{2}$, while the second relay R2 transmits $\tilde{x}_{k+1,2} = +1/\sqrt{2}$. Similarly, at second transmission interval of the (k+1)th block,first relay node R1 transmit $\tilde{x}_{k+1,2} = +1/\sqrt{2}$. while the second relay node R2 transmits $\tilde{x}_{k+1,1}^{*} = +1/\sqrt{2}$. .Table 1 shows the BPSK signals transmitted by the relay nodes.

| Node | $k_{th}$ block | | $(k+1)_{th}$ block | |
|---|---|---|---|---|
| $R_1$ | $\tilde{x}_{k,1} = +1/\sqrt{2}$ | $-\tilde{x}_{k,2}^{*} = -1/\sqrt{2}$ | $\tilde{x}_{k+1,1} = +1/\sqrt{2}$ | $-\tilde{x}_{k+1,2}^{*} = -1/\sqrt{2}$ |
| $R_2$ | $\tilde{x}_{k,2} = +1/\sqrt{2}$ | $\tilde{x}_{k,1}^{*} = +1/\sqrt{2}$ | $\tilde{x}_{k+1,2} = +1/\sqrt{2}$ | $\tilde{x}_{k+1,1}^{*} = +1/\sqrt{2}$ |

Table 1: BPSK Differential Encoding at the Relays Nodes

**C**. Implementing Differential Encoding Using Co-efficient Vectors (QPSK): For the QPSK configuration, consider the normalized signal points, $-1/\sqrt{2}, +1/\sqrt{2}, -j/\sqrt{2}$ and $+j/\sqrt{2}$. .The coefficient vector set is computed by each node as in multiple antenna systems[10].

$$B = \{(1,0),(0,1),(0,-1),(-1,0),(j,0),(0,j),(0,-j),(-j,0),(0.5+0.5j,-0.5+0.5j),(-0.5+0.5j,0.5+0.5j),(-0.5-0.5j,0.5-0.5j),(0.5-0.5j,-0.5-0.5j),(0.5-0.5j,0.5+0.5j),(-0.5-0.5j,-0.5+0.5j),(-0.5+0.5j,-0.5-0.5j),(0.5+0.5j,0.5-0.5j)\}$$

The components of the vector set depend on the 2m information bits and the random one-to-one mapping technique N(.), where the components of N(.) are as follows:

$$\begin{Bmatrix}(0000),(0001),(0010),(0011),(0100),(0101),(0110),(0111)\\(1000),(1001),(1010),(1011),(1100),(1101),(1110),(1111)\end{Bmatrix}$$

Thus, the mapping N(.) maps four input bits onto B and the differential encoding follows the same procedure as in the BPSK configuration, using (5).

*D.* Differential Decoding Using Co-efficient Vectors: Next, the mode through which the differential decoding is Implemented is discussed. The destination node is equipped with a single antenna, thus the received signal from the relay nodes in each block at the $t_{th}$ transmission interval is given by:

$$y_{k,1} = \tilde{x}_{k,1} g_1 + \tilde{x}_{k,2} g_2 + z_{k,1}$$
$$y_{k,2} = -\tilde{x}^*_{k,2}\, g_1 + \tilde{x}^*_{k,1}\, g_2 + z_{k,2}$$
$$y_{k+1,1} = \tilde{x}_{k+1,1} g_1 + \tilde{s}_{k+1,2} g_2 + z_{k+1,1}$$
$$y_{k+1,2} = -\tilde{x}_{k+1,2}{}^* g_1 + \tilde{x}_{k+1,1}{}^* g_2 + z_{k+1,2} \qquad (5)$$

where $g_n$ is the Rayleigh flat fading channel between the $n_{th}$ relay node and the destination node, and $Z_{K,n}$ $K \in \{k, k+1\}$represents the corresponding noise. The vector representation of the received signals is given by:

$$\begin{bmatrix} y_{k,1} \\ y_{k,2}{}^* \end{bmatrix} = \boldsymbol{G} \begin{bmatrix} \tilde{x}_{k,1} \\ \tilde{x}^*_{k,2} \end{bmatrix} + \begin{bmatrix} z_{k,1} \\ z_{k,2}{}^* \end{bmatrix} \qquad (6)$$

$$\begin{bmatrix} y_{k+1,1} \\ y_{k+1,2}{}^* \end{bmatrix} = \boldsymbol{G} \begin{bmatrix} \tilde{x}_{k+1,1} \\ \tilde{x}_{k+1,2} \end{bmatrix} + \begin{bmatrix} z_{k+1,1} \\ z_{k+1,2}{}^* \end{bmatrix} \qquad (7)$$

$$\begin{bmatrix} y_{k,2} \\ -y_{k,1}{}^* \end{bmatrix} = \boldsymbol{G} \begin{bmatrix} -\tilde{x}^*_{k,2} \\ \tilde{x}_{k,1}{}^* \end{bmatrix} + \begin{bmatrix} z_{k,2} \\ -z_{k,1}{}^* \end{bmatrix} \qquad (8)$$

where $\boldsymbol{G} = \begin{bmatrix} g_1 & g_2{}^* \\ g_2 & -g_1{}^* \end{bmatrix}$ is the equivalent matrix.Estimated decision statistics $[\tilde{a}_{1,n}, \tilde{a}_{2,n}]^{\mathrm{T}},\ n \in \{1, 2, \ldots, 2^{2m}\}$ are computed at the destination node as the dot product of the received signal vectors in (6) to (8) as follows:

$$\tilde{a}_{1,n} = [y_{k+1,1}, y_{k+1,2}{}^*]^{\mathrm{T}} \cdot [y_{k,1}, y_{k,2}{}^*]^{\mathrm{T}}$$
$$= \boldsymbol{G} \begin{bmatrix} \tilde{x}_{k+1,1} \\ \tilde{x}_{k+1,2} \end{bmatrix} + \begin{bmatrix} z_{k+1,1} \\ z_{k+1,2}{}^* \end{bmatrix} \boldsymbol{G} \begin{bmatrix} \tilde{x}_{k,1} \\ \tilde{x}^*_{k,2} \end{bmatrix} + \begin{bmatrix} z_{k,1} \\ z_{k,2}{}^* \end{bmatrix} =$$
$$\left[\boldsymbol{G} \begin{bmatrix} \tilde{x}_{k+1,1} \\ \tilde{x}_{k+1,2} \end{bmatrix} + \begin{bmatrix} z_{k+1,1} \\ z_{k+1,2}{}^* \end{bmatrix}\right] \left[\boldsymbol{G} \begin{bmatrix} \tilde{x}_{k,1} \\ \tilde{x}_{k,2} \end{bmatrix} + \begin{bmatrix} z_{k,1} \\ z_{k,2}{}^* \end{bmatrix}\right]^H \qquad (9)$$

In substituting for G in (9), the equation below is obtained:

$$\tilde{a}_{1,n} = (|g_1|^2 + |g_2|^2)(\tilde{x}_{k,1}{}^* \tilde{x}_{k+1,1} + \tilde{x}_{k,2}{}^* \tilde{x}_{k+1,2}) + \tilde{z}_1$$
$$\tilde{a}_{1,n} = (|g_1|^2 + |g_2|^2) a_{1,n} + \tilde{z}_1 \qquad (10)$$

Similarly,

$$\tilde{a}_{2,n} = [y_{k+1,1}, y_{k+1,2}{}^*]^T \cdot [y_{k,2}, -y_{k,1}{}^*]^T$$
$$= \boldsymbol{G} \begin{bmatrix} \tilde{x}_{k+1,1} \\ \tilde{x}_{k+1,2} \end{bmatrix} + \begin{bmatrix} z_{k+1,1} \\ z_{k+1,2}{}^* \end{bmatrix} \boldsymbol{G} \begin{bmatrix} -\tilde{x}^*_{k,2} \\ \tilde{x}_{k,1}{}^* \end{bmatrix} + \begin{bmatrix} z_{k,2} \\ -z_{k,1}{}^* \end{bmatrix} =$$
$$\left[\boldsymbol{G} \begin{bmatrix} \tilde{x}_{k+1,1} \\ \tilde{x}_{k+1,2} \end{bmatrix} + \begin{bmatrix} z_{k+1,1} \\ z_{k+1,2}{}^* \end{bmatrix}\right] \left[\boldsymbol{G} \begin{bmatrix} -\tilde{x}^*_{k,2} \\ \tilde{x}_{k,1}{}^* \end{bmatrix} + \begin{bmatrix} z_{k,2} \\ -z_{k,1}{}^* \end{bmatrix}\right]^H \qquad (11)$$

In substituting for G into (11), (12) below is obtained:

$$\tilde{a}_{2,n} = (|g_1|^2 + |g_2|^2)(\tilde{x}_{k,1}{}^* \tilde{x}_{k+1,1} - \tilde{x}_{k,2}{}^* \tilde{x}_{k+1,2}) + \tilde{z}_2$$
$$\tilde{a}_{2,n} = (|g_1|^2 + |g_2|^2) a_{2,n} + \tilde{z}_2 \qquad (12)$$

Now, the vector representation of the estimated decision statistics is obtained through the combination of (10) and (12) and then (13) below is deduced:

$$\begin{bmatrix} \tilde{a}_{1,n} \\ \tilde{a}_{2,n} \end{bmatrix} = \begin{bmatrix} |g_1|^2 \\ |g_2|^2 \end{bmatrix} \begin{bmatrix} a_{1,n} \\ a_{2,n} \end{bmatrix} + \begin{bmatrix} \tilde{z}_1 \\ \tilde{z}_2 \end{bmatrix} \qquad (13)$$

From (13), the estimated decision statistics ă1,n and ă2,n only serve as a function of the corresponding elements of the coefficient vector set obtained in (12). However, since all the elements of the co-efficient vector set B have equal lengths, the destination node selects the closest co-efficient vector to ă1,n and ă2,n from B as the detector output. This generally requires an exhaustive search over the $2^{2m}$ combinations. Then the inverse mapping is applied to recover the information bits.

*E.* Differential Square Real-orthogonal Designs using Coefficient Vectors: In this set-up, the focus is on how the differential encoding and decoding techniques occur at the source and destination nodes respectively.

$\boldsymbol{X}_k = [\boldsymbol{x}_{k(1),t}, \ldots, \boldsymbol{x}_{k(N),t}]$ where $\boldsymbol{x}_{k(n),t} = [x_{k(n),1}, \ldots, x_{k(n),T}]^T$. Let Xk denote the T X N reference orthogonal matrix. The source node transmits $\boldsymbol{x}_{k(1),t} = [x_{k(1),1}, x_{k(1),2}, x_{k(1),3} x_{k(1),4}]^T$ to the N = 4 cooperating nodes. In the Kth block, the source node transmits a column vector of Xk. The N cooperating relay nodes then construct code words using their relay matrices to generate the N × T square real-orthogonal matrix Xk at the destination node.In the (k+1)th block, a set of Nm information bits from m=log2M MPSK constellation is generated at the source node by the encoder. Note that for real orthogonal designs, the resultant symbols must be real.

The source computes a co-efficient vector set:

$B = \{[a_{1,1}, a_{2,1}]^{\mathrm{T}}, [a_{1,2}, a_{2,2}]^{\mathrm{T}}, \ldots, [a_{1,2^{2m}}, a_{2,2^{2m}}]^{\mathrm{T}}\}$ with $2^{Nm}$ elements all made up of unit-length distinct vectors. Then based on the input information bits, the encoder selects the corresponding N-length co-efficient vector $[a_{1,j}, \ldots, a_{N,j}]^{\mathrm{T}},\ j \in \{1,2, \ldots, 2^{Nm}\}$ from the co-efficient vector set. The source node then computes the information signals for the (k+1)th block using the information signals in the Kth block and the selected co-efficient vector as follows:

$$\boldsymbol{x}_{k+1(1),t} = \boldsymbol{x}_{k(1),t}[a_{1,j}, \ldots, a_{N,j}]^{\mathrm{T}},\ j \in \{1,2, \ldots, 2^{Nm}\} \qquad (14)$$

The elements of Xk form an orthonormal basis for an N dimensional real signal space, which implies $\boldsymbol{X}_k{}^H \boldsymbol{X}_k = I_N$ thus, taking the conjugate-transpose of both sides of Equation 4.44, the equation below is obtained:

$$[a_{1,j}, \ldots, a_{N,j}]^{\mathrm{T}} = \boldsymbol{X}_k \boldsymbol{x}_{k+1(1),t}{}^H \qquad (15)$$

The selected coefficient vector can be represented using (15),such that, given all the possible outcomes of $x_{k+1(1),t}, t = 1,2, \ldots, T$,there exists $2^{Nm}$ corresponding coefficient vectors. In other words, there is a one-to-one mapping between the coefficient vectors and the input information signals. Assuming the relay nodes are capable of computing the coefficient vector set such that their received signals are differentially decoded and re-encoded, and if the destination node is designed with a single antenna, then the signal received in the Kth block will be:

$$\boldsymbol{Y}_k = [\boldsymbol{y}_{k,1}, \boldsymbol{y}_{k,2}, \ldots, \boldsymbol{y}_{k,n}]^{\mathrm{T}} = \widetilde{\boldsymbol{X}}_k \boldsymbol{G}_k + [\boldsymbol{z}_{k,1}, \boldsymbol{z}_{k,2}, \ldots, \boldsymbol{z}_{k,n}]^{\mathrm{T}} \qquad (16)$$

where Gk is the N × T channel matrix between the relay and destination nodes, Zk represents the noise vector. In addition, the signal received in the first transmission interval of the (k+1)th block is given by:

$$\boldsymbol{y}_{k+1,1} = \widetilde{\boldsymbol{x}}_{k+1,1} \boldsymbol{G}_{k+1} + \boldsymbol{z}_{k+1,1} \qquad (17)$$

Assuming the fading conditions remain constant during the transmission in both blocks, which means that $\boldsymbol{G}_k \cong \boldsymbol{G}_{k+1}$ and then the estimate of components of the co-efficient vector is calculated as the dot product of the signals received in both blocks in (16) and (17) as:

$$\begin{aligned}[\tilde{a}_{1,j}, \tilde{a}_{2,j}, \ldots, \tilde{a}_{N,j}] &= \boldsymbol{y}_{k+1,1} \cdot \boldsymbol{y}_{k,n} \\ &= [\widetilde{\boldsymbol{x}}_{k+1,1} \boldsymbol{G}_{k+1} + \boldsymbol{z}_{k+1,1}]\,[\widetilde{\boldsymbol{x}}_{k,1} \boldsymbol{G}_k + \boldsymbol{z}_{k,n}]^H \\ &= \textstyle\sum_{n=1}^{N} |g|^2\, \widetilde{\boldsymbol{x}}_{k+1,1} \widetilde{\boldsymbol{X}}_k^H + \boldsymbol{z}_{k,n} \end{aligned} \qquad (18)$$

If the relay nodes perfectively recover the information signals, then by substituting (16) into (18) the equation below is obtained:

$$[\tilde{a}_{1,j}, \tilde{a}_{2,j}, \ldots, \tilde{a}_{N,j}] = \textstyle\sum_{n=1}^{N} |g_n|^2\, [a_{1,j}, a_{2,j}, \ldots, a_{N,j}] + \boldsymbol{z}_{eq} \quad (19)$$

Thus, the estimates of the co-efficient vectors are only a function of the differential co-efficient vectors. Then the inverse mapping is applied to recover the information bits. From (19), the ability of the differential real-orthogonal design in the N-relay cooperative set-up achieving a N-level transmit diversity is clear.

## IV. Simulation Results

The differential orthogonal scheme is implemented using two cooperating relay nodes over flat Rayleigh faded channels and its performance is analyzed via simulation. The fading is assumed to remain constant for at least two consecutive information blocks.

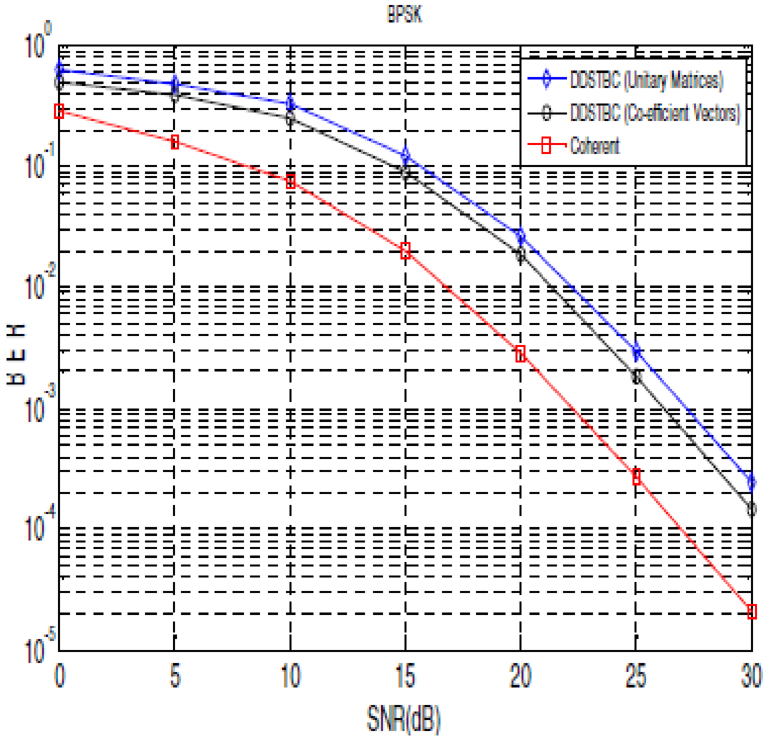


Fig 3: Co-efficient Vector and Unitary Matrices schemes in BPSK

From the results obtained, the co-efficient vector scheme shows a slight improvement when compared to the unitary matrices scheme in terms or performance especially in the high SNR area. However, at 15dB or lower SNR values, there is no significant difference in the performance. A significant difference between the designs is however observed in terms of the computation complexity of the decoder at the relay nodes and the destination node as described in the numerical analysis in previous section.

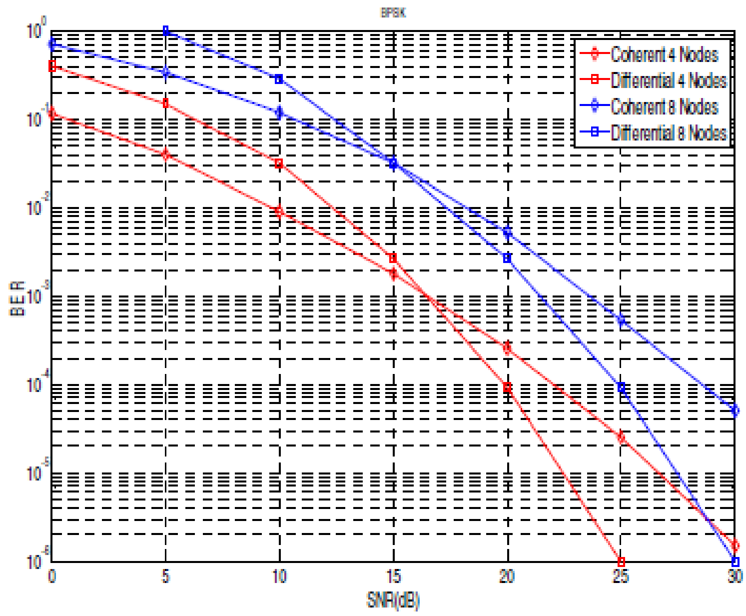


Figure 4: Differential Techniques Implemented on Four and Eight Relay Nodes

In Figure 4, the coherent scheme is compared with the differential scheme and it is observed that the performance curve of the differential scheme with four cooperating relay nodes is parallel to those with eight relay nodes. This shows that the co-efficient vector scheme is also capable of achieving full diversity similar to the unitary matrices scheme. In addition, there is an increase in the diversity performance alongside the number of cooperating nodes. Assuming this is applied to four relay nodes for example, the differential square real-orthogonal codes at $10^{-4}$BER the four-relay network scheme, incurs approximately 3dB SNR degradation in comparison to the coherent networks with four relay nodes.

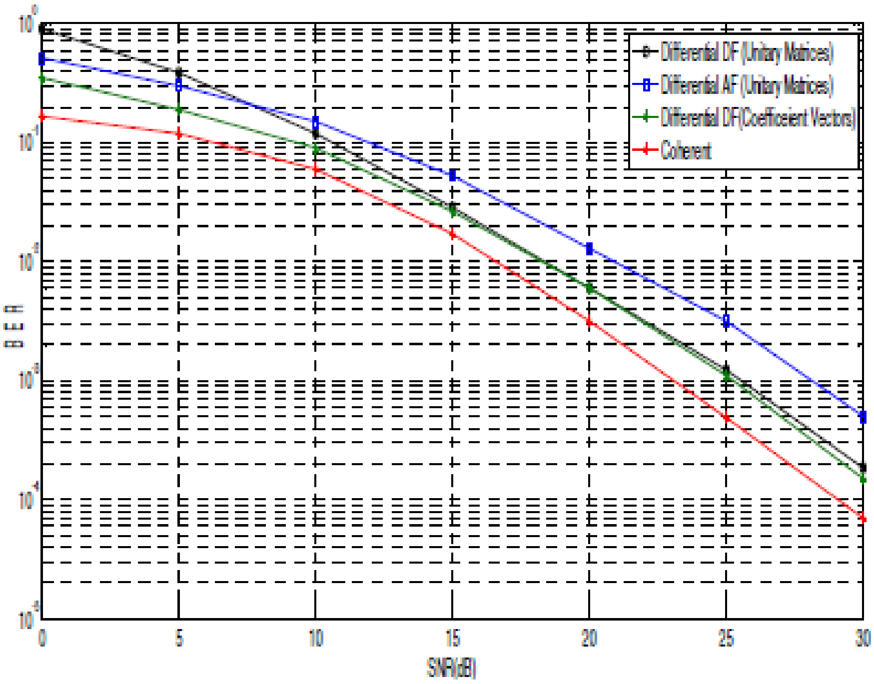


Figure 5: Comparison of Unitary and Coefficient Vector-based Schemes Using the Relay Protocols on QPSK Configuration

In Figure 5, it is observed that the performance of coefficient vector-based scheme is slightly better than the performance of the unitary matrices scheme in the low SNR region. The performance improves significantly in the high SNR region.From the simulation result, it can be observed that at $10^{-3}$ BER,the improvement in performance is about 3dB.

## V. Conclusion

The implementation of the co-efficient vector based design on the differential DSTBC offers codes a low computation complexity of the decoder at the relay and destination nodes respectively. In addition, from the simulation results in Figure 3, it is obvious that the co-efficient vector scheme has a slightly improved performance when compared to that of the existing scheme. The coefficient vector based technique has also been generalized to cooperative networks with three, four and eight nodes to show the potency and universality of the proposed technique. The results in Figure 4 also prove the co-efficient vector based technique is capable of achieving full diversity similar to its unitary matrices based counterpart. The digital base band of the PHY layer in MB-OFDM UWB system was implemented, first design the system in states CFO effect greatly reduces the BER effect.

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