BLIND RELAY NETWORK WITH VITERBI DETECTION

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ANALYSIS OF DIFFERENT DETECTION SCHEMES IN RELAY CASE

The following faculty members have examined the final copy of this thesis for form and content, and recommend that it be accepted in partial fulfillment of the requirement for the degree of Master of Science with a major in Electrical Engineering.

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ABSTRACT

This thesis compared the performance of a blind relay communication system with that of a non-blind relay communication system. For a blind system, a differential space-time block code (DSTBC) or a blind Viterbi detection were used, and for a non-blind system, a space-time block code (STBC) was used. Also, this thesis took another blind detection mechanism, the Zhang's code, and compared its performance with that of the blind Viterbi detection under a Jakes' fading environment. It was found that the case of a relay closer to the destination shows better performance than the other case of a relay closer to the destination. It was also observed that the blind Viterbi decoder shows better performance than the Zhang's code under the Jakes' fading environment.

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LIST OF ABBREVIATIONS/NOMENCLATURE

AF	Amplify and Forward
BER	Bit Error Rate
BPSK	Binary Phase Shift Keying
dB	Decibel
DF	Decode and Forward
Dsd	Distance between Source and Relay
DSTBC	Differential Space-Time Block Code
QPSK	Quadrature Phase Shift Keying
SER	Symbol Error Rate
SNR	Signal-to-Noise Ratio
STBC	Space-Time Block Code
3PSK	Three Phase Shift Keying

CHAPTER 1

INTRODUCTION

1.1 Introduction to Relay System

A typical amplify-and-forward (AF) relay network consists of a source, a relay, and a destination. A source transmits its message to both the relay and the destination during the first slot time interval. And the relay amplifies its received signal and transmits to the destination during the second slot time interval. The destination combines the signals received from both the source and the relay during the first and second slot time intervals, respectively.

A typical decode-and-forward (DF) relay network decodes the information at the relay, and re-encodes and transmits it to the destination during the second slot time interval. There are many variations [1].

1.2 Introduction to Coherent and Noncoherent Detection

Coherent detection means the channel coefficients are known to the relay and the destination. For example, the space-time block code (STBC) requires the channel coefficient information for detection. On the other hand, noncoherent detection means that the channel coefficients are unknown to the relay and the destination. For example, the following do not require channel coefficient information: differential space-time block code (DSTBC) as used by Tarokh and Jafarkhani [2], the blind Viterbi detection as used by Shao et al. [3], and blind detection as used by Zhang and Ma [4].

1.3 Thesis Contribution

The contribution of this thesis is the application of various instances of blind detection [2], [3], [4] in a relay network and comparisons of their performances.

1.4 Thesis Outline

This thesis is organized as follows:

- Chapter 2. Review of Coherent and Noncoherent Schemes
- Chapter 3. System Model
- Chapter 4. Simulation Results
- Chapter 5. Conclusion

CHAPTER 2

REVIEW OF COHERENT AND NONCOHERENT SCHEMES

2.1 Space-Time Block Code

In this thesis, a system with two transmit antennas and one receive antenna was considered. The modulation set was given as

$$A = \left\{ \frac{e^{\frac{2\pi k j}{M}}}{\sqrt{2}}, k = 0, 1, \dots, M - 1 \right\} \quad (2.1)$$

where $M = 2^b$, $\sqrt{-1} = j$, b = the number of bits per symbol, and the division with $\sqrt{2}$ is for the normalized power shared by two transmit antennas.

At the first symbol time, two symbols will be sent simultaneously by two antennas. The symbol sent by antenna one is denoted by s_1 , and the symbol sent by antenna two is denoted by s_2 . At the next symbol time, $-s_2^*$ will be sent by antenna one, and s_1^* will be sent by antenna two, where the superscript (*) is the complex conjugate operation. Therefore, the STBC can be represented as shown in Table 2.1

TABLE 2.1

THE STBC ENCODING AND TRANSMISSION SEQUENCE

	Antenna One	Antenna Two
First Symbol Time	s_1	s_2
Second Symbol Time	$-s_2^*$	s_1^*

At the receiver, the received signals in those two symbol periods, r_1 and r_2 , can be expressed as

$$r_1 = h_1 s_1 + h_2 s_2 + n_1 \quad (2.2)$$

$$r_2 = -h_1 s_2^* + h_2 s_1^* + n_2$$

where r_t , $t = 1, 2$ indicates the received signals at the t -th symbol time; h_i , $i = 1, 2$ are the fading coefficients for the i -th transmitter to the receiver; and n_i , $i = 1, 2$ are the complex Gaussian noise random variables.

For the STBC, it was assumed that the receivers completely know the channel state information. Therefore, the STBC is a coherent detection scheme. Then the S_1 and S_2 can be estimated as

$$\hat{s}_1 = h_1^* r_1 + h_2 r_2^* \quad (2.3)$$

$$\hat{s}_2 = h_2^* r_1 - h_1 r_2^*.$$

Those combined signals, $\hat{s}_1$ and $\hat{s}_2$, will be decoded by the maximum likelihood detector. Having s_1 and s_2 estimated, this process is repeated to estimate $s_3, s_4, \dots$ until the end-of-information symbols are in a frame.

2.2 Differential Space-Time Block Code

The constellation was restricted to be the same as the STBC case, as shown in equation (2.1). The STBC uses two symbols (one block) to decode two symbols (one block), Here, the DSTBC uses four symbols (two blocks) to decode two symbols (one block) [2]. Therefore, there should be four received combining signals from the first symbol time to the fourth symbol time as follows:

$$r_1 = h_1 s_1 + h_2 s_2 + n_1 \quad (2.4)$$

$$r_2 = -h_1 s_2^* + h_2 s_1^* + n_2$$

$$r_3 = h_1 s_3 + h_2 s_4 + n_3$$

$$r_4 = -h_1 s_4^* + h_2 s_3^* + n_4.$$

Because the complex vectors $(s_1 \ s_2)$ and $(-s_2^*, s_1^*)$ are orthogonal to each other and have unit lengths, another two-dimensional vector at time t , $(s_t \ s_{t+1})$ can be uniquely represented in the orthonormal basis given by these vectors. The orthonormal basis is denoted as

$$D_1 = \begin{bmatrix} s_1 & s_2 \\ -s_2^* & s_1^* \end{bmatrix} \quad (2.5)$$

where D_B is the B -th block orthonormal basis. Then by using D_1 , the (s_3, s_4) can be uniquely represented as

$$(s_3, s_4) = \mathcal{R}_1 D_1 = \mathcal{R}_1^1 (s_1, s_2) + \mathcal{R}_1^2 (-s_2^*, s_1^*) \quad (2.6)$$

where $\mathcal{R}_1 = (\mathcal{R}_1^1, \mathcal{R}_1^2)$ is the coefficient vector.

At the decoder, without knowing the channel coefficients, the estimation of $\mathcal{R}_B$ is calculated from the received signals r_1, r_2, r_3 , and r_4 as

$$\tilde{\mathcal{R}}_B^1 = r_{2t+1} r_{2t-1}^* + r_{2t+2}^* r_{2t} \quad (2.7)$$

$$\tilde{\mathcal{R}}_B^2 = r_{2t+1} r_{2t}^* - r_{2t+2}^* r_{2t-1}$$

where B indicates the B -th block of the vector $\mathcal{R}$.

The set V is defined as all possible vectors of $\mathcal{R}_B$. After $\mathcal{R}_B$ has been estimated, the receiver now computes the closest vector V to $(\tilde{\mathcal{R}}_B^1, \tilde{\mathcal{R}}_B^2)$. Once the vector is calculated, the inverse mapping of V will be made to decode original bits. For the binary phase shift keying (BPSK) case, the mapping is shown in Table 2.2

TABLE 2.2

BPSK MAPPING

(b_1, b_2)	$(\mathcal{R}^1, \mathcal{R}^2)$
(0, 0)	(1, 0)
(1, 0)	(0, 1)
(0, 1)	(0, -1)
(1, 1)	(-1, 0)

where b_1, b_2 indicate the first and second transmitted bits, respectively.

Compared with the coherent STBC detection scheme, typically, a 3 decibel (dB) loss in signal-to-noise (SNR) ratio is expected for the non-blind DSTBC detection.

2.3 Blind Viterbi as Decoder

The same encoder of DSTBC is used for the blind Viterbi detection [3]. Hence, two blocks of signals that are the same as in equation (2.4) are received. By using equation (2.7), the receiver will calculate $\tilde{\mathcal{R}}_B = (\tilde{\mathcal{R}}_B^1, \tilde{\mathcal{R}}_B^2)$, and then those vectors will be fed to the blind Viterbi decoder. The state of Viterbi trellis, S , indicates the original transmitted symbols. The pair of states S_j^t and S_i^{t-1} is linked by the trellis branch labeled by the coefficient vector $\mathcal{R}_{ij}$, where i and j indicate from the i -th state to the j -th state. The number of states is decided by modulation. In M-PSK, $i, j = 1, 2, \dots, 2^{2b} - 1$. This assumes 200 symbols per frame, where the fading coefficients will not be changed.

For example, in the case of BPSK, the trellis is shown in Figure 2.1.

Figure 2.1. Trellis of BPSK.

The size of V is different if different modulation is used. For the BPSK case, the vectors of V are listed in Table 2.3

TABLE 2.3
COEFFICIENT VECTOR SET V FOR BPSK

$\mathcal{R}_{00} = \mathcal{R}_{11} = \mathcal{R}_{22} = \mathcal{R}_{33}$	$(1, 0)$
$\mathcal{R}_{01} = \mathcal{R}_{13} = \mathcal{R}_{20} = \mathcal{R}_{32}$	$(0, -1)$
$\mathcal{R}_{02} = \mathcal{R}_{10} = \mathcal{R}_{23} = \mathcal{R}_{31}$	$(0, 1)$
$\mathcal{R}_{03} = \mathcal{R}_{12} = \mathcal{R}_{21} = \mathcal{R}_{30}$	$(-1, 0)$

All possible vectors of V for the quadrature phase shift keying (QPSK) modulation are listed in Table 2.4

TABLE 2.4
COEFFICIENT VECTOR SET V FOR QPSK

$(1, 0)$	$(0.5+0.5j, -0.5+0.5j)$	$(-0.5+0.5j, 0.5+0.5j)$
$(-1, 0)$	$(0.5-0.5j, -0.5-0.5j)$	$(-0.5+0.5j, -0.5+0.5j)$
$(0, 1)$	$(0.5+0.5j, 0.5-0.5j)$	$(0.5+0.5j, -0.5+0.5j)$
$(0, -1)$	$(-0.5+0.5j, -0.5-0.5j)$	$(0.5+0.5j, 0.5+0.5j)$
$(j, 0)$	$(-0.5+0.5j, 0.5+0.5j)$	$(-0.5-0.5j, -0.5+0.5j)$
$(-j, 0)$	$(-0.5-0.5j, 0.5-0.5j)$	$(-0.5-0.5j, 0.5+0.5j)$
$(0, j)$	$(0.5-0.5j, 0.5+0.5j)$	$(0.5-0.5j, -0.5+0.5j)$
$(0, -j)$	$(-0.5-0.5j, -0.5+0.5j)$	$(0.5-0.5j, 0.5+0.5j)$

It can be seen that the size of V in BPSK is the same as the input information block set. But the size of V in QPSK is larger than the input information block set. This is

due to redundancy introduced by the encoder. It is expected that the blind Viterbi detection is 1~1.5 dB better than the original blind detection scheme, i.e., DSTBC, for QPSK or a higher modulation case.

$\tilde{\mathcal{R}}_B = (\tilde{\mathcal{R}}_B^1, \tilde{\mathcal{R}}_B^2)$ is calculated using equation (2.7). This estimated coefficient vectors will be fed to the Viterbi decoder. The branch metric, $Y_{i,j}$, between state i to j is calculated as

$$Y_{i,j}(t) = \|\tilde{\mathcal{R}}_B - \mathcal{R}_{i,j}\|^2 \quad (2.8)$$

2.4 Zhang's Code

The encoder used by Zhang and Ma [4] the same as the DSTBC used by Tarokh and Jafarkhani [2]. The difference is that the first block uses a p -ary PSK constellation, and the second block uses a q -ary PSK constellation, and p, q are co-prime. Therefore, at the receiver antenna, the received signals during the four consecutive time slots of the first and second blocks, Z_1 and Z_2 , respectively, can be written in matrix form as

$$\begin{pmatrix} z_1(1) \\ z_1(2) \end{pmatrix} = \begin{pmatrix} x_1 & x_2 \\ -x_2^* & x_1^* \end{pmatrix} \begin{pmatrix} h_1 \\ h_2 \end{pmatrix} + \begin{pmatrix} n_1 \\ n_2 \end{pmatrix} \quad (2.9)$$

$$\begin{pmatrix} z_2(1) \\ z_2(2) \end{pmatrix} = \begin{pmatrix} y_1 & y_2 \\ -y_2^* & y_1^* \end{pmatrix} \begin{pmatrix} h_1 \\ h_2 \end{pmatrix} + \begin{pmatrix} n_3 \\ n_4 \end{pmatrix}$$

where x and y are p -PSK modulation and q -PSK modulation symbols, respectively. Let S denote the symbol block $\begin{pmatrix} x_1 & x_2 \\ -x_2^* & x_1^* \end{pmatrix}$ or $\begin{pmatrix} y_1 & y_2 \\ -y_2^* & y_1^* \end{pmatrix}$, for $L = 1$ single block.

In a part of the decoder, the original symbol block S is estimated by extending it to L blocks as

$$S = \arg \min_{S \in A} \{S^H P S\} \quad (2.10)$$

where $\mathbf{S} = (s_1^*(1), s_1(2), s_2^*(1), s_2(2), s_3^*(1), s_3(2), \dots, s_L^*(1), s_L(2))^T$, L is the number of blocks, $\mathbf{P} = (\|\bar{\mathbf{z}}\|_2^2 + 1)\mathbf{I}_{2L} - \bar{\mathbf{z}}^H \bar{\mathbf{z}}$, and

$$\bar{\mathbf{z}} = \begin{pmatrix} z_1(1), & -z_1(2), & z_2(1), & -z_2(2), & \dots & z_L(1), & -z_L(2) \\ z_1^*(2), & z_1^*(1), & z_2^*(2), & z_2^*(1), & \dots & z_L^*(2), & z_L^*(1) \end{pmatrix}.$$

The simulation results from Zhang and Ma [4] show that the greater number of blocks for the Zhang's code shows better performance. In Chapter 4, it will be shown that if Zhang's code uses four blocks, then the performance is worse than the DSTBC.

CHAPTER 3

SYSTEM MODEL

This thesis focused on a two-user cooperation scheme. In particular, the source (or user 1) sends information to the relay (or user 2) in timeslot 1, and the destination also receives the information. Then, the relay helps the source forward the information in timeslot 2, and the source also sends new information to its destination. This thesis considered a simple-triangle single-relay system, as shown in Figure 3.1. The channel coefficients are denoted by h_{sr} , h_{rd} , and h_{sd} for the link from the source to the relay, the relay to the destination, and the source to the destination, respectively.

Figure 3.1. Simple triangle relay.

3.1 Detection Schemes Combined with Decode and Forward Protocol

3.1.1 Combined with STBC

For the STBC, to encode the first block symbol during two symbol intervals, it is necessary to feed the first block information to the encoder. The first symbol fed to encode is denoted as S_1 , and the second is denoted as S_2 . The received signal at the relay during the t -th symbol time is denoted by Y_{srt} . Also, Y_{sdt} denotes the received signal at the destination during the t -th symbol time, and n_{srt} and n_{rdt} denote the zero-mean AWGN noises corresponding to the received and destination links, respectively.

When DF is used at the single relay, it takes four symbol times. At the first symbol time, the source sends S_1 to the relay; the relay receives the information and then decodes and re-encodes it. Hence, the received symbols at the relay during the first symbol time can be written as

$$Y_{sr1} = h_{sr}S_1 + n_{sr1}. \quad (3.1)$$

After S_1 has been decoded and re-encoded, it will have the estimated symbol, $\tilde{S}_1$.

At the second symbol time, the relay forwards $\tilde{S}_1$ to the destination, and the source sends S_2 to its destination simultaneously. Hence, the received symbol at the destination during the second symbol time can be written as

$$Y_{d2} = h_{rd}\tilde{S}_1 + h_{sd}S_2 + n_{rd2}. \quad (3.2)$$

During the third symbol time, the source sends $(-S_2^*)$ to the relay, and the relay receives information and decodes and then re-encodes it. The received symbol during the third symbol time at the relay can be written as

$$Y_{sr3} = h_{sr}(-S_2^*) + n_{sr3}. \quad (3.3)$$

Again, after $(-S_2^*)$ has been decoded and re-encoded, it will have the estimated symbol $-\tilde{S}_2^*$.

For the last symbol time, i.e., the fourth symbol time, the relay forwards $\tilde{S}_2^*$ to the destination, and the source sends S_1^* to the destination simultaneously. The received symbols at the destination during the fourth symbol time can be written as

$$Y_{d4} = h_{sd}S_1^* + h_{rd}(-\tilde{S}_2^*) + n_{rd2}. \quad (3.4)$$

Hence, after four symbol times, a whole block will be sent by this relay system. It can be assumed that the fading coefficients do not change during the four symbol times.

Chapter 4 will present bit error rate or symbol error rate performance of this scheme. As an example, this procedure is demonstrated in Table 3.1.

TABLE 3.1
PROCEDURE OF STBC COMBINED WITH DF RELAY

t=1		$Y_{sr1} = h_{sr}S_1 + n_{sr1}$
t=2		$Y_{d2} = h_{rd}\tilde{S}_1 + h_{sd}S_2 + n_{rd2}$
t=3		$Y_{sr3} = h_{sr}(-S_2^*) + n_{sr3}$
t=4		$Y_{d4} = h_{sd}S_1^* + h_{rd}(-\tilde{S}_2^*) + n_{rd2}$

3.1.2 Combined DSTBC and Blind Viterbi Decoder

DSTBC needs two block symbols, which take four symbol times to decode one block. This can be done by repeating the STBC preprocessing but for eight symbol times. Also, blind Viterbi will work in the same way as the DSTBC because it also requires eight symbol times. Performance of those schemes will be shown in Chapter 4.

3.1.3 Parallel-Relay Case

This section describes the location of relay considered in this thesis. The source, relay, and destination are parallel with each other. The distance between source and

relay is D_{sr} , and the distance between the relay destination is D_{rd} . Figure 3.2 shows the single-relay case. Performance of this scheme will be presented in Chapter 4.

Figure 3.2. Parallel relay case.

3.2 Detection Schemes Combined with Amplify-and-Forward Protocol

3.2.1 Combined with STBC

The only difference compared with the DF protocol is that the AF relay will amplify the received information from the source and forward it to the destination without decoding and re-encoding as in the DF protocol.

Again, an entire procedure takes four symbol times for this case. During the first symbol time, the source sends S_1 to the relay, and the relay receives the signal. The received signal at the relay can be expressed as

$$Y_{sr1} = h_{sr}S_1 + n_{sr1}. \quad (3.5)$$

During the second symbol time, the relay amplifies Y_{sr1} and forwards it to the destination. Meanwhile, the source sends S_2 to the destination simultaneously. The received signal at the destination can be written as

$$Y_{d2} = h_{rd} Y_{sr1}b + h_{sd}S_2 + n_{rd2} \quad (3.6)$$

where b is the amplification coefficient and satisfies the power constraint, that is,

$$b = \frac{\sqrt{P}}{\sqrt{P|h_{sr}|^2 + N_0}} \quad (3.7)$$

where P is the relay power. Again, the noise terms are modeled as the zero-mean complex Gaussian random variables with variance $N_0/2$ per dimension.

During the third symbol time, the source sends $(-S_2^*)$ to the relay, and the relay receives this signal. The received signal at the relay can be written as

$$Y_{sr3} = h_{sr}(-S_2^*) + n_{sr3}. \quad (3.8)$$

During the fourth symbol time, the relay amplifies Y_{sr3} and forwards it to the destination, and the source sends S_1^* to the relay simultaneously. The combined signal at the destination is

$$Y_{d4} = h_{sd}S_1^* + h_{rd} Y_{sr3}b + n_{rd2} \quad (3.9)$$

After four symbol times, the entire two blocks will be completely sent. Again, it can be assumed that the fading coefficients are not changing during the four symbol times. Chapter 4 will present bit error rate or symbol error rate performance of this scheme. Again, the procedure is shown in Table 3.2.

TABLE 3.2

PROCEDURE OF STBC COMBINED WITH AF RELAY

t=1		$Y_{sr1} = h_{sr}S_1 + n_{sr1}$
t=2		$Y_{d2} = h_{rd} Y_{sr1}b + h_{sd}S_2 + n_{rd2}$
t=3		$Y_{sr3} = h_{sr}(-S_2^*) + n_{sr3}$
t=4		$Y_{d4} = h_{sd}S_1^* + h_{rd} Y_{sr3}b + n_{rd2}$

3.2.2 Combined with DSTBC and Blind Viterbi Decoder

The procedure was repeated, as shown in Section 3.1.2. However, it can be seen that those blind detection schemes performed poorly for the AF protocol. The reason for this is because one more fading coefficients has been introduced to the destination. The orthogonal decoding structure was destroyed. Chapter 4 will present bit error rate or symbol error rate performance of this scheme.

3.3 Zhang's Code and Blind Viterbi Decoder under Jakes' Fading

Jakes' fading is a Rayleigh fading associated with the Doppler spectrum. The Doppler effect is the change in frequency of a wave for an observer moving relative to the source of the wave. This means that in Jakes' fading, the channel coefficients vary based on the speed and direction of the mobile with respect to the base station.

According to Jakes [7], using fading coefficients under Jakes' fading, the channel coefficient, $y(t)$, is generated as

$$y(t) = x_c(t)\cos\omega_c t + x_s(t)\sin\omega_c t \quad (3.10)$$

where $x_c(t) = 2 \sum_{n=1}^{N_0} \cos\beta_n \cos\omega_n t + \sqrt{2}\cos\alpha t \cos\omega_m t$, $x_s(t) = 2 \sum_{n=1}^{N_0} \sin\beta_n \cos\omega_n t + \sqrt{2}\sin\alpha \cos\omega_m t$, N_0 is the low-frequency oscillator with frequencies equal to the Doppler shifts, that is,

$$\omega_n = \omega_m \cos \frac{2\pi n}{N} \quad (3.11)$$

where $\omega_m = 2\pi \frac{V}{V_c} f_c$, $N = 1, 2, \dots, N_0$, V is the mobile speed, V_c is the speed of the light, and f_c is the carry frequency. In this thesis, the following was chosen: $N_0 = 8$, and $\alpha = \frac{\pi}{4}$.

CHAPTER 4

SIMULATION RESULTS

4.1 Simulation Parameters

This section shows the performance of the relay system combined with the STBC coherent detection scheme and blind detection schemes, i.e., DSTBC, the blind Viterbi, and Zhang's code. Also, the performance of the different relay location is presented. All simulation results were obtained using 1,000,000 bits, and 200 symbols per frame. During those 200 symbols, the fading coefficients, h_{sd} , h_{rd} , and h_{sr} , were assumed to be constant. The BPSK or QPSK modulations were considered. It was also assumed that the distance (D_{sd}) between the source and the destination is normalized to 1, and the transmitted signal has unit energy. The simulation code are shown in Appendix A, B, C, D, E, F and G.

4.2 DF Relay Combined with STBC

Figure 4.1 shows BER performance of a single-relay system with the DF protocol when coherent STBC detection is used.

Figure 4.1. BER performance of single relay system with DF protocol when coherent STBC detection is used.

4.3 DF Relay Combined with DSTBC

Figure 4.2 shows BER performance of a single-relay system with the DF protocol when the noncoherent DSTBC detection is used.

Figure 4.2. BER performance of single-relay system with DF protocol when noncoherent DSTBC detection is used.

4.4 DF Relay Combined with Blind Viterbi Decoder

Figure 4.3 shows BER performance of the single-relay system with the DF protocol when the noncoherent blind Viterbi decoder is used.

Figures 4.1, 4.2, and 4.3 show that regardless of using coherent or noncoherent detection schemes, when the relay is closer to the source, performance is better for the parallel relay, as shown in Figure 3.2. If the relay is getting closer to the destination, then the performance is closer to that of the simple triangle relay, as shown in Figure

3.1

Figure 4.3. BER performance of single relay system with DF protocol when the noncoherent blind Viterbi decoder is used.

4.5 Single AF Relay

Figure 4.4 shows BER performance of the single-relay system with the AF protocol when the STBC, DSTBC, and blind Viterbi decoder are used. It can be seen that when noncoherent detection schemes combine with the AF single relay, performance becomes unacceptable. This is because orthogonality is destroyed.

Figure 4.4. BER performance of single relay system with AF protocol when STBC, DSTBC, and blind Viterbi decoder are used.

4.6 SER Performance of Zhang's Code and Blind Viterbi

Figure 4.5 shows SER performance of Zhang's code and the blind Viterbi decoder under a Jakes' fading case when $fdTs = 0.01$. As shown, the Zhang's code is worse than the blind Viterbi decoder, when the four-block length is used. It can be assumed that the fading coefficients are not changing during the four blocks, and the Zhang's code uses the 3PSK and QPSK for its encoder. Also note that in the case of the QPSK blind Viterbi decoder, the performance is better than with BPSK. This is due to the redundancy introduced in the coefficient vector set V .

Figure 4.5. BER performance of Zhang's code and blind Viterbi decoder under Jakes' fading case.

CHAPTER 5

CONCLUSION

5.1 Conclusion

Simulation results shows that the blind detection schemes did not work with the amplify-and-forward relay protocol. This is because one more fading coefficient was introduced to the decoder, thus destroying orthogonality. It was observed that the estimation equations at the decoder for the DSTBC and the blind Viterbi decoder contained two fading coefficients. This means that introducing one more fading coefficient would destroy the orthogonal decoding structure.

However, it was also observed that the blind detection schemes with the DF protocol performed well. The reason for this is because estimation was performed at the relay. Again, it was noticed that in the case of the parallel relay, the closer the relay to the source, the better the performance.

For Zhang's code and the blind Viterbi decoder under Jakes fading, assuming that Zhang's code uses four blocks as the blind Viterbi decoder, it was observed that using Zhang's code was 1 dB worse than using the BPSK blind Viterbi decoder, and 4–4.5 dB worse than using the QPSK blind Viterbi decoder. This is because redundancy was introduced by the encoder for the QPSK or higher modulation.

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REFERENCES

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APPENDIXES

APPENDIX A

PROGRAM OF DF RELAY COMBINED WITH STBC

```
clear all;
clc;
% tic;

k=100000;
SNRindB=0:2:25;
No=1./10.^(SNRindB./10);
sgma=sqrt(No/2);

Psr=1;Psd=1;Dsd=1;

Dsr=3/4;

Drd=Dsr-Dsd;
Psr=(Psd*(Dsd^2))/(Dsr^2);
Prd=(Psd*(Dsd^2))/(Drd^2);

S0=randint(1,k/2);
S1=randint(1,k/2);

hsr=sqrt(Psr).*sqrt(0.5).*(randn(1,k/2)+1i.*randn(1,k/2));
hsd=sqrt(Psd).*sqrt(0.5).*(randn(1,k/2)+1i.*randn(1,k/2));
hrd=sqrt(Prd).*sqrt(0.5).*(randn(1,k/2)+1i.*randn(1,k/2));

s0=(pskmod(S0,2))/sqrt(2);
s1=(pskmod(S1,2))/sqrt(2);

for snr=1:length(SNRindB)

    snr

    for n=1:k/2

        ysr111(n)=hsr(n)*s0(n)+sgma(snr)*(randn+1i*randn);
        ysr11(n)=pskdemod((conj(hsr(n))*ysr111(n)),2);
        ysr1(n)=pskmod(ysr11(n),2);

        r0(n)=hrd(n)*ysr1(n)+hsd(n)*s1(n)+sgma(snr)*(randn+1i*randn);

        ysr222(n)=hsr(n)*s1(n)+sgma(snr)*(randn+1i*randn);
        ysr22(n)=pskdemod((conj(hsr(n))*ysr222(n)),2);
        ysr2(n)=pskmod(ysr22(n),2);
```

APPENDIX A (Continued)

```
    r1(n)=(-
conj(ySr2(n))*hrd(n)+hsd(n)*(conj(s0(n)))+sgma(snr)*(randn+1i*randn);

    s_0(n)=conj(hrd(n))*r0(n)+hsd(n)*conj(r1(n));
    s_1(n)=conj(hsd(n))*r0(n)-hrd(n)*conj(r1(n));

end
m0=pskdemod(s_0,2);
m1=pskdemod(s_1,2);

er0(snr)=nnz(S0-m0);
er1(snr)=nnz(S1-m1);
err(snr)=er0(snr)+er1(snr);
end

semilogy(SNRindB,err/k, '-k+');
grid on
hold on
% toc;
```

APPENDIX B

PROGRAM OF DF RELAY COMBINED WITH DSTBC

```
clear all;
clc;
tic
k=100;
SNRindB=0:4:30;
ci=1;
reset1=0;
no_frame=10000;
bb=zeros(1,k);% finall bits will go to bb
er_frame=zeros(1,length(SNRindB));

Psr=1;Psd=1;Dsd=1;

Dsr=5/10;

Drd=Dsr-Dsd;
Psr=(Psd*(Dsd^2))/(Dsr^2);
Prd=(Psd*(Dsd^2))/(Drd^2);
for avg=1:ci
    avg

    for i=1:length(SNRindB) %loop for SNR
        i
        snr=10^(SNRindB(i)/10);
        sigma=sqrt(1/snr/2);

        for no_fra=1:no_frame %loop for frame
            b=randint(1,k);
            b(1)=0;
            b(2)=0;
            %== mod '0'to 1/sqrt(2) , '1'to -1/sqrt(2)
            a=(exp( b.*pi.*sqrt(-1)))/sqrt(2);
            %=== state 0
            s=randint(1,k)/sqrt(2);
            s(1)=1/sqrt(2);
            s(2)=1/sqrt(2);
            ysr111(1)=1/sqrt(2);
            ysr111(2)=1/sqrt(2);

            hsr=sqrt(Psr)*sqrt(0.5).*(randn+1i.*randn);
            hsd=sqrt(Psd)*sqrt(0.5).*(randn+1i.*randn);
            hrd=sqrt(Prd)*sqrt(0.5).*(randn+1i.*randn);
            %
            %
            %
            hsr=1;
            hsd=1;
            hrd=1;
```

APPENDIX B (Continued)

```

for t1=1:(k-2)/2 % t1=(k-2)/2 pairs of AB

    A(t1)=a(2*t1+1)*conj(a(1))+a(2*t1+2)*conj(a(2));
    B(t1)=-a(2*t1+1)*a(2)+a(2*t1+2)*a(1);

    % next s3 and s4
    s(2*t1+1)=A(t1)*s(2*t1-1)-B(t1)*conj(s(2*t1));
    s(2*t1+2)=A(t1)*s(2*t1)+B(t1)*conj(s(2*t1-1));

    ysr111(2*t1-1)=hsr*s(2*t1-1)+sgma*(randn+1i*randn);
    ysr11(2*t1-1)=pskdemod((conj(hsr)*ysr111(2*t1-1)),2);
    ysr(2*t1-1)=pskmod(ysr11(2*t1-1),2); % decoded s(2*t1-1)

    ysr111(2*t1)=hsr*s(2*t1)+sgma*(randn+1i*randn);
    ysr11(2*t1)=pskdemod((conj(hsr)*ysr111(2*t1)),2);
    ysr(2*t1)=pskmod(ysr11(2*t1),2);

    ysr111(2*t1+1)=hsr*s(2*t1+1)+sgma*(randn+1i*randn);
    ysr11(2*t1+1)=pskdemod((conj(hsr)*ysr111(2*t1+1)),2);
    ysr(2*t1+1)=pskmod(ysr11(2*t1+1),2);

    ysr111(2*t1+2)=hsr*s(2*t1+2)+sgma*(randn+1i*randn);
    ysr11(2*t1+2)=pskdemod((conj(hsr)*ysr111(2*t1+2)),2);
    ysr(2*t1+2)=pskmod(ysr11(2*t1+2),2);

    R(2*t1-1)=hrd*ysr(2*t1-1)+hsd*s(2*t1);
    R(2*t1)=hrd*(-conj(ysr(2*t1)))+hsd*(conj(s(2*t1-1)));
    R(2*t1+1)=hrd*ysr(2*t1+1)+hsd*s(2*t1+2);
    R(2*t1+2)=hrd*(-conj(ysr(2*t1+2)))+hsd*(conj(s(2*t1+1)));

end
r=(R+sgma.*(randn(1,k)+1i*randn(1,k)));
% r=(R );
for i2=1:(k-2)/2
    % % =====big R in (17) (23) in the paper
    dar1(i2)=r(2*i2+1)*conj(r(2*i2-1))+conj(r(2*i2+2))*r(2*i2);
    dar2(i2)=r(2*i2+1)*conj(r(2*i2))-conj(r(2*i2+2))*r(2*i2-1);

    %===== distance with four points
    d1=(1-dar1(i2))*conj(1-dar1(i2))+ (0-dar2(i2))*conj(0-
dar2(i2));
    d2=(0-dar1(i2))*conj(0-dar1(i2))+ (1-dar2(i2))*conj(1-
dar2(i2));
    d3=(-1-dar1(i2))*conj(-1-dar1(i2))+ (0-dar2(i2))*conj(0-
dar2(i2));
    d4=(0-dar1(i2))*conj(0-dar1(i2))+ (-1-dar2(i2))*conj(-1-
dar2(i2));

```

APPENDIX B (Continued)

```
d=[d1,d2,d3,d4];
m=min(d);
if d1==m
    bb((2*i2)+1)=0;
    bb(2*(i2)+2)=0;
end
if d2==m
    bb((2*i2)+1)=1;
    bb(2*(i2)+2)=0;
end
if d3==m
    bb((2*i2)+1)=1;
    bb(2*(i2)+2)=1;
end
if d4==m
    bb((2*i2)+1)=0;
    bb(2*(i2)+2)=1;
end

end

er_bits(i)=nnz(b-bb);
er_frame(i)=er_bits(i)+er_frame(i);
end

end

reset1=er_frame+reset1;

end

avg_er=reset1/ci;
semilogy(SNRindB, avg_er/(k*no_frame-2), '-r+');
toc
grid on
hold on
```


APPENDIX C

PROGRAM OF DF RELAY COMBINED WITH BLIND VITERBI DECODER

```
clear all;
clc;

k=100;
SNRindB=0:5:40;
ci=5;
reset1=0;
no_frame=10000;

Psr=1;Psd=1;Dsd=1;

Dsr=9/10;

Drd=Dsr-Dsd;
Psr=(Psd*(Dsd^2))/(Dsr^2);
Prd=(Psd*(Dsd^2))/(Drd^2);

for avg=1:ci
    avg

    for SNR=1:length(SNRindB)
        er_frame=0;
        er_bit=0;
        SNR
        snr=10^(SNRindB(SNR)/10);
        sigma=sqrt(1/snr/2);

        for no_fra=1:no_frame

            msg=2*randint(1,k)-1;
            schu=[1 1];
            S=[schu,msg]./sqrt(2);

            hsr=sqrt(Psr)*sqrt(0.5)*(randn(1,1)+1i.*randn(1,1));
            hsd=sqrt(Psd)*sqrt(0.5)*(randn(1,1)+1i.*randn(1,1));
            hrd=sqrt(Prd)*sqrt(0.5)*(randn(1,1)+1i.*randn(1,1));

            for n=1:(length(msg)/2)
                if n==1
                    n1=sigma.*(randn(1,1)+1i.*randn(1,1));
                    n2=sigma.*(randn(1,1)+1i.*randn(1,1));
                    n3=sigma.*(randn(1,1)+1i.*randn(1,1));
                    n4=sigma.*(randn(1,1)+1i.*randn(1,1));
                else
                    n1=n3;
                    n2=n4;
                    n3=sigma.*(randn(1,1)+1i.*randn(1,1));
                end
            end
        end
    end
end
```

APPENDIX C (Continued)

```

n4=sgma.*(randn(1,1)+1i*randn(1,1));
end

ysr1_11(n)=hsr*S(2*n-1)+sgma*(randn+1i*randn);
ysr1_1(n)=pskdemod((conj(hsr)*ysr1_11(n)),2);
ysr1(n)=pskmod(ysr1_1(n),2);

r1(n)=hrd*ysr1(n)+hsd*S(2*n)+n1;

ysr2_22(n)=hsr*S(2*n)+sgma*(randn+1i*randn);
ysr2_2(n)=pskdemod((conj(hsr)*ysr2_22(n)),2);
ysr2(n)=pskmod(ysr2_2(n),2);

r2(n)=(-conj(ysr2(n)))*hrd+hsd*(conj(S(2*n-1)))+n2;

ysr3_11(n)=hsr*S(2*n+1)+sgma*(randn+1i*randn);
ysr3_1(n)=pskdemod((conj(hsr)*ysr3_11(n)),2);
ysr3(n)=pskmod(ysr3_1(n),2);

r3(n)=hrd*ysr3(n)+hsd*S(2*n+2)+n3;

ysr4_22(n)=hsr*S(2*n+2)+sgma*(randn+1i*randn);
ysr4_2(n)=pskdemod((conj(hsr)*ysr4_22(n)),2);
ysr4(n)=pskmod(ysr4_2(n),2);

r4(n)=(-conj(ysr4(n)))*hrd+hsd*(conj(S(2*n+1)))+n4;

r(2*n-1)=r3(n)*conj(r1(n))+conj(r4(n))*r2(n);
r(2*n)=r3(n)*conj(r2(n))-conj(r4(n))*r1(n);
end

% function m=baseB1(r)
ll=(length(r)/2)+1;
u11=zeros(1,ll);u12=zeros(1,ll);u13=zeros(1,ll);u14=zeros(1,ll);
u21=zeros(1,ll);u22=zeros(1,ll);u23=zeros(1,ll);u24=zeros(1,ll);
u31=zeros(1,ll);u32=zeros(1,ll);u33=zeros(1,ll);u34=zeros(1,ll);
u41=zeros(1,ll);u42=zeros(1,ll);u43=zeros(1,ll);u44=zeros(1,ll);
Q=zeros(4,ll);Q(1,1)=1;
mu1=zeros(1,ll);mu2=zeros(1,ll);mu3=zeros(1,ll);mu4=zeros(1,ll);

for t1=2:ll

    t=t1-1;

    if Q(1,t)==1
        u11(t1)=(((norm(r(2*t-1)-1))^2)+((norm(r(2*t)-
0))^2));Q(1,t1)=1;
        u12(t1)=(((norm(r(2*t-1)-
0))^2)+((norm(r(2*t)+1))^2));Q(2,t1)=1;

```

APPENDIX C (Continued)

```

    u13(t1)=((norm(r(2*t-1)-0))^2)+((norm(r(2*t)-
1))^2));Q(3,t1)=1;
    u14(t1)=((norm(r(2*t-1)+1))^2)+((norm(r(2*t)-
0))^2));Q(4,t1)=1;
end
if Q(2,t)==1
    u21(t1)=((norm(r(2*t-1)-0))^2)+((norm(r(2*t)-
1))^2));Q(1,t1)=1;
    u22(t1)=((norm(r(2*t-1)-1))^2)+((norm(r(2*t)-
0))^2));Q(2,t1)=1;
    u23(t1)=((norm(r(2*t-1)+1))^2)+((norm(r(2*t)-
0))^2));Q(3,t1)=1;
    u24(t1)=((norm(r(2*t-1)-
0))^2)+((norm(r(2*t)+1))^2));Q(4,t1)=1;
end
if Q(3,t)==1
    u31(t1)=((norm(r(2*t-1)-
0))^2)+((norm(r(2*t)+1))^2));Q(1,t1)=1;
    u32(t1)=((norm(r(2*t-1)+1))^2)+((norm(r(2*t)-
0))^2));Q(2,t1)=1;
    u33(t1)=((norm(r(2*t-1)-1))^2)+((norm(r(2*t)-
0))^2));Q(3,t1)=1;
    u34(t1)=((norm(r(2*t-1)-0))^2)+((norm(r(2*t)-
1))^2));Q(4,t1)=1;
end
if Q(4,t)==1
    u41(t1)=((norm(r(2*t-1)+1))^2)+((norm(r(2*t)-
0))^2));Q(1,t1)=1;
    u42(t1)=((norm(r(2*t-1)-0))^2)+((norm(r(2*t)-
1))^2));Q(2,t1)=1;
    u43(t1)=((norm(r(2*t-1)-
0))^2)+((norm(r(2*t)+1))^2));Q(3,t1)=1;
    u44(t1)=((norm(r(2*t-1)-1))^2)+((norm(r(2*t)-
0))^2));Q(4,t1)=1;
end

if t1==2
    u21(2)=u11(2);u31(2)=u11(2);u41(2)=u11(2);
    u22(2)=u12(2);u32(2)=u12(2);u42(2)=u12(2);
    u23(2)=u13(2);u33(2)=u13(2);u43(2)=u13(2);
    u24(2)=u14(2);u34(2)=u14(2);u44(2)=u14(2);
end

    jh1=[mu1(t)+u11(t1) mu2(t)+u21(t1) mu3(t)+u31(t1)
mu4(t)+u41(t1)];
    jh2=[mu1(t)+u12(t1) mu2(t)+u22(t1) mu3(t)+u32(t1)
mu4(t)+u42(t1)];
    jh3=[mu1(t)+u13(t1) mu2(t)+u23(t1) mu3(t)+u33(t1)
mu4(t)+u43(t1)];
    jh4=[mu1(t)+u14(t1) mu2(t)+u24(t1) mu3(t)+u34(t1)
mu4(t)+u44(t1)];

mu1(t1)=min(jh1);mu2(t1)=min(jh2);mu3(t1)=min(jh3);mu4(t1)=min(jh4);

```

APPENDIX C (Continued)

```

if mu1(t1)==mu1(t)+u11(t1)
    go1(t)=1;
elseif mu1(t1)==mu2(t)+u21(t1)
    go1(t)=2;
elseif mu1(t1)==mu3(t)+u31(t1)
    go1(t)=3;
elseif mu1(t1)==mu4(t)+u41(t1)
    go1(t)=4;
end

```

```

if mu2(t1)==mu1(t)+u12(t1)
    go2(t)=1;
elseif mu2(t1)==mu2(t)+u22(t1)
    go2(t)=2;
elseif mu2(t1)==mu3(t)+u32(t1)
    go2(t)=3;
elseif mu2(t1)==mu4(t)+u42(t1)
    go2(t)=4;
end

```

```

if mu3(t1)==mu1(t)+u13(t1)
    go3(t)=1;
elseif mu3(t1)==mu2(t)+u23(t1)
    go3(t)=2;
elseif mu3(t1)==mu3(t)+u33(t1)
    go3(t)=3;
elseif mu3(t1)==mu4(t)+u43(t1)
    go3(t)=4;
end

```

```

if mu4(t1)==mu1(t)+u14(t1)
    go4(t)=1;
elseif mu4(t1)==mu2(t)+u24(t1)
    go4(t)=2;
elseif mu4(t1)==mu3(t)+u34(t1)
    go4(t)=3;
elseif mu4(t1)==mu4(t)+u44(t1)
    go4(t)=4;
end

```

```

end

```

```

%=====

```

```

go(1,:)=go1;go(2,:)=go2;go(3,:)=go3;go(4,:)=go4;

```

```

Last=[mu1(l1) mu2(l1) mu3(l1) mu4(l1)];
start=min(Last);

```

```

if start==mu1(l1)
    l1(length(go1)+1)=1;
    m(2*length(go1)-1)=1;m(2*length(go1))=1;

```

APPENDIX C (Continued)

```
l1(length(go1))=go(1,length(go1));
for t2=length(go1):-1:2
    l1(t2-1)=go(l1(t2),t2-1);
    if l1(t2)==1
        m(2*t2-3)=1;m(2*t2-2)=1;
    elseif l1(t2)==2
        m(2*t2-3)=1;m(2*t2-2)=-1;
    elseif l1(t2)==3
        m(2*t2-3)=-1;m(2*t2-2)=1;
    elseif l1(t2)==4
        m(2*t2-3)=-1;m(2*t2-2)=-1;
    end
end

elseif start==mu2(l1)
    l1(length(go1)+1)=2;
    m(2*length(go1)-1)=1;m(2*length(go1))=-1;
    l1(length(go1))=go(2,length(go1));
    for t2=length(go1):-1:2
        l1(t2-1)=go(l1(t2),t2-1);
        if l1(t2)==1
            m(2*t2-3)=1;m(2*t2-2)=1;
        elseif l1(t2)==2
            m(2*t2-3)=1;m(2*t2-2)=-1;
        elseif l1(t2)==3
            m(2*t2-3)=-1;m(2*t2-2)=1;
        elseif l1(t2)==4
            m(2*t2-3)=-1;m(2*t2-2)=-1;
        end
    end

elseif start==mu3(l1)
    l1(length(go1)+1)=3;
    m(2*length(go1)-1)=-1;m(2*length(go1))=1;
    l1(length(go1))=go(3,length(go1));
    for t2=length(go1):-1:2
        l1(t2-1)=go(l1(t2),t2-1);
        if l1(t2)==1
            m(2*t2-3)=1;m(2*t2-2)=1;
        elseif l1(t2)==2
            m(2*t2-3)=1;m(2*t2-2)=-1;
        elseif l1(t2)==3
            m(2*t2-3)=-1;m(2*t2-2)=1;
        elseif l1(t2)==4
            m(2*t2-3)=-1;m(2*t2-2)=-1;
        end
    end

elseif start==mu4(l1)
    l1(length(go1)+1)=4;
    m(2*length(go1)-1)=-1;m(2*length(go1))=-1;
    l1(length(go1))=go(4,length(go1));
    for t2=length(go1):-1:2
        l1(t2-1)=go(l1(t2),t2-1);
```

APPENDIX C (Continued)

```

        if l1(t2)==1
            m(2*t2-3)=1;m(2*t2-2)=1;
        elseif l1(t2)==2
            m(2*t2-3)=1;m(2*t2-2)=-1;
        elseif l1(t2)==3
            m(2*t2-3)=-1;m(2*t2-2)=1;
        elseif l1(t2)==4
            m(2*t2-3)=-1;m(2*t2-2)=-1;
        end
    end
end

% =====for frame error rate=====
%     er=msg-m;
%     if nnz(er)~=0
%         er_frame=er_frame+1;
%     end
%     error(SNR)=er_frame;
%     =====

% =====for bit error rate=====

%     er=msg-m;
%     er_bit=er_bit+nnz(er);
%     error(SNR)=er_bit;

% =====

    end
end
reset1=error+reset1;

end
avg_er=reset1/ci;

semilogy(SNRindB,avg_er/(no_frame*k), '-b+'); % BER

% semilogy(SNRindB,avg_er/no_frame, '-r+');
grid on
hold on

```

APPENDIX D

PROGRAM OF BLIND VITERBI COMBINED WITH AF

```
clear all;
clc;

k=100;
SNRindB=0:5:40;
ci=3;
reset1=0;
no_frame=10000;
P=1/2;

for avg=1:ci
    avg

    for SNR=1:length(SNRindB)
        er_frame=0;
        er_bit=0;
        SNR
        No=P/10^(SNRindB(SNR)/10);
        sgma=sqrt(No/2);

        for no_fra=1:no_frame

            msg=2*randint(1,k)-1;
            schu=[1 1];
            S=[schu,msg]./sqrt(2);

            hsr=sqrt(0.5).*(randn(1,1)+1i.*randn(1,1));
            hsd=sqrt(0.5).*(randn(1,1)+1i.*randn(1,1));
            hrd=sqrt(0.5).*(randn(1,1)+1i.*randn(1,1));
            b=sqrt(P/(P*(abs(hsr))^2+No));

            for n=1:(length(msg)/2)
                if n==1
                    n1=sgma.*(randn(1,1)+1i.*randn(1,1));
                    n2=sgma.*(randn(1,1)+1i.*randn(1,1));
                    n3=sgma.*(randn(1,1)+1i.*randn(1,1));
                    n4=sgma.*(randn(1,1)+1i.*randn(1,1));
                else
                    n1=n3;
                    n2=n4;
                    n3=sgma.*(randn(1,1)+1i.*randn(1,1));
                    n4=sgma.*(randn(1,1)+1i.*randn(1,1));
                end

                ysr1_11(n)=hsr*S(2*n-1)+sgma*(randn+1i.*randn);
```

APPENDIX D (Continued)

```

r1(n)=ysr1_11(n)*hrd*b+hsd*S(2*n)+n1;
%
ysr2_22(n)=hsr*S(2*n)+sgma*(randn+1i*randn);
r2(n)=(-conj(ysr2_22(n)))*hrd*b+hsd*(conj(S(2*n-1)))+n2;
%
ysr3_11(n)=hsr*S(2*n+1)+sgma*(randn+1i*randn);
r3(n)=hrd*ysr3_11(n)*b+hsd*S(2*n+2)+n3;
%
ysr4_22(n)=hsr*S(2*n+2)+sgma*(randn+1i*randn);
r4(n)=(-conj(ysr4_22(n)))*hrd*b+hsd*(conj(S(2*n+1)))+n4;
r(2*n-1)=r3(n)*conj(r1(n))+conj(r4(n))*r2(n);
r(2*n)=r3(n)*conj(r2(n))-conj(r4(n))*r1(n);
end

% function m=baseB1(r)
ll=(length(r)/2)+1;
u11=zeros(1,ll);u12=zeros(1,ll);u13=zeros(1,ll);u14=zeros(1,ll);
u21=zeros(1,ll);u22=zeros(1,ll);u23=zeros(1,ll);u24=zeros(1,ll);
u31=zeros(1,ll);u32=zeros(1,ll);u33=zeros(1,ll);u34=zeros(1,ll);
u41=zeros(1,ll);u42=zeros(1,ll);u43=zeros(1,ll);u44=zeros(1,ll);
Q=zeros(4,ll);Q(1,1)=1;
mu1=zeros(1,ll);mu2=zeros(1,ll);mu3=zeros(1,ll);mu4=zeros(1,ll);

for t1=2:ll
    t=t1-1;
    if Q(1,t)==1
        u11(t1)=((norm(r(2*t-1)-1))^2)+((norm(r(2*t)-
0))^2));Q(1,t1)=1;
        u12(t1)=((norm(r(2*t-1)-
0))^2)+((norm(r(2*t)+1))^2));Q(2,t1)=1;
        u13(t1)=((norm(r(2*t-1)-0))^2)+((norm(r(2*t)-
1))^2));Q(3,t1)=1;
        u14(t1)=((norm(r(2*t-1)+1))^2)+((norm(r(2*t)-
0))^2));Q(4,t1)=1;
    end
    if Q(2,t)==1
        u21(t1)=((norm(r(2*t-1)-0))^2)+((norm(r(2*t)-
1))^2));Q(1,t1)=1;
        u22(t1)=((norm(r(2*t-1)-1))^2)+((norm(r(2*t)-
0))^2));Q(2,t1)=1;
        u23(t1)=((norm(r(2*t-1)+1))^2)+((norm(r(2*t)-
0))^2));Q(3,t1)=1;

```

APPENDIX C (Continued)

APPENDIX D (Continued)

```

        u24(t1)=((norm(r(2*t-1)-
0))^2)+((norm(r(2*t)+1))^2);Q(4,t1)=1;
    end
    if Q(3,t)==1
        u31(t1)=((norm(r(2*t-1)-
0))^2)+((norm(r(2*t)+1))^2);Q(1,t1)=1;
        u32(t1)=((norm(r(2*t-1)+1))^2)+((norm(r(2*t)-
0))^2);Q(2,t1)=1;
        u33(t1)=((norm(r(2*t-1)-1))^2)+((norm(r(2*t)-
0))^2);Q(3,t1)=1;
        u34(t1)=((norm(r(2*t-1)-0))^2)+((norm(r(2*t)-
1))^2);Q(4,t1)=1;
    end
    if Q(4,t)==1
        u41(t1)=((norm(r(2*t-1)+1))^2)+((norm(r(2*t)-
0))^2);Q(1,t1)=1;
        u42(t1)=((norm(r(2*t-1)-0))^2)+((norm(r(2*t)-
1))^2);Q(2,t1)=1;
        u43(t1)=((norm(r(2*t-1)-
0))^2)+((norm(r(2*t)+1))^2);Q(3,t1)=1;
        u44(t1)=((norm(r(2*t-1)-1))^2)+((norm(r(2*t)-
0))^2);Q(4,t1)=1;
    end

    if t1==2
        u21(2)=u11(2);u31(2)=u11(2);u41(2)=u11(2);
        u22(2)=u12(2);u32(2)=u12(2);u42(2)=u12(2);
        u23(2)=u13(2);u33(2)=u13(2);u43(2)=u13(2);
        u24(2)=u14(2);u34(2)=u14(2);u44(2)=u14(2);
    end

    jh1=[mu1(t)+u11(t1) mu2(t)+u21(t1) mu3(t)+u31(t1)
mu4(t)+u41(t1)];
    jh2=[mu1(t)+u12(t1) mu2(t)+u22(t1) mu3(t)+u32(t1)
mu4(t)+u42(t1)];
    jh3=[mu1(t)+u13(t1) mu2(t)+u23(t1) mu3(t)+u33(t1)
mu4(t)+u43(t1)];
    jh4=[mu1(t)+u14(t1) mu2(t)+u24(t1) mu3(t)+u34(t1)
mu4(t)+u44(t1)];

    mu1(t1)=min(jh1);mu2(t1)=min(jh2);mu3(t1)=min(jh3);mu4(t1)=min(jh4);

    if mu1(t1)==mu1(t)+u11(t1)
        go1(t)=1;
    elseif mu1(t1)==mu2(t)+u21(t1)
        go1(t)=2;
    elseif mu1(t1)==mu3(t)+u31(t1)
        go1(t)=3;
    elseif mu1(t1)==mu4(t)+u41(t1)
        go1(t)=4;
    end

```

APPENDIX D (Continued)

```

if mu2(t1)==mu1(t)+u12(t1)
    go2(t)=1;
elseif mu2(t1)==mu2(t)+u22(t1)
    go2(t)=2;
elseif mu2(t1)==mu3(t)+u32(t1)
    go2(t)=3;
elseif mu2(t1)==mu4(t)+u42(t1)
    go2(t)=4;
end

```

```

if mu3(t1)==mu1(t)+u13(t1)
    go3(t)=1;
elseif mu3(t1)==mu2(t)+u23(t1)
    go3(t)=2;
elseif mu3(t1)==mu3(t)+u33(t1)
    go3(t)=3;
elseif mu3(t1)==mu4(t)+u43(t1)
    go3(t)=4;
end

```

```

if mu4(t1)==mu1(t)+u14(t1)
    go4(t)=1;
elseif mu4(t1)==mu2(t)+u24(t1)
    go4(t)=2;
elseif mu4(t1)==mu3(t)+u34(t1)
    go4(t)=3;
elseif mu4(t1)==mu4(t)+u44(t1)
    go4(t)=4;
end

```

```

end

```

```

%=====

```

```

go(1,:)=go1;go(2,:)=go2;go(3,:)=go3;go(4,:)=go4;

```

```

Last=[mu1(l1) mu2(l1) mu3(l1) mu4(l1)];
start=min(Last);

```

```

if start==mu1(l1)
    l1(length(go1)+1)=1;
    m(2*length(go1)-1)=1;m(2*length(go1))=1;
    l1(length(go1))=go(1,length(go1));
    for t2=length(go1):-1:2
        l1(t2-1)=go(l1(t2),t2-1);
        if l1(t2)==1
            m(2*t2-3)=1;m(2*t2-2)=1;
        elseif l1(t2)==2
            m(2*t2-3)=1;m(2*t2-2)=-1;
        elseif l1(t2)==3
            m(2*t2-3)=-1;m(2*t2-2)=1;
        elseif l1(t2)==4
            m(2*t2-3)=-1;m(2*t2-2)=-1;
        end
    end
end

```

APPENDIX D (Continued)

```
end
end

elseif start==mu2(l1)
    l1(length(go1)+1)=2;
    m(2*length(go1)-1)=1;m(2*length(go1))=-1;
    l1(length(go1))=go(2,length(go1));
    for t2=length(go1):-1:2
        l1(t2-1)=go(l1(t2),t2-1);
        if l1(t2)==1
            m(2*t2-3)=1;m(2*t2-2)=1;
        elseif l1(t2)==2
            m(2*t2-3)=1;m(2*t2-2)=-1;
        elseif l1(t2)==3
            m(2*t2-3)=-1;m(2*t2-2)=1;
        elseif l1(t2)==4
            m(2*t2-3)=-1;m(2*t2-2)=-1;
        end
    end
end

elseif start==mu3(l1)
    l1(length(go1)+1)=3;
    m(2*length(go1)-1)=-1;m(2*length(go1))=1;
    l1(length(go1))=go(3,length(go1));
    for t2=length(go1):-1:2
        l1(t2-1)=go(l1(t2),t2-1);
        if l1(t2)==1
            m(2*t2-3)=1;m(2*t2-2)=1;
        elseif l1(t2)==2
            m(2*t2-3)=1;m(2*t2-2)=-1;
        elseif l1(t2)==3
            m(2*t2-3)=-1;m(2*t2-2)=1;
        elseif l1(t2)==4
            m(2*t2-3)=-1;m(2*t2-2)=-1;
        end
    end
end

elseif start==mu4(l1)
    l1(length(go1)+1)=4;
    m(2*length(go1)-1)=-1;m(2*length(go1))=-1;
    l1(length(go1))=go(4,length(go1));
    for t2=length(go1):-1:2
        l1(t2-1)=go(l1(t2),t2-1);
        if l1(t2)==1
            m(2*t2-3)=1;m(2*t2-2)=1;
        elseif l1(t2)==2
            m(2*t2-3)=1;m(2*t2-2)=-1;
        elseif l1(t2)==3
            m(2*t2-3)=-1;m(2*t2-2)=1;
        elseif l1(t2)==4
            m(2*t2-3)=-1;m(2*t2-2)=-1;
        end
    end
end
end
```

APPENDIX D (Continued)

```

% =====for frame error rate=====
%     er=msg-m;
%     if nnz(er)~=0
%         er_frame=er_frame+1;
%     end
%     error(SNR)=er_frame;
% =====

%=====for bit error rate=====

er=msg-m;
er_bit=er_bit+nnz(er);
error(SNR)=er_bit;

%=====

    end
end
reset1=error+reset1;

end
avg_er=reset1/ci;

semilogy(SNRindB,avg_er/(no_frame*k), '-r+');

% semilogy(SNRindB,avg_er/no_frame, '-r+');
grid on
hold on

```

APPENDIX E

PROGRAM OF DSTBC RELAY COMBINED WITH AF

```
clear all;
clc;
% tic;

k=1000000;
P=1;
SNRindB=0:2:22;
No=P./10.^(SNRindB./10);
sgma=sqrt(No/2);

S0=randint(1,k/2);
S1=randint(1,k/2);

hsr=sqrt(0.5).*(randn(1,k/2)+1i.*randn(1,k/2));
hsd=sqrt(0.5).*(randn(1,k/2)+1i.*randn(1,k/2));
hrd=sqrt(0.5).*(randn(1,k/2)+1i.*randn(1,k/2));
% hsr=ones(1,k/2);
% hsd=ones(1,k/2);
% hrd=ones(1,k/2);

s0=(pskmod(S0,2))/sqrt(2);
s1=(pskmod(S1,2))/sqrt(2);

for snr=1:length(SNRindB)

    snr

    for n=1:k/2
        b(n)=sqrt(P/(P*(abs(hsr(n)))^2+No(snr)));

        ysr1(n)=hsr(n)*s0(n)+sgma(snr)*(randn+1i*randn);

        r0(n)=ysr1(n)*hrd(n)*b(n)+hsd(n)*s1(n)+sgma(snr)*(randn+1i*randn);

        ysr2(n)=hsr(n)*(-conj(s1(n)))+sgma(snr)*(randn+1i*randn);

        r1(n)=(ysr2(n))*hrd(n)*b(n)+hsd(n)*conj(s0(n))+sgma(snr)*(randn+1i*randn);

        s_0(n)=conj(hrd(n))*conj(hsr(n))*r0(n)+hsd(n)*conj(r1(n));
        s_1(n)=conj(hsd(n))*r0(n)-(hrd(n)*hsr(n))*conj(r1(n));
    end
end
```

APPENDIX E (Continued)

```
end
m0=pskdemod(s_0,2);
m1=pskdemod(s_1,2);

er0(snr)=nnz(S0-m0);
er1(snr)=nnz(S1-m1);
err(snr)=er0(snr)+er1(snr);
end

semilogy(SNRindB,err/k, '-b+');
grid on
hold on
% toc;
```

APPENDIX F

PROGRAM OF ZHANG'S CODE IN CASE OF JAKES' FADING

```
clear all;
clc;
close all;
n=24000;
SNR_dB=0:3:21;
No=1./10.^(SNR_dB/10);
sgma=sqrt(No/2);

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% JAKES FADING starts here %%%%%%%%%%
%           v=3*1000/3600;%velocity of vehicle
vc = 3e8;% velocity of light [m/sec]
fc=2e9;%carrier frequency
%           fd=v*fc/vc;% maximum doppler shift frequency
N_fb=1;% number of bits in one fading block=one code symbol size
Rb = 100e3; %10kbits/sec
Tb = 1/Rb;

fdTs=0.01;
fd=fdTs/Tb;
v=fd*vc/fc;

fb_num = 1;
fb2_num = 1000000;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Jakes Model Parameter %%%%%%%%%%
No = 8;% number of oscillators
N = 4*No + 2;
alpha = pi/4;
% Other Parameters
k1 = linspace(1, No, No);
betan = pi*k1/No;
wn=2*pi*fd*cos(2*pi*k1/N);
tmpc=0;
tmps=0;

for ii=1:1:(n/2)/N_fb
    tmpc=0;
    tmps=0;
    tmpc2=0;
    tmps2=0;
    t=fb_num*Tb;%%% synchronizing fading block time with Tb time
    t2=fb2_num*Tb;
    for g=1:1:No
        c = cos(betan(g))*cos(wn(g)*t);
        s = sin(betan(g))*cos(wn(g)*t);
        tmpc=tmpc+c;
        tmps=tmps+s;
    end
end
```

APPENDIX F (Continued)

```

cc = cos(betan(g))*cos(wn(g)*t2);
ss = sin(betan(g))*cos(wn(g)*t2);
tmpc2=tmpc2+cc;
tmps2=tmps2+ss;
end
xc=(2*tmpc+(sqrt(2)*cos(alpha)*cos(2*pi*fd*t)))/sqrt(2*No);%%%%%sqrt(No)
is to normalize
xs=(2*tmps+(sqrt(2)*sin(alpha)*cos(2*pi*fd*t)))/sqrt(2*(No+1));%%%%and 2
as we have complex fading ie,. two components sin and cos.
fadel(ii) = xc + (sqrt(-1)*xs);

xcc=(2*tmpc2+(sqrt(2)*cos(alpha)*cos(2*pi*fd*t2)))/sqrt(2*No);%%%%%sqrt(No)
is to normalize
xss=(2*tmps2+(sqrt(2)*sin(alpha)*cos(2*pi*fd*t2)))/sqrt(2*(No+1));%%%%and
2 as we have complex fading ie,. two components sin and cos.

fade2(ii) = xcc + (sqrt(-1)*xss);
fb_num=fb_num+N_fb;
fb2_num=fb2_num+N_fb;
end

```

%%%%%%%%%=====Jakes End=====

```

for k=1:length(SNR_dB)
    k
    nErr=0;
    for m=1:n/8 %/ the number of block of all symbols

        msg1=randint(1,1,3);
        s1=cos(msg1*2*pi/3)+j*sin(msg1*2*pi/3);
        msg2=randint(1,1,3);
        s2=cos(msg2*2*pi/3)+j*sin(msg2*2*pi/3);
        msg3=randint(1,1,4);
        s3=pskmod(msg3,4);
        msg4=randint(1,1,4);
        s4=pskmod(msg4,4);

        msg5=randint(1,1,3);
        s5=cos(msg5*2*pi/3)+j*sin(msg5*2*pi/3);
        msg6=randint(1,1,3);
        s6=cos(msg6*2*pi/3)+j*sin(msg6*2*pi/3);
        msg7=randint(1,1,4);
        s7=pskmod(msg7,4);
        msg8=randint(1,1,4);
        s8=pskmod(msg8,4);
    end
end

```


APPENDIX F (Continued)

```

%          h1=1/sqrt(2)*(randn+j*randn);
%          h2=1/sqrt(2)*(randn+j*randn);

h1=fade1(2*m);
h2=fade2(2*m);

%          xiaos1=[s1 s2;-conj(s2) conj(s1)]*[h1(4*m-3);h2(4*m-3)];
%          xiaos2=[s3 s4;-conj(s4) conj(s3)]*[h1(4*m-2);h2(4*m-2)];
%          xiaos3=[s5 s6;-conj(s6) conj(s5)]*[h1(4*m-1);h2(4*m-1)];
%          xiaos4=[s7 s8;-conj(s8) conj(s7)]*[h1(4*m);h2(4*m)];
%          SH=[xiaos1;xiaos2;xiaos3;xiaos4];

S=[s1 s2;-conj(s2) conj(s1);s3 s4;-conj(s4) conj(s3);s5 s6;-conj(s6)
conj(s5);s7 s8;-conj(s8) conj(s7)];
H=[h1;h2];
N=[sgma(k)*(randn+j*randn) sgma(k)*(randn+j*randn)
sgma(k)*(randn+j*randn) sgma(k)*(randn+j*randn) sgma(k)*(randn+j*randn)
sgma(k)*(randn+j*randn) sgma(k)*(randn+j*randn) sgma(k)*(randn+j*randn)]';
%          Z=SH+N;
Z=S*H+N;
Z_bar=[Z(1) -Z(2) Z(3) -Z(4) Z(5) -Z(6) Z(7) -Z(8); conj(Z(2))
conj(Z(1)) conj(Z(4)) conj(Z(3)) conj(Z(6)) conj(Z(5)) conj(Z(8))
conj(Z(7))];
P=(trace(Z_bar'*Z_bar)+1)*eye(8)-Z_bar'*Z_bar;
s_hat=inf;

for count1=0:2
    for count2=0:2
        for count3=0:3
            for count4=0:3
                for count5=0:2
                    for count6=0:2
                        for count7=0:3
                            for count8=0:3

x1=cos(count1*2*pi/3)+j*sin(count1*2*pi/3);

x2=cos(count2*2*pi/3)+j*sin(count2*2*pi/3);
y1=pskmod(count3,4);
y2=pskmod(count4,4);

x3=cos(count5*2*pi/3)+j*sin(count5*2*pi/3);

x4=cos(count6*2*pi/3)+j*sin(count6*2*pi/3);
y3=pskmod(count7,4);
y4=pskmod(count8,4);

s=[conj(x1); x2; conj(y1);
y2; conj(x3); x4; conj(y3); y4];

if abs(s'*P*s) < abs(s_hat)
    s_hat=s'*P*s;

```

APPENDIX F (Continued)

```

x1_hat=count1;
x2_hat=count2;
y1_hat=count3;
y2_hat=count4;

x3_hat=count5;
x4_hat=count6;
y3_hat=count7;
y4_hat=count8;
end
end
end
end
end
end
end
end
if x1_hat~=msg1
    nErr=nErr+1;
end
if x2_hat~=msg2
    nErr=nErr+1;
end
if y1_hat~=msg3
    nErr=nErr+1;
end
if y2_hat~=msg4
    nErr=nErr+1;
end
if x3_hat~=msg5
    nErr=nErr+1;
end
if x4_hat~=msg6
    nErr=nErr+1;
end
if y3_hat~=msg7
    nErr=nErr+1;
end
if y4_hat~=msg8
    nErr=nErr+1;
end
end
SER(k)=nErr/n;
end

semilogy(SNR_dB, SER, '-') %symbol error rate
grid on

```

APPENDIX G

PROGRAM OF QPSK BLIND VITERBI IN CASE OF JAKES' FADING

```
clear all
clc

k=4;
SNRindB=0:3:21;
ci=400;
reset1=0;
no_frame=10000;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% JAKES FADING starts here %%%%%%%%%%
Rb = 100e3; %10kbits/sec
Tb = 1/Rb;
%      v=3*1000/3600;%velocity of vehicle
vc = 3e8;% velocity of light [m/sec]
fc=2e9;%carrier frequency
%      fd=v*fc/vc;% maximum doppler shift frequency
fdTs=0.01;
fd=fdTs/Tb;
v=fd*vc/fc;

N_fb=1;% number of bits in one fading block=one code symbol size

fb_num1 = 1;
fb_num2 = 100000;
% fb_num3 = 10000000;
% fb_num4 = 1000000000;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Jakes Model Parameter %%%%%%%%%%
No = 8;% number of oscillators
N = 4*No + 2;
alpha = pi/4;
% Other Parameters
k1 = linspace(1, No, No);
betan = pi*k1/No;
wn=2*pi*fd*cos(2*pi*k1/N);
tmpc=0;
tmps=0;
tmpc2=0;
tmps2=0;

for ii=1:1:((k*no_frame/2)/N_fb)
    tmpc=0;
    tmps=0;
    tmpc2=0;
    tmps2=0;

    t1=fb_num1*Tb;%%%% synchronizing fading block time with Tb time
```

APPENDIX G (Continued)

```

t11(ii)=t1;
t2=fb_num2*Tb;%%%% synchronizing fading block time with Tb time
t22(ii)=t2;

for n=1:1:No
    c = cos(betan(n))*cos(wn(n)*t1);
    s = sin(betan(n))*cos(wn(n)*t1);
    c2 = cos(betan(n))*cos(wn(n)*t2);
    s2 = sin(betan(n))*cos(wn(n)*t2);

    tmpc=tmpc+c;
    tmps=tmps+s;
    tmpc2=tmpc2+c2;
    tmps2=tmps2+s2;
%     tmpc3=tmpc3+c3;
%     tmps3=tmps3+s3;
%     tmpc4=tmpc4+c4;
%     tmps4=tmps4+s4;

end

xc=(2*tmpc+(sqrt(2)*cos(alpha)*cos(2*pi*fd*t1)))/sqrt(2*No);%%%%%sqrt(No) is
to normalize
xs=(2*tmps+(sqrt(2)*sin(alpha)*cos(2*pi*fd*t1)))/sqrt(2*(No+1));%%%%and 2
as we have complex fading ie,. two components sin and cos.
fade(ii) = xc + (sqrt(-1)*xs);

xc2=(2*tmpc2+(sqrt(2)*cos(alpha)*cos(2*pi*fd*t2)))/sqrt(2*No);%%%%%sqrt(No)
is to normalize
xs2=(2*tmps2+(sqrt(2)*sin(alpha)*cos(2*pi*fd*t2)))/sqrt(2*(No+1));%%%%and
2 as we have complex fading ie,. two components sin and cos.
fade2(ii) = xc2 + (sqrt(-1)*xs2);

fb_num1=fb_num1+N_fb;
fb_num2=fb_num2+N_fb;
%     fb_num3=fb_num3+N_fb;
%     fb_num4=fb_num4+N_fb;

end

for avg=1:ci
    avg

    for SNR=1:length(SNRindB)
        er_frame=0;
        SNR;
        snr=10^(SNRindB(SNR)/10);
        sigma=sqrt(1/snr/2);

```

APPENDIX G (Continued)

```

for no_fra=1:no_frame
    msg=randint(1,k);
    for num_b=1:(k/2)

        if msg(2*num_b-1)==0 && msg(2*num_b)==0
            msg_mod(num_b)=1;
        elseif msg(2*num_b-1)==0 && msg(2*num_b)==1
            msg_mod(num_b)=i;
        elseif msg(2*num_b-1)==1 && msg(2*num_b)==1
            msg_mod(num_b)=-1;
        elseif msg(2*num_b-1)==1 && msg(2*num_b)==0
            msg_mod(num_b)=-i;
        end
    end
    schu=[1 1];
    S=[schu,msg_mod]./sqrt(2);

% %                h1=sqrt(0.5).*(randn(1,1)+j.*randn(1,1));
% %                h2=sqrt(0.5).*(randn(1,1)+j.*randn(1,1));

h1=fade(2*no_fra-1);
h2=fade2(2*no_fra-1);

for xiaor_pair=1:(length(msg_mod)/2)

    if xiaor_pair==1
        n1=sgma.*(randn(1,1)+j*randn(1,1));
        n2=sgma.*(randn(1,1)+j*randn(1,1));
        n3=sgma.*(randn(1,1)+j*randn(1,1));
        n4=sgma.*(randn(1,1)+j*randn(1,1));
    else
        n1=n3;
        n2=n4;
        n3=sgma.*(randn(1,1)+j*randn(1,1));
        n4=sgma.*(randn(1,1)+j*randn(1,1));
    end
    r1(xiaor_pair)=h1*S(2*xiaor_pair-1)+h2*S(2*xiaor_pair)+n1;
    r2(xiaor_pair)=-conj(S(2*xiaor_pair))*h1+conj(S(2*xiaor_pair-1))*h2+n2;
    r3(xiaor_pair)=h1*S(2*xiaor_pair+1)+h2*S(2*xiaor_pair+2)+n3;
    r4(xiaor_pair)=-conj(S(2*xiaor_pair+2))*h1+conj(S(2*xiaor_pair+1))*h2+n4;
%                 r1(xiaor_pair)=h1*S(2*xiaor_pair-
1)+h2*S(2*xiaor_pair);
%                 r2(xiaor_pair)=-conj(S(2*xiaor_pair))*h1+conj(S(2*xiaor_pair-1))*h2;
%                 r3(xiaor_pair)=h1*S(2*xiaor_pair+1)+h2*S(2*xiaor_pair+2);
%                 r4(xiaor_pair)=-conj(S(2*xiaor_pair+2))*h1+conj(S(2*xiaor_pair+1))*h2;
%
end

```

APPENDIX G (Continued)

```

        r(2*xiaor_pair-
1)=r3(xiaor_pair)*conj(r1(xiaor_pair))+conj(r4(xiaor_pair))*r2(xiaor_pair);
        r(2*xiaor_pair)=r3(xiaor_pair)*conj(r2(xiaor_pair))-
conj(r4(xiaor_pair))*r1(xiaor_pair);
    end

%=====
% caculate R***r
a1=1/sqrt(2); %----S1
a2=1/sqrt(2);

        a3=1/sqrt(2);a4=1/sqrt(2);          A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R1_1=[A,B];
        a3=1/sqrt(2);a4=1i/sqrt(2);          A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R1_2=[A,B];
        a3=1/sqrt(2);a4=-1/sqrt(2);          A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R1_3=[A,B];
        a3=1/sqrt(2);a4=-1i/sqrt(2);          A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R1_4=[A,B];

        a3=1i/sqrt(2);a4=1/sqrt(2);          A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R1_5=[A,B];
        a3=1i/sqrt(2);a4=1i/sqrt(2);          A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R1_6=[A,B];
        a3=1i/sqrt(2);a4=-1/sqrt(2);          A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R1_7=[A,B];
        a3=1i/sqrt(2);a4=-1i/sqrt(2);          A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R1_8=[A,B];

        a3=-1/sqrt(2);a4=1/sqrt(2);          A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R1_9=[A,B];
        a3=-1/sqrt(2);a4=1i/sqrt(2);          A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R1_10=[A,B];
        a3=-1/sqrt(2);a4=-1/sqrt(2);          A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R1_11=[A,B];
        a3=-1/sqrt(2);a4=-1i/sqrt(2);          A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R1_12=[A,B];

        a3=-1i/sqrt(2);a4=1/sqrt(2);          A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R1_13=[A,B];
        a3=-1i/sqrt(2);a4=1i/sqrt(2);          A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R1_14=[A,B];
        a3=-1i/sqrt(2);a4=-1/sqrt(2);          A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R1_15=[A,B];
        a3=-1i/sqrt(2);a4=-1i/sqrt(2);
A=a3*conj(a1)+a4*conj(a2);B=-a3*a2+a4*a1;R1_16=[A,B];

        a1=1/sqrt(2);%----S2
        a2=1i/sqrt(2);

        a3=1/sqrt(2);a4=1/sqrt(2);          A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R2_1=[A,B];

```

APPENDIX G (Continued)

$a_3=1/\sqrt{2}; a_4=1i/\sqrt{2};$ $a_3*a_2+a_4*a_1; R2_2=[A, B];$ $a_3=1/\sqrt{2}; a_4=-1/\sqrt{2};$ $a_3*a_2+a_4*a_1; R2_3=[A, B];$ $a_3=1/\sqrt{2}; a_4=-1i/\sqrt{2};$ $a_3*a_2+a_4*a_1; R2_4=[A, B];$	$A=a_3*\text{conj}(a_1)+a_4*\text{conj}(a_2); B=-$ $A=a_3*\text{conj}(a_1)+a_4*\text{conj}(a_2); B=-$ $A=a_3*\text{conj}(a_1)+a_4*\text{conj}(a_2); B=-$
$a_3=1i/\sqrt{2}; a_4=1/\sqrt{2};$ $a_3*a_2+a_4*a_1; R2_5=[A, B];$ $a_3=1i/\sqrt{2}; a_4=1i/\sqrt{2};$ $a_3*a_2+a_4*a_1; R2_6=[A, B];$ $a_3=1i/\sqrt{2}; a_4=-1/\sqrt{2};$ $a_3*a_2+a_4*a_1; R2_7=[A, B];$ $a_3=1i/\sqrt{2}; a_4=-1i/\sqrt{2};$ $a_3*a_2+a_4*a_1; R2_8=[A, B];$	$A=a_3*\text{conj}(a_1)+a_4*\text{conj}(a_2); B=-$ $A=a_3*\text{conj}(a_1)+a_4*\text{conj}(a_2); B=-$ $A=a_3*\text{conj}(a_1)+a_4*\text{conj}(a_2); B=-$ $A=a_3*\text{conj}(a_1)+a_4*\text{conj}(a_2); B=-$
$a_3=-1/\sqrt{2}; a_4=1/\sqrt{2};$ $a_3*a_2+a_4*a_1; R2_9=[A, B];$ $a_3=-1/\sqrt{2}; a_4=1i/\sqrt{2};$ $a_3*a_2+a_4*a_1; R2_10=[A, B];$ $a_3=-1/\sqrt{2}; a_4=-1/\sqrt{2};$ $a_3*a_2+a_4*a_1; R2_11=[A, B];$ $a_3=-1/\sqrt{2}; a_4=-1i/\sqrt{2};$ $a_3*a_2+a_4*a_1; R2_12=[A, B];$	$A=a_3*\text{conj}(a_1)+a_4*\text{conj}(a_2); B=-$ $A=a_3*\text{conj}(a_1)+a_4*\text{conj}(a_2); B=-$ $A=a_3*\text{conj}(a_1)+a_4*\text{conj}(a_2); B=-$ $A=a_3*\text{conj}(a_1)+a_4*\text{conj}(a_2); B=-$
$a_3=-1i/\sqrt{2}; a_4=1/\sqrt{2};$ $a_3*a_2+a_4*a_1; R2_13=[A, B];$ $a_3=-1i/\sqrt{2}; a_4=1i/\sqrt{2};$ $a_3*a_2+a_4*a_1; R2_14=[A, B];$ $a_3=-1i/\sqrt{2}; a_4=-1/\sqrt{2};$ $a_3*a_2+a_4*a_1; R2_15=[A, B];$ $a_3=-1i/\sqrt{2}; a_4=-1i/\sqrt{2};$ $A=a_3*\text{conj}(a_1)+a_4*\text{conj}(a_2); B=-a_3*a_2+a_4*a_1; R2_16=[A, B];$	$A=a_3*\text{conj}(a_1)+a_4*\text{conj}(a_2); B=-$ $A=a_3*\text{conj}(a_1)+a_4*\text{conj}(a_2); B=-$ $A=a_3*\text{conj}(a_1)+a_4*\text{conj}(a_2); B=-$
$a_1=1/\sqrt{2}; \% \text{---S3}$ $a_2=-1/\sqrt{2};$	
$a_3=1/\sqrt{2}; a_4=1/\sqrt{2};$ $a_3*a_2+a_4*a_1; R3_1=[A, B];$ $a_3=1/\sqrt{2}; a_4=1i/\sqrt{2};$ $a_3*a_2+a_4*a_1; R3_2=[A, B];$ $a_3=1/\sqrt{2}; a_4=-1/\sqrt{2};$ $a_3*a_2+a_4*a_1; R3_3=[A, B];$ $a_3=1/\sqrt{2}; a_4=-1i/\sqrt{2};$ $a_3*a_2+a_4*a_1; R3_4=[A, B];$	$A=a_3*\text{conj}(a_1)+a_4*\text{conj}(a_2); B=-$ $A=a_3*\text{conj}(a_1)+a_4*\text{conj}(a_2); B=-$ $A=a_3*\text{conj}(a_1)+a_4*\text{conj}(a_2); B=-$ $A=a_3*\text{conj}(a_1)+a_4*\text{conj}(a_2); B=-$
$a_3=1i/\sqrt{2}; a_4=1/\sqrt{2};$ $a_3*a_2+a_4*a_1; R3_5=[A, B];$ $a_3=1i/\sqrt{2}; a_4=1i/\sqrt{2};$ $a_3*a_2+a_4*a_1; R3_6=[A, B];$ $a_3=1i/\sqrt{2}; a_4=-1/\sqrt{2};$ $a_3*a_2+a_4*a_1; R3_7=[A, B];$	$A=a_3*\text{conj}(a_1)+a_4*\text{conj}(a_2); B=-$ $A=a_3*\text{conj}(a_1)+a_4*\text{conj}(a_2); B=-$ $A=a_3*\text{conj}(a_1)+a_4*\text{conj}(a_2); B=-$

APPENDIX G (Continued)

$a_3 = 1i/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3*a_2+a_4*a_1; R3_8 = [A, B];$	$A = a_3*\text{conj}(a_1) + a_4*\text{conj}(a_2); B = -$
$a_3 = -1/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3*a_2+a_4*a_1; R3_9 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3*a_2+a_4*a_1; R3_10 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3*a_2+a_4*a_1; R3_11 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3*a_2+a_4*a_1; R3_12 = [A, B];$	$A = a_3*\text{conj}(a_1) + a_4*\text{conj}(a_2); B = -$ $A = a_3*\text{conj}(a_1) + a_4*\text{conj}(a_2); B = -$ $A = a_3*\text{conj}(a_1) + a_4*\text{conj}(a_2); B = -$ $A = a_3*\text{conj}(a_1) + a_4*\text{conj}(a_2); B = -$
$a_3 = -1i/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3*a_2+a_4*a_1; R3_13 = [A, B];$ $a_3 = -1i/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3*a_2+a_4*a_1; R3_14 = [A, B];$ $a_3 = -1i/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3*a_2+a_4*a_1; R3_15 = [A, B];$ $a_3 = -1i/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $A = a_3*\text{conj}(a_1) + a_4*\text{conj}(a_2); B = -a_3*a_2+a_4*a_1; R3_16 = [A, B];$	$A = a_3*\text{conj}(a_1) + a_4*\text{conj}(a_2); B = -$ $A = a_3*\text{conj}(a_1) + a_4*\text{conj}(a_2); B = -$ $A = a_3*\text{conj}(a_1) + a_4*\text{conj}(a_2); B = -$
$a_1 = 1/\sqrt{2}; \% \text{---S4}$ $a_2 = -1i/\sqrt{2};$	
$a_3 = 1/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3*a_2+a_4*a_1; R4_1 = [A, B];$ $a_3 = 1/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3*a_2+a_4*a_1; R4_2 = [A, B];$ $a_3 = 1/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3*a_2+a_4*a_1; R4_3 = [A, B];$ $a_3 = 1/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3*a_2+a_4*a_1; R4_4 = [A, B];$	$A = a_3*\text{conj}(a_1) + a_4*\text{conj}(a_2); B = -$ $A = a_3*\text{conj}(a_1) + a_4*\text{conj}(a_2); B = -$ $A = a_3*\text{conj}(a_1) + a_4*\text{conj}(a_2); B = -$ $A = a_3*\text{conj}(a_1) + a_4*\text{conj}(a_2); B = -$
$a_3 = 1i/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3*a_2+a_4*a_1; R4_5 = [A, B];$ $a_3 = 1i/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3*a_2+a_4*a_1; R4_6 = [A, B];$ $a_3 = 1i/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3*a_2+a_4*a_1; R4_7 = [A, B];$ $a_3 = 1i/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3*a_2+a_4*a_1; R4_8 = [A, B];$	$A = a_3*\text{conj}(a_1) + a_4*\text{conj}(a_2); B = -$ $A = a_3*\text{conj}(a_1) + a_4*\text{conj}(a_2); B = -$ $A = a_3*\text{conj}(a_1) + a_4*\text{conj}(a_2); B = -$ $A = a_3*\text{conj}(a_1) + a_4*\text{conj}(a_2); B = -$
$a_3 = -1/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3*a_2+a_4*a_1; R4_9 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3*a_2+a_4*a_1; R4_10 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3*a_2+a_4*a_1; R4_11 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3*a_2+a_4*a_1; R4_12 = [A, B];$	$A = a_3*\text{conj}(a_1) + a_4*\text{conj}(a_2); B = -$ $A = a_3*\text{conj}(a_1) + a_4*\text{conj}(a_2); B = -$ $A = a_3*\text{conj}(a_1) + a_4*\text{conj}(a_2); B = -$ $A = a_3*\text{conj}(a_1) + a_4*\text{conj}(a_2); B = -$

APPENDIX G (Continued)

```

a3=-1i/sqrt(2);a4=1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R4_13=[A,B];
a3=-1i/sqrt(2);a4=1i/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R4_14=[A,B];
a3=-1i/sqrt(2);a4=-1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R4_15=[A,B];
a3=-1i/sqrt(2);a4=-1i/sqrt(2);
A=a3*conj(a1)+a4*conj(a2);B=-a3*a2+a4*a1;R4_16=[A,B];

a1=1i/sqrt(2);%----S5
a2=1/sqrt(2);

a3=1/sqrt(2);a4=1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R5_1=[A,B];
a3=1/sqrt(2);a4=1i/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R5_2=[A,B];
a3=1/sqrt(2);a4=-1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R5_3=[A,B];
a3=1/sqrt(2);a4=-1i/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R5_4=[A,B];

a3=1i/sqrt(2);a4=1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R5_5=[A,B];
a3=1i/sqrt(2);a4=1i/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R5_6=[A,B];
a3=1i/sqrt(2);a4=-1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R5_7=[A,B];
a3=1i/sqrt(2);a4=-1i/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R5_8=[A,B];

a3=-1/sqrt(2);a4=1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R5_9=[A,B];
a3=-1/sqrt(2);a4=1i/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R5_10=[A,B];
a3=-1/sqrt(2);a4=-1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R5_11=[A,B];
a3=-1/sqrt(2);a4=-1i/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R5_12=[A,B];

a3=-1i/sqrt(2);a4=1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R5_13=[A,B];
a3=-1i/sqrt(2);a4=1i/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R5_14=[A,B];
a3=-1i/sqrt(2);a4=-1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R5_15=[A,B];
a3=-1i/sqrt(2);a4=-1i/sqrt(2);
A=a3*conj(a1)+a4*conj(a2);B=-a3*a2+a4*a1;R5_16=[A,B];

a1=1i/sqrt(2);%----S6
a2=1i/sqrt(2);

a3=1/sqrt(2);a4=1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R6_1=[A,B];

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APPENDIX G (Continued)

$a_3 = 1/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R6_2 = [A, B];$ $a_3 = 1/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R6_3 = [A, B];$ $a_3 = 1/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R6_4 = [A, B];$	$A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$
$a_3 = 1i/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R6_5 = [A, B];$ $a_3 = 1i/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R6_6 = [A, B];$ $a_3 = 1i/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R6_7 = [A, B];$ $a_3 = 1i/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R6_8 = [A, B];$	$A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$
$a_3 = -1/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R6_9 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R6_10 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R6_11 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R6_12 = [A, B];$	$A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$
$a_3 = -1i/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R6_13 = [A, B];$ $a_3 = -1i/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R6_14 = [A, B];$ $a_3 = -1i/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R6_15 = [A, B];$ $a_3 = -1i/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -a_3 * a_2 + a_4 * a_1; R6_16 = [A, B];$	$A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$
$a_1 = 1i/\sqrt{2}; \%---S7$ $a_2 = -1/\sqrt{2};$	
$a_3 = 1/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R7_1 = [A, B];$ $a_3 = 1/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R7_2 = [A, B];$ $a_3 = 1/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R7_3 = [A, B];$ $a_3 = 1/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R7_4 = [A, B];$	$A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$
$a_3 = 1i/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R7_5 = [A, B];$ $a_3 = 1i/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R7_6 = [A, B];$ $a_3 = 1i/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R7_7 = [A, B];$	$A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$

APPENDIX G (Continued)

$a_3 = 1i/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R7_8 = [A, B];$	$A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$
$a_3 = -1/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R7_9 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R7_10 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R7_11 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R7_12 = [A, B];$	$A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$
$a_3 = -1i/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R7_13 = [A, B];$ $a_3 = -1i/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R7_14 = [A, B];$ $a_3 = -1i/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R7_15 = [A, B];$ $a_3 = -1i/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -a_3^*a_2 + a_4^*a_1; R7_16 = [A, B];$	$A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$
$a_1 = 1i/\sqrt{2}; \% \text{---S8}$ $a_2 = -1i/\sqrt{2};$	
$a_3 = 1/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R8_1 = [A, B];$ $a_3 = 1/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R8_2 = [A, B];$ $a_3 = 1/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R8_3 = [A, B];$ $a_3 = 1/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R8_4 = [A, B];$	$A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$
$a_3 = 1i/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R8_5 = [A, B];$ $a_3 = 1i/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R8_6 = [A, B];$ $a_3 = 1i/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R8_7 = [A, B];$ $a_3 = 1i/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R8_8 = [A, B];$	$A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$
$a_3 = -1/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R8_9 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R8_10 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R8_11 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R8_12 = [A, B];$	$A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$
$a_3 = -1i/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R8_13 = [A, B];$	$A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$

APPENDIX G (Continued)

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a3=-1i/sqrt(2);a4=1i/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R8_14=[A,B];
a3=-1i/sqrt(2);a4=-1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R8_15=[A,B];
a3=-1i/sqrt(2);a4=-1i/sqrt(2);
A=a3*conj(a1)+a4*conj(a2);B=-a3*a2+a4*a1;R8_16=[A,B];

a1=-1/sqrt(2);%-----S9
a2=1/sqrt(2);

a3=1/sqrt(2);a4=1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R9_1=[A,B];
a3=1/sqrt(2);a4=1i/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R9_2=[A,B];
a3=1/sqrt(2);a4=-1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R9_3=[A,B];
a3=1/sqrt(2);a4=-1i/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R9_4=[A,B];

a3=1i/sqrt(2);a4=1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R9_5=[A,B];
a3=1i/sqrt(2);a4=1i/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R9_6=[A,B];
a3=1i/sqrt(2);a4=-1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R9_7=[A,B];
a3=1i/sqrt(2);a4=-1i/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R9_8=[A,B];

a3=-1/sqrt(2);a4=1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R9_9=[A,B];
a3=-1/sqrt(2);a4=1i/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R9_10=[A,B];
a3=-1/sqrt(2);a4=-1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R9_11=[A,B];
a3=-1/sqrt(2);a4=-1i/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R9_12=[A,B];

a3=-1i/sqrt(2);a4=1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R9_13=[A,B];
a3=-1i/sqrt(2);a4=1i/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R9_14=[A,B];
a3=-1i/sqrt(2);a4=-1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R9_15=[A,B];
a3=-1i/sqrt(2);a4=-1i/sqrt(2);
A=a3*conj(a1)+a4*conj(a2);B=-a3*a2+a4*a1;R9_16=[A,B];

a1=-1/sqrt(2);%-----S10
a2=1i/sqrt(2);

a3=1/sqrt(2);a4=1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R10_1=[A,B];

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APPENDIX G (Continued)

$a3=1/\sqrt{2}; a4=1i/\sqrt{2};$ $a3*a2+a4*a1; R10_2=[A, B];$ $a3=1/\sqrt{2}; a4=-1/\sqrt{2};$ $a3*a2+a4*a1; R10_3=[A, B];$ $a3=1/\sqrt{2}; a4=-1i/\sqrt{2};$ $a3*a2+a4*a1; R10_4=[A, B];$	$A=a3*\text{conj}(a1)+a4*\text{conj}(a2); B=-$ $A=a3*\text{conj}(a1)+a4*\text{conj}(a2); B=-$ $A=a3*\text{conj}(a1)+a4*\text{conj}(a2); B=-$
$a3=1i/\sqrt{2}; a4=1/\sqrt{2};$ $a3*a2+a4*a1; R10_5=[A, B];$ $a3=1i/\sqrt{2}; a4=1i/\sqrt{2};$ $a3*a2+a4*a1; R10_6=[A, B];$ $a3=1i/\sqrt{2}; a4=-1/\sqrt{2};$ $a3*a2+a4*a1; R10_7=[A, B];$ $a3=1i/\sqrt{2}; a4=-1i/\sqrt{2};$ $a3*a2+a4*a1; R10_8=[A, B];$	$A=a3*\text{conj}(a1)+a4*\text{conj}(a2); B=-$ $A=a3*\text{conj}(a1)+a4*\text{conj}(a2); B=-$ $A=a3*\text{conj}(a1)+a4*\text{conj}(a2); B=-$ $A=a3*\text{conj}(a1)+a4*\text{conj}(a2); B=-$
$a3=-1/\sqrt{2}; a4=1/\sqrt{2};$ $a3*a2+a4*a1; R10_9=[A, B];$ $a3=-1/\sqrt{2}; a4=1i/\sqrt{2};$ $a3*a2+a4*a1; R10_10=[A, B];$ $a3=-1/\sqrt{2}; a4=-1/\sqrt{2};$ $a3*a2+a4*a1; R10_11=[A, B];$ $a3=-1/\sqrt{2}; a4=-1i/\sqrt{2};$ $a3*a2+a4*a1; R10_12=[A, B];$	$A=a3*\text{conj}(a1)+a4*\text{conj}(a2); B=-$ $A=a3*\text{conj}(a1)+a4*\text{conj}(a2); B=-$ $A=a3*\text{conj}(a1)+a4*\text{conj}(a2); B=-$ $A=a3*\text{conj}(a1)+a4*\text{conj}(a2); B=-$
$a3=-1i/\sqrt{2}; a4=1/\sqrt{2};$ $a3*a2+a4*a1; R10_13=[A, B];$ $a3=-1i/\sqrt{2}; a4=1i/\sqrt{2};$ $a3*a2+a4*a1; R10_14=[A, B];$ $a3=-1i/\sqrt{2}; a4=-1/\sqrt{2};$ $a3*a2+a4*a1; R10_15=[A, B];$ $a3=-1i/\sqrt{2}; a4=-1i/\sqrt{2};$ $A=a3*\text{conj}(a1)+a4*\text{conj}(a2); B=-a3*a2+a4*a1; R10_16=[A, B];$	$A=a3*\text{conj}(a1)+a4*\text{conj}(a2); B=-$ $A=a3*\text{conj}(a1)+a4*\text{conj}(a2); B=-$ $A=a3*\text{conj}(a1)+a4*\text{conj}(a2); B=-$
$a1=-1/\sqrt{2}; \%-----S11$ $a2=-1/\sqrt{2};$	
$a3=1/\sqrt{2}; a4=1/\sqrt{2};$ $a3*a2+a4*a1; R11_1=[A, B];$ $a3=1/\sqrt{2}; a4=1i/\sqrt{2};$ $a3*a2+a4*a1; R11_2=[A, B];$ $a3=1/\sqrt{2}; a4=-1/\sqrt{2};$ $a3*a2+a4*a1; R11_3=[A, B];$ $a3=1/\sqrt{2}; a4=-1i/\sqrt{2};$ $a3*a2+a4*a1; R11_4=[A, B];$	$A=a3*\text{conj}(a1)+a4*\text{conj}(a2); B=-$ $A=a3*\text{conj}(a1)+a4*\text{conj}(a2); B=-$ $A=a3*\text{conj}(a1)+a4*\text{conj}(a2); B=-$ $A=a3*\text{conj}(a1)+a4*\text{conj}(a2); B=-$
$a3=1i/\sqrt{2}; a4=1/\sqrt{2};$ $a3*a2+a4*a1; R11_5=[A, B];$ $a3=1i/\sqrt{2}; a4=1i/\sqrt{2};$ $a3*a2+a4*a1; R11_6=[A, B];$ $a3=1i/\sqrt{2}; a4=-1/\sqrt{2};$ $a3*a2+a4*a1; R11_7=[A, B];$	$A=a3*\text{conj}(a1)+a4*\text{conj}(a2); B=-$ $A=a3*\text{conj}(a1)+a4*\text{conj}(a2); B=-$ $A=a3*\text{conj}(a1)+a4*\text{conj}(a2); B=-$

APPENDIX G (Continued)

$a_3 = 1i/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R11_8 = [A, B];$	$A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$
$a_3 = -1/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R11_9 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R11_10 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R11_11 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R11_12 = [A, B];$	$A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$
$a_3 = -1i/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R11_13 = [A, B];$ $a_3 = -1i/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R11_14 = [A, B];$ $a_3 = -1i/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R11_15 = [A, B];$ $a_3 = -1i/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -a_3^*a_2 + a_4^*a_1; R11_16 = [A, B];$	$A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$
$a_1 = -1/\sqrt{2}; \% \text{---S12}$ $a_2 = -1i/\sqrt{2};$	
$a_3 = 1/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R12_1 = [A, B];$ $a_3 = 1/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R12_2 = [A, B];$ $a_3 = 1/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R12_3 = [A, B];$ $a_3 = 1/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R12_4 = [A, B];$	$A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$
$a_3 = 1i/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R12_5 = [A, B];$ $a_3 = 1i/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R12_6 = [A, B];$ $a_3 = 1i/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R12_7 = [A, B];$ $a_3 = 1i/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R12_8 = [A, B];$	$A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$
$a_3 = -1/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R12_9 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R12_10 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R12_11 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R12_12 = [A, B];$	$A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$
$a_3 = -1i/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R12_13 = [A, B];$	$A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$

APPENDIX G (Continued)

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a3=-1i/sqrt(2);a4=1i/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R12_14=[A,B];
a3=-1i/sqrt(2);a4=-1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R12_15=[A,B];
a3=-1i/sqrt(2);a4=-1i/sqrt(2);
A=a3*conj(a1)+a4*conj(a2);B=-a3*a2+a4*a1;R12_16=[A,B];

a1=-1i/sqrt(2);%----S13
a2=1/sqrt(2);

a3=1/sqrt(2);a4=1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R13_1=[A,B];
a3=1/sqrt(2);a4=1i/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R13_2=[A,B];
a3=1/sqrt(2);a4=-1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R13_3=[A,B];
a3=1/sqrt(2);a4=-1i/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R13_4=[A,B];

a3=1i/sqrt(2);a4=1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R13_5=[A,B];
a3=1i/sqrt(2);a4=1i/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R13_6=[A,B];
a3=1i/sqrt(2);a4=-1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R13_7=[A,B];
a3=1i/sqrt(2);a4=-1i/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R13_8=[A,B];

a3=-1/sqrt(2);a4=1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R13_9=[A,B];
a3=-1/sqrt(2);a4=1i/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R13_10=[A,B];
a3=-1/sqrt(2);a4=-1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R13_11=[A,B];
a3=-1/sqrt(2);a4=-1i/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R13_12=[A,B];

a3=-1i/sqrt(2);a4=1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R13_13=[A,B];
a3=-1i/sqrt(2);a4=1i/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R13_14=[A,B];
a3=-1i/sqrt(2);a4=-1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R13_15=[A,B];
a3=-1i/sqrt(2);a4=-1i/sqrt(2);
A=a3*conj(a1)+a4*conj(a2);B=-a3*a2+a4*a1;R13_16=[A,B];

a1=-1i/sqrt(2);%----S14
a2=1i/sqrt(2);

a3=1/sqrt(2);a4=1/sqrt(2);      A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R14_1=[A,B];

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APPENDIX G (Continued)

$a_3 = 1/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R14_2 = [A, B];$ $a_3 = 1/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R14_3 = [A, B];$ $a_3 = 1/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R14_4 = [A, B];$	$A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$
$a_3 = 1i/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R14_5 = [A, B];$ $a_3 = 1i/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R14_6 = [A, B];$ $a_3 = 1i/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R14_7 = [A, B];$ $a_3 = 1i/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R14_8 = [A, B];$	$A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$
$a_3 = -1/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R14_9 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R14_10 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R14_11 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R14_12 = [A, B];$	$A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$
$a_3 = -1i/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R14_13 = [A, B];$ $a_3 = -1i/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R14_14 = [A, B];$ $a_3 = -1i/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R14_15 = [A, B];$ $a_3 = -1i/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -a_3 * a_2 + a_4 * a_1; R14_16 = [A, B];$	$A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$
$a_1 = -1i/\sqrt{2}; \% \text{----S15}$ $a_2 = -1/\sqrt{2};$	
$a_3 = 1/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R15_1 = [A, B];$ $a_3 = 1/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R15_2 = [A, B];$ $a_3 = 1/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R15_3 = [A, B];$ $a_3 = 1/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R15_4 = [A, B];$	$A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$
$a_3 = 1i/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R15_5 = [A, B];$ $a_3 = 1i/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R15_6 = [A, B];$ $a_3 = 1i/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3 * a_2 + a_4 * a_1; R15_7 = [A, B];$	$A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$ $A = a_3 * \text{conj}(a_1) + a_4 * \text{conj}(a_2); B = -$

APPENDIX G (Continued)

$a_3 = 1i/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R15_8 = [A, B];$	$A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$
$a_3 = -1/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R15_9 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R15_10 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R15_11 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R15_12 = [A, B];$	$A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$
$a_3 = -1i/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R15_13 = [A, B];$ $a_3 = -1i/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R15_14 = [A, B];$ $a_3 = -1i/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R15_15 = [A, B];$ $a_3 = -1i/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -a_3^*a_2 + a_4^*a_1; R15_16 = [A, B];$	$A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$
$a_1 = -1i/\sqrt{2}; \% \text{----S16}$ $a_2 = -1i/\sqrt{2};$	
$a_3 = 1/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R16_1 = [A, B];$ $a_3 = 1/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R16_2 = [A, B];$ $a_3 = 1/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R16_3 = [A, B];$ $a_3 = 1/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R16_4 = [A, B];$	$A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$
$a_3 = 1i/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R16_5 = [A, B];$ $a_3 = 1i/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R16_6 = [A, B];$ $a_3 = 1i/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R16_7 = [A, B];$ $a_3 = 1i/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R16_8 = [A, B];$	$A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$
$a_3 = -1/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R16_9 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = 1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R16_10 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = -1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R16_11 = [A, B];$ $a_3 = -1/\sqrt{2}; a_4 = -1i/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R16_12 = [A, B];$	$A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$ $A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$
$a_3 = -1i/\sqrt{2}; a_4 = 1/\sqrt{2};$ $a_3^*a_2 + a_4^*a_1; R16_13 = [A, B];$	$A = a_3^*\text{conj}(a_1) + a_4^*\text{conj}(a_2); B = -$

APPENDIX G (Continued)

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        a3=-1i/sqrt(2);a4=1i/sqrt(2);          A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R16_14=[A,B];
        a3=-1i/sqrt(2);a4=-1/sqrt(2);          A=a3*conj(a1)+a4*conj(a2);B=-
a3*a2+a4*a1;R16_15=[A,B];
        a3=-1i/sqrt(2);a4=-1i/sqrt(2);
A=a3*conj(a1)+a4*conj(a2);B=-a3*a2+a4*a1;R16_16=[A,B];

%=====
        l1=(length(r)/2)+1;

u1_1=zeros(1,l1);u1_2=zeros(1,l1);u1_3=zeros(1,l1);u1_4=zeros(1,l1);
u1_5=zeros(1,l1);u1_6=zeros(1,l1);u1_7=zeros(1,l1);u1_8=zeros(1,l1);
u1_9=zeros(1,l1);u1_10=zeros(1,l1);u1_11=zeros(1,l1);u1_12=zeros(1,l1);
u1_13=zeros(1,l1);u1_14=zeros(1,l1);u1_15=zeros(1,l1);u1_16=zeros(1,l1);

u2_1=zeros(1,l1);u2_2=zeros(1,l1);u2_3=zeros(1,l1);u2_4=zeros(1,l1);
u2_5=zeros(1,l1);u2_6=zeros(1,l1);u2_7=zeros(1,l1);u2_8=zeros(1,l1);
u2_9=zeros(1,l1);u2_10=zeros(1,l1);u2_11=zeros(1,l1);u2_12=zeros(1,l1);
u2_13=zeros(1,l1);u2_14=zeros(1,l1);u2_15=zeros(1,l1);u2_16=zeros(1,l1);

u3_1=zeros(1,l1);u3_2=zeros(1,l1);u3_3=zeros(1,l1);u3_4=zeros(1,l1);
u3_5=zeros(1,l1);u3_6=zeros(1,l1);u3_7=zeros(1,l1);u3_8=zeros(1,l1);
u3_9=zeros(1,l1);u3_10=zeros(1,l1);u3_11=zeros(1,l1);u3_12=zeros(1,l1);
u3_13=zeros(1,l1);u3_14=zeros(1,l1);u3_15=zeros(1,l1);u3_16=zeros(1,l1);

u4_1=zeros(1,l1);u4_2=zeros(1,l1);u4_3=zeros(1,l1);u4_4=zeros(1,l1);
u4_5=zeros(1,l1);u4_6=zeros(1,l1);u4_7=zeros(1,l1);u4_8=zeros(1,l1);
u4_9=zeros(1,l1);u4_10=zeros(1,l1);u4_11=zeros(1,l1);u4_12=zeros(1,l1);
u4_13=zeros(1,l1);u4_14=zeros(1,l1);u4_15=zeros(1,l1);u4_16=zeros(1,l1);

u5_1=zeros(1,l1);u5_2=zeros(1,l1);u5_3=zeros(1,l1);u5_4=zeros(1,l1);
u5_5=zeros(1,l1);u5_6=zeros(1,l1);u5_7=zeros(1,l1);u5_8=zeros(1,l1);
u5_9=zeros(1,l1);u5_10=zeros(1,l1);u5_11=zeros(1,l1);u5_12=zeros(1,l1);

```

APPENDIX G (Continued)

u5_13=zeros(1,11);u5_14=zeros(1,11);u5_15=zeros(1,11);u5_16=zeros(1,11);

u6_1=zeros(1,11);u6_2=zeros(1,11);u6_3=zeros(1,11);u6_4=zeros(1,11);

u6_5=zeros(1,11);u6_6=zeros(1,11);u6_7=zeros(1,11);u6_8=zeros(1,11);

u6_9=zeros(1,11);u6_10=zeros(1,11);u6_11=zeros(1,11);u6_12=zeros(1,11);

u6_13=zeros(1,11);u6_14=zeros(1,11);u6_15=zeros(1,11);u6_16=zeros(1,11);

u7_1=zeros(1,11);u7_2=zeros(1,11);u7_3=zeros(1,11);u7_4=zeros(1,11);

u7_5=zeros(1,11);u7_6=zeros(1,11);u7_7=zeros(1,11);u7_8=zeros(1,11);

u7_9=zeros(1,11);u7_10=zeros(1,11);u7_11=zeros(1,11);u7_12=zeros(1,11);

u7_13=zeros(1,11);u7_14=zeros(1,11);u7_15=zeros(1,11);u7_16=zeros(1,11);

u8_1=zeros(1,11);u8_2=zeros(1,11);u8_3=zeros(1,11);u8_4=zeros(1,11);

u8_5=zeros(1,11);u8_6=zeros(1,11);u8_7=zeros(1,11);u8_8=zeros(1,11);

u8_9=zeros(1,11);u8_10=zeros(1,11);u8_11=zeros(1,11);u8_12=zeros(1,11);

u8_13=zeros(1,11);u8_14=zeros(1,11);u8_15=zeros(1,11);u8_16=zeros(1,11);

u9_1=zeros(1,11);u9_2=zeros(1,11);u9_3=zeros(1,11);u9_4=zeros(1,11);

u9_5=zeros(1,11);u9_6=zeros(1,11);u9_7=zeros(1,11);u9_8=zeros(1,11);

u9_9=zeros(1,11);u9_10=zeros(1,11);u9_11=zeros(1,11);u9_12=zeros(1,11);

u9_13=zeros(1,11);u9_14=zeros(1,11);u9_15=zeros(1,11);u9_16=zeros(1,11);

u10_1=zeros(1,11);u10_2=zeros(1,11);u10_3=zeros(1,11);u10_4=zeros(1,11);

u10_5=zeros(1,11);u10_6=zeros(1,11);u10_7=zeros(1,11);u10_8=zeros(1,11);

u10_9=zeros(1,11);u10_10=zeros(1,11);u10_11=zeros(1,11);u10_12=zeros(1,11);

u10_13=zeros(1,11);u10_14=zeros(1,11);u10_15=zeros(1,11);u10_16=zeros(1,11);

u11_1=zeros(1,11);u11_2=zeros(1,11);u11_3=zeros(1,11);u11_4=zeros(1,11);

u11_5=zeros(1,11);u11_6=zeros(1,11);u11_7=zeros(1,11);u11_8=zeros(1,11);

APPENDIX G (Continued)

```
u11_9=zeros(1,11);u11_10=zeros(1,11);u11_11=zeros(1,11);u11_12=zeros(1,11);  
u11_13=zeros(1,11);u11_14=zeros(1,11);u11_15=zeros(1,11);u11_16=zeros(1,11);
```

```
u12_1=zeros(1,11);u12_2=zeros(1,11);u12_3=zeros(1,11);u12_4=zeros(1,11);  
u12_5=zeros(1,11);u12_6=zeros(1,11);u12_7=zeros(1,11);u12_8=zeros(1,11);  
u12_9=zeros(1,11);u12_10=zeros(1,11);u12_11=zeros(1,11);u12_12=zeros(1,11);  
u12_13=zeros(1,11);u12_14=zeros(1,11);u12_15=zeros(1,11);u12_16=zeros(1,11);
```

```
u13_1=zeros(1,11);u13_2=zeros(1,11);u13_3=zeros(1,11);u13_4=zeros(1,11);  
u13_5=zeros(1,11);u13_6=zeros(1,11);u13_7=zeros(1,11);u13_8=zeros(1,11);  
u13_9=zeros(1,11);u13_10=zeros(1,11);u13_11=zeros(1,11);u13_12=zeros(1,11);  
u13_13=zeros(1,11);u13_14=zeros(1,11);u13_15=zeros(1,11);u13_16=zeros(1,11);
```

```
u14_1=zeros(1,11);u14_2=zeros(1,11);u14_3=zeros(1,11);u14_4=zeros(1,11);  
u14_5=zeros(1,11);u14_6=zeros(1,11);u14_7=zeros(1,11);u14_8=zeros(1,11);  
u14_9=zeros(1,11);u14_10=zeros(1,11);u14_11=zeros(1,11);u14_12=zeros(1,11);  
u14_13=zeros(1,11);u14_14=zeros(1,11);u14_15=zeros(1,11);u14_16=zeros(1,11);
```

```
u15_1=zeros(1,11);u15_2=zeros(1,11);u15_3=zeros(1,11);u15_4=zeros(1,11);  
u15_5=zeros(1,11);u15_6=zeros(1,11);u15_7=zeros(1,11);u15_8=zeros(1,11);  
u15_9=zeros(1,11);u15_10=zeros(1,11);u15_11=zeros(1,11);u15_12=zeros(1,11);  
u15_13=zeros(1,11);u15_14=zeros(1,11);u15_15=zeros(1,11);u15_16=zeros(1,11);
```

```
u16_1=zeros(1,11);u16_2=zeros(1,11);u16_3=zeros(1,11);u16_4=zeros(1,11);  
u16_5=zeros(1,11);u16_6=zeros(1,11);u16_7=zeros(1,11);u16_8=zeros(1,11);  
u16_9=zeros(1,11);u16_10=zeros(1,11);u16_11=zeros(1,11);u16_12=zeros(1,11);  
u16_13=zeros(1,11);u16_14=zeros(1,11);u16_15=zeros(1,11);u16_16=zeros(1,11);
```

```
Q=zeros(16,11);Q(1,1)=1;  
mu1=zeros(1,11);mu2=zeros(1,11);mu3=zeros(1,11);mu4=zeros(1,11);  
mu5=zeros(1,11);mu6=zeros(1,11);mu7=zeros(1,11);mu8=zeros(1,11);
```

APPENDIX G (Continued)

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mu9=zeros(1,11);mu10=zeros(1,11);mu11=zeros(1,11);mu12=zeros(1,11);

mu13=zeros(1,11);mu14=zeros(1,11);mu15=zeros(1,11);mu16=zeros(1,11);

% m=baseQ1(r)
for t1=2:11

    t=t1-1;
    if Q(1,t)==1
        u1_1(t1)= ((norm(r(2*t-1)-R1_1(1)))^2)+ ((norm(r(2*t)-
R1_1(2)))^2)); Q(1,t1)=1;
        u1_2(t1)= ((norm(r(2*t-1)-R1_2(1)))^2)+ ((norm(r(2*t)-
R1_2(2)))^2)); Q(2,t1)=1;
        u1_3(t1)= ((norm(r(2*t-1)-R1_3(1)))^2)+ ((norm(r(2*t)-
R1_3(2)))^2)); Q(3,t1)=1;
        u1_4(t1)= ((norm(r(2*t-1)-R1_4(1)))^2)+ ((norm(r(2*t)-
R1_4(2)))^2)); Q(4,t1)=1;
        u1_5(t1)= ((norm(r(2*t-1)-R1_5(1)))^2)+ ((norm(r(2*t)-
R1_5(2)))^2)); Q(5,t1)=1;
        u1_6(t1)= ((norm(r(2*t-1)-R1_6(1)))^2)+ ((norm(r(2*t)-
R1_6(2)))^2)); Q(6,t1)=1;
        u1_7(t1)= ((norm(r(2*t-1)-R1_7(1)))^2)+ ((norm(r(2*t)-
R1_7(2)))^2)); Q(7,t1)=1;
        u1_8(t1)= ((norm(r(2*t-1)-R1_8(1)))^2)+ ((norm(r(2*t)-
R1_8(2)))^2)); Q(8,t1)=1;
        u1_9(t1)= ((norm(r(2*t-1)-R1_9(1)))^2)+ ((norm(r(2*t)-
R1_9(2)))^2)); Q(9,t1)=1;
        u1_10(t1)=((norm(r(2*t-1)-R1_10(1)))^2)+((norm(r(2*t)-
R1_10(2)))^2));Q(10,t1)=1;
        u1_11(t1)=((norm(r(2*t-1)-R1_11(1)))^2)+((norm(r(2*t)-
R1_11(2)))^2));Q(11,t1)=1;
        u1_12(t1)=((norm(r(2*t-1)-R1_12(1)))^2)+((norm(r(2*t)-
R1_12(2)))^2));Q(12,t1)=1;
        u1_13(t1)=((norm(r(2*t-1)-R1_13(1)))^2)+((norm(r(2*t)-
R1_13(2)))^2));Q(13,t1)=1;
        u1_14(t1)=((norm(r(2*t-1)-R1_14(1)))^2)+((norm(r(2*t)-
R1_14(2)))^2));Q(14,t1)=1;
        u1_15(t1)=((norm(r(2*t-1)-R1_15(1)))^2)+((norm(r(2*t)-
R1_15(2)))^2));Q(15,t1)=1;
        u1_16(t1)=((norm(r(2*t-1)-R1_16(1)))^2)+((norm(r(2*t)-
R1_16(2)))^2));Q(16,t1)=1;

    end
    if Q(2,t)==1
        u2_1(t1)= ((norm(r(2*t-1)-R2_1(1)))^2)+ ((norm(r(2*t)-
R2_1(2)))^2)); Q(1,t1)=1;
        u2_2(t1)= ((norm(r(2*t-1)-R2_2(1)))^2)+ ((norm(r(2*t)-
R2_2(2)))^2)); Q(2,t1)=1;
        u2_3(t1)= ((norm(r(2*t-1)-R2_3(1)))^2)+ ((norm(r(2*t)-
R2_3(2)))^2)); Q(3,t1)=1;
        u2_4(t1)= ((norm(r(2*t-1)-R2_4(1)))^2)+ ((norm(r(2*t)-
R2_4(2)))^2)); Q(4,t1)=1;

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APPENDIX G (Continued)

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        u2_5(t1)= ((norm(r(2*t-1)-R2_5(1)))^2)+ ((norm(r(2*t)-
R2_5(2)))^2)); Q(5,t1)=1;
        u2_6(t1)= ((norm(r(2*t-1)-R2_6(1)))^2)+ ((norm(r(2*t)-
R2_6(2)))^2)); Q(6,t1)=1;
        u2_7(t1)= ((norm(r(2*t-1)-R2_7(1)))^2)+ ((norm(r(2*t)-
R2_7(2)))^2)); Q(7,t1)=1;
        u2_8(t1)= ((norm(r(2*t-1)-R2_8(1)))^2)+ ((norm(r(2*t)-
R2_8(2)))^2)); Q(8,t1)=1;
        u2_9(t1)= ((norm(r(2*t-1)-R2_9(1)))^2)+ ((norm(r(2*t)-
R2_9(2)))^2)); Q(9,t1)=1;
        u2_10(t1)=((norm(r(2*t-1)-R2_10(1)))^2)+((norm(r(2*t)-
R2_10(2)))^2));Q(10,t1)=1;
        u2_11(t1)=((norm(r(2*t-1)-R2_11(1)))^2)+((norm(r(2*t)-
R2_11(2)))^2));Q(11,t1)=1;
        u2_12(t1)=((norm(r(2*t-1)-R2_12(1)))^2)+((norm(r(2*t)-
R2_12(2)))^2));Q(12,t1)=1;
        u2_13(t1)=((norm(r(2*t-1)-R2_13(1)))^2)+((norm(r(2*t)-
R2_13(2)))^2));Q(13,t1)=1;
        u2_14(t1)=((norm(r(2*t-1)-R2_14(1)))^2)+((norm(r(2*t)-
R2_14(2)))^2));Q(14,t1)=1;
        u2_15(t1)=((norm(r(2*t-1)-R2_15(1)))^2)+((norm(r(2*t)-
R2_15(2)))^2));Q(15,t1)=1;
        u2_16(t1)=((norm(r(2*t-1)-R2_16(1)))^2)+((norm(r(2*t)-
R2_16(2)))^2));Q(16,t1)=1;
    end
    if Q(3,t)==1
        u3_1(t1)= ((norm(r(2*t-1)-R3_1(1)))^2)+ ((norm(r(2*t)-
R3_1(2)))^2)); Q(1,t1)=1;
        u3_2(t1)= ((norm(r(2*t-1)-R3_2(1)))^2)+ ((norm(r(2*t)-
R3_2(2)))^2)); Q(2,t1)=1;
        u3_3(t1)= ((norm(r(2*t-1)-R3_3(1)))^2)+ ((norm(r(2*t)-
R3_3(2)))^2)); Q(3,t1)=1;
        u3_4(t1)= ((norm(r(2*t-1)-R3_4(1)))^2)+ ((norm(r(2*t)-
R3_4(2)))^2)); Q(4,t1)=1;
        u3_5(t1)= ((norm(r(2*t-1)-R3_5(1)))^2)+ ((norm(r(2*t)-
R3_5(2)))^2)); Q(5,t1)=1;
        u3_6(t1)= ((norm(r(2*t-1)-R3_6(1)))^2)+ ((norm(r(2*t)-
R3_6(2)))^2)); Q(6,t1)=1;
        u3_7(t1)= ((norm(r(2*t-1)-R3_7(1)))^2)+ ((norm(r(2*t)-
R3_7(2)))^2)); Q(7,t1)=1;
        u3_8(t1)= ((norm(r(2*t-1)-R3_8(1)))^2)+ ((norm(r(2*t)-
R3_8(2)))^2)); Q(8,t1)=1;
        u3_9(t1)= ((norm(r(2*t-1)-R3_9(1)))^2)+ ((norm(r(2*t)-
R3_9(2)))^2)); Q(9,t1)=1;
        u3_10(t1)=((norm(r(2*t-1)-R3_10(1)))^2)+((norm(r(2*t)-
R3_10(2)))^2));Q(10,t1)=1;
        u3_11(t1)=((norm(r(2*t-1)-R3_11(1)))^2)+((norm(r(2*t)-
R3_11(2)))^2));Q(11,t1)=1;
        u3_12(t1)=((norm(r(2*t-1)-R3_12(1)))^2)+((norm(r(2*t)-
R3_12(2)))^2));Q(12,t1)=1;
        u3_13(t1)=((norm(r(2*t-1)-R3_13(1)))^2)+((norm(r(2*t)-
R3_13(2)))^2));Q(13,t1)=1;
        u3_14(t1)=((norm(r(2*t-1)-R3_14(1)))^2)+((norm(r(2*t)-
R3_14(2)))^2));Q(14,t1)=1;

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APPENDIX G (Continued)

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        u3_15(t1)=((norm(r(2*t-1)-R3_15(1)))^2)+((norm(r(2*t)-
R3_15(2)))^2));Q(15,t1)=1;
        u3_16(t1)=((norm(r(2*t-1)-R3_16(1)))^2)+((norm(r(2*t)-
R3_16(2)))^2));Q(16,t1)=1;
    end
    if Q(4,t)==1
        u4_1(t1)=((norm(r(2*t-1)-R4_1(1)))^2)+((norm(r(2*t)-
R4_1(2)))^2));Q(1,t1)=1;
        u4_2(t1)=((norm(r(2*t-1)-R4_2(1)))^2)+((norm(r(2*t)-
R4_2(2)))^2));Q(2,t1)=1;
        u4_3(t1)=((norm(r(2*t-1)-R4_3(1)))^2)+((norm(r(2*t)-
R4_3(2)))^2));Q(3,t1)=1;
        u4_4(t1)=((norm(r(2*t-1)-R4_4(1)))^2)+((norm(r(2*t)-
R4_4(2)))^2));Q(4,t1)=1;
        u4_5(t1)=((norm(r(2*t-1)-R4_5(1)))^2)+((norm(r(2*t)-
R4_5(2)))^2));Q(5,t1)=1;
        u4_6(t1)=((norm(r(2*t-1)-R4_6(1)))^2)+((norm(r(2*t)-
R4_6(2)))^2));Q(6,t1)=1;
        u4_7(t1)=((norm(r(2*t-1)-R4_7(1)))^2)+((norm(r(2*t)-
R4_7(2)))^2));Q(7,t1)=1;
        u4_8(t1)=((norm(r(2*t-1)-R4_8(1)))^2)+((norm(r(2*t)-
R4_8(2)))^2));Q(8,t1)=1;
        u4_9(t1)=((norm(r(2*t-1)-R4_9(1)))^2)+((norm(r(2*t)-
R4_9(2)))^2));Q(9,t1)=1;
        u4_10(t1)=((norm(r(2*t-1)-R4_10(1)))^2)+((norm(r(2*t)-
R4_10(2)))^2));Q(10,t1)=1;
        u4_11(t1)=((norm(r(2*t-1)-R4_11(1)))^2)+((norm(r(2*t)-
R4_11(2)))^2));Q(11,t1)=1;
        u4_12(t1)=((norm(r(2*t-1)-R4_12(1)))^2)+((norm(r(2*t)-
R4_12(2)))^2));Q(12,t1)=1;
        u4_13(t1)=((norm(r(2*t-1)-R4_13(1)))^2)+((norm(r(2*t)-
R4_13(2)))^2));Q(13,t1)=1;
        u4_14(t1)=((norm(r(2*t-1)-R4_14(1)))^2)+((norm(r(2*t)-
R4_14(2)))^2));Q(14,t1)=1;
        u4_15(t1)=((norm(r(2*t-1)-R4_15(1)))^2)+((norm(r(2*t)-
R4_15(2)))^2));Q(15,t1)=1;
        u4_16(t1)=((norm(r(2*t-1)-R4_16(1)))^2)+((norm(r(2*t)-
R4_16(2)))^2));Q(16,t1)=1;
    end

    if Q(5,t)==1
        u5_1(t1)=((norm(r(2*t-1)-R5_1(1)))^2)+((norm(r(2*t)-
R5_1(2)))^2));Q(1,t1)=1;
        u5_2(t1)=((norm(r(2*t-1)-R5_2(1)))^2)+((norm(r(2*t)-
R5_2(2)))^2));Q(2,t1)=1;
        u5_3(t1)=((norm(r(2*t-1)-R5_3(1)))^2)+((norm(r(2*t)-
R5_3(2)))^2));Q(3,t1)=1;
        u5_4(t1)=((norm(r(2*t-1)-R5_4(1)))^2)+((norm(r(2*t)-
R5_4(2)))^2));Q(4,t1)=1;
        u5_5(t1)=((norm(r(2*t-1)-R5_5(1)))^2)+((norm(r(2*t)-
R5_5(2)))^2));Q(5,t1)=1;
        u5_6(t1)=((norm(r(2*t-1)-R5_6(1)))^2)+((norm(r(2*t)-
R5_6(2)))^2));Q(6,t1)=1;

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APPENDIX G (Continued)

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        u5_7(t1)= (((norm(r(2*t-1)-R5_7(1)))^2)+ ((norm(r(2*t)-
R5_7(2)))^2)); Q(7,t1)=1;
        u5_8(t1)= (((norm(r(2*t-1)-R5_8(1)))^2)+ ((norm(r(2*t)-
R5_8(2)))^2)); Q(8,t1)=1;
        u5_9(t1)= (((norm(r(2*t-1)-R5_9(1)))^2)+ ((norm(r(2*t)-
R5_9(2)))^2)); Q(9,t1)=1;
        u5_10(t1)= (((norm(r(2*t-1)-R5_10(1)))^2)+ ((norm(r(2*t)-
R5_10(2)))^2)); Q(10,t1)=1;
        u5_11(t1)= (((norm(r(2*t-1)-R5_11(1)))^2)+ ((norm(r(2*t)-
R5_11(2)))^2)); Q(11,t1)=1;
        u5_12(t1)= (((norm(r(2*t-1)-R5_12(1)))^2)+ ((norm(r(2*t)-
R5_12(2)))^2)); Q(12,t1)=1;
        u5_13(t1)= (((norm(r(2*t-1)-R5_13(1)))^2)+ ((norm(r(2*t)-
R5_13(2)))^2)); Q(13,t1)=1;
        u5_14(t1)= (((norm(r(2*t-1)-R5_14(1)))^2)+ ((norm(r(2*t)-
R5_14(2)))^2)); Q(14,t1)=1;
        u5_15(t1)= (((norm(r(2*t-1)-R5_15(1)))^2)+ ((norm(r(2*t)-
R5_15(2)))^2)); Q(15,t1)=1;
        u5_16(t1)= (((norm(r(2*t-1)-R5_16(1)))^2)+ ((norm(r(2*t)-
R5_16(2)))^2)); Q(16,t1)=1;
    end

    if Q(6,t)==1
        u6_1(t1)= (((norm(r(2*t-1)-R6_1(1)))^2)+ ((norm(r(2*t)-
R6_1(2)))^2)); Q(1,t1)=1;
        u6_2(t1)= (((norm(r(2*t-1)-R6_2(1)))^2)+ ((norm(r(2*t)-
R6_2(2)))^2)); Q(2,t1)=1;
        u6_3(t1)= (((norm(r(2*t-1)-R6_3(1)))^2)+ ((norm(r(2*t)-
R6_3(2)))^2)); Q(3,t1)=1;
        u6_4(t1)= (((norm(r(2*t-1)-R6_4(1)))^2)+ ((norm(r(2*t)-
R6_4(2)))^2)); Q(4,t1)=1;
        u6_5(t1)= (((norm(r(2*t-1)-R6_5(1)))^2)+ ((norm(r(2*t)-
R6_5(2)))^2)); Q(5,t1)=1;
        u6_6(t1)= (((norm(r(2*t-1)-R6_6(1)))^2)+ ((norm(r(2*t)-
R6_6(2)))^2)); Q(6,t1)=1;
        u6_7(t1)= (((norm(r(2*t-1)-R6_7(1)))^2)+ ((norm(r(2*t)-
R6_7(2)))^2)); Q(7,t1)=1;
        u6_8(t1)= (((norm(r(2*t-1)-R6_8(1)))^2)+ ((norm(r(2*t)-
R6_8(2)))^2)); Q(8,t1)=1;
        u6_9(t1)= (((norm(r(2*t-1)-R6_9(1)))^2)+ ((norm(r(2*t)-
R6_9(2)))^2)); Q(9,t1)=1;
        u6_10(t1)= (((norm(r(2*t-1)-R6_10(1)))^2)+ ((norm(r(2*t)-
R6_10(2)))^2)); Q(10,t1)=1;
        u6_11(t1)= (((norm(r(2*t-1)-R6_11(1)))^2)+ ((norm(r(2*t)-
R6_11(2)))^2)); Q(11,t1)=1;
        u6_12(t1)= (((norm(r(2*t-1)-R6_12(1)))^2)+ ((norm(r(2*t)-
R6_12(2)))^2)); Q(12,t1)=1;
        u6_13(t1)= (((norm(r(2*t-1)-R6_13(1)))^2)+ ((norm(r(2*t)-
R6_13(2)))^2)); Q(13,t1)=1;
        u6_14(t1)= (((norm(r(2*t-1)-R6_14(1)))^2)+ ((norm(r(2*t)-
R6_14(2)))^2)); Q(14,t1)=1;
        u6_15(t1)= (((norm(r(2*t-1)-R6_15(1)))^2)+ ((norm(r(2*t)-
R6_15(2)))^2)); Q(15,t1)=1;

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APPENDIX G (Continued)

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        u6_16(t1)=(((norm(r(2*t-1)-R6_16(1)))^2)+((norm(r(2*t)-
R6_16(2)))^2));Q(16,t1)=1;
        end

        if Q(7,t)==1
            u7_1(t1)=(((norm(r(2*t-1)-R7_1(1)))^2)+((norm(r(2*t)-
R7_1(2)))^2)); Q(1,t1)=1;
            u7_2(t1)=(((norm(r(2*t-1)-R7_2(1)))^2)+((norm(r(2*t)-
R7_2(2)))^2)); Q(2,t1)=1;
            u7_3(t1)=(((norm(r(2*t-1)-R7_3(1)))^2)+((norm(r(2*t)-
R7_3(2)))^2)); Q(3,t1)=1;
            u7_4(t1)=(((norm(r(2*t-1)-R7_4(1)))^2)+((norm(r(2*t)-
R7_4(2)))^2)); Q(4,t1)=1;
            u7_5(t1)=(((norm(r(2*t-1)-R7_5(1)))^2)+((norm(r(2*t)-
R7_5(2)))^2)); Q(5,t1)=1;
            u7_6(t1)=(((norm(r(2*t-1)-R7_6(1)))^2)+((norm(r(2*t)-
R7_6(2)))^2)); Q(6,t1)=1;
            u7_7(t1)=(((norm(r(2*t-1)-R7_7(1)))^2)+((norm(r(2*t)-
R7_7(2)))^2)); Q(7,t1)=1;
            u7_8(t1)=(((norm(r(2*t-1)-R7_8(1)))^2)+((norm(r(2*t)-
R7_8(2)))^2)); Q(8,t1)=1;
            u7_9(t1)=(((norm(r(2*t-1)-R7_9(1)))^2)+((norm(r(2*t)-
R7_9(2)))^2)); Q(9,t1)=1;
            u7_10(t1)=(((norm(r(2*t-1)-R7_10(1)))^2)+((norm(r(2*t)-
R7_10(2)))^2));Q(10,t1)=1;
            u7_11(t1)=(((norm(r(2*t-1)-R7_11(1)))^2)+((norm(r(2*t)-
R7_11(2)))^2));Q(11,t1)=1;
            u7_12(t1)=(((norm(r(2*t-1)-R7_12(1)))^2)+((norm(r(2*t)-
R7_12(2)))^2));Q(12,t1)=1;
            u7_13(t1)=(((norm(r(2*t-1)-R7_13(1)))^2)+((norm(r(2*t)-
R7_13(2)))^2));Q(13,t1)=1;
            u7_14(t1)=(((norm(r(2*t-1)-R7_14(1)))^2)+((norm(r(2*t)-
R7_14(2)))^2));Q(14,t1)=1;
            u7_15(t1)=(((norm(r(2*t-1)-R7_15(1)))^2)+((norm(r(2*t)-
R7_15(2)))^2));Q(15,t1)=1;
            u7_16(t1)=(((norm(r(2*t-1)-R7_16(1)))^2)+((norm(r(2*t)-
R7_16(2)))^2));Q(16,t1)=1;
        end

        if Q(8,t)==1
            u8_1(t1)=(((norm(r(2*t-1)-R8_1(1)))^2)+((norm(r(2*t)-
R8_1(2)))^2)); Q(1,t1)=1;
            u8_2(t1)=(((norm(r(2*t-1)-R8_2(1)))^2)+((norm(r(2*t)-
R8_2(2)))^2)); Q(2,t1)=1;
            u8_3(t1)=(((norm(r(2*t-1)-R8_3(1)))^2)+((norm(r(2*t)-
R8_3(2)))^2)); Q(3,t1)=1;
            u8_4(t1)=(((norm(r(2*t-1)-R8_4(1)))^2)+((norm(r(2*t)-
R8_4(2)))^2)); Q(4,t1)=1;
            u8_5(t1)=(((norm(r(2*t-1)-R8_5(1)))^2)+((norm(r(2*t)-
R8_5(2)))^2)); Q(5,t1)=1;
            u8_6(t1)=(((norm(r(2*t-1)-R8_6(1)))^2)+((norm(r(2*t)-
R8_6(2)))^2)); Q(6,t1)=1;

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APPENDIX G (Continued)

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        u8_7(t1)= (((norm(r(2*t-1)-R8_7(1)))^2)+ ((norm(r(2*t)-
R8_7(2)))^2)); Q(7,t1)=1;
        u8_8(t1)= (((norm(r(2*t-1)-R8_8(1)))^2)+ ((norm(r(2*t)-
R8_8(2)))^2)); Q(8,t1)=1;
        u8_9(t1)= (((norm(r(2*t-1)-R8_9(1)))^2)+ ((norm(r(2*t)-
R8_9(2)))^2)); Q(9,t1)=1;
        u8_10(t1)= (((norm(r(2*t-1)-R8_10(1)))^2)+((norm(r(2*t)-
R8_10(2)))^2));Q(10,t1)=1;
        u8_11(t1)= (((norm(r(2*t-1)-R8_11(1)))^2)+((norm(r(2*t)-
R8_11(2)))^2));Q(11,t1)=1;
        u8_12(t1)= (((norm(r(2*t-1)-R8_12(1)))^2)+((norm(r(2*t)-
R8_12(2)))^2));Q(12,t1)=1;
        u8_13(t1)= (((norm(r(2*t-1)-R8_13(1)))^2)+((norm(r(2*t)-
R8_13(2)))^2));Q(13,t1)=1;
        u8_14(t1)= (((norm(r(2*t-1)-R8_14(1)))^2)+((norm(r(2*t)-
R8_14(2)))^2));Q(14,t1)=1;
        u8_15(t1)= (((norm(r(2*t-1)-R8_15(1)))^2)+((norm(r(2*t)-
R8_15(2)))^2));Q(15,t1)=1;
        u8_16(t1)= (((norm(r(2*t-1)-R8_16(1)))^2)+((norm(r(2*t)-
R8_16(2)))^2));Q(16,t1)=1;
    end

    if Q(9,t)==1
        u9_1(t1)= (((norm(r(2*t-1)-R9_1(1)))^2)+ ((norm(r(2*t)-
R9_1(2)))^2)); Q(1,t1)=1;
        u9_2(t1)= (((norm(r(2*t-1)-R9_2(1)))^2)+ ((norm(r(2*t)-
R9_2(2)))^2)); Q(2,t1)=1;
        u9_3(t1)= (((norm(r(2*t-1)-R9_3(1)))^2)+ ((norm(r(2*t)-
R9_3(2)))^2)); Q(3,t1)=1;
        u9_4(t1)= (((norm(r(2*t-1)-R9_4(1)))^2)+ ((norm(r(2*t)-
R9_4(2)))^2)); Q(4,t1)=1;
        u9_5(t1)= (((norm(r(2*t-1)-R9_5(1)))^2)+ ((norm(r(2*t)-
R9_5(2)))^2)); Q(5,t1)=1;
        u9_6(t1)= (((norm(r(2*t-1)-R9_6(1)))^2)+ ((norm(r(2*t)-
R9_6(2)))^2)); Q(6,t1)=1;
        u9_7(t1)= (((norm(r(2*t-1)-R9_7(1)))^2)+ ((norm(r(2*t)-
R9_7(2)))^2)); Q(7,t1)=1;
        u9_8(t1)= (((norm(r(2*t-1)-R9_8(1)))^2)+ ((norm(r(2*t)-
R9_8(2)))^2)); Q(8,t1)=1;
        u9_9(t1)= (((norm(r(2*t-1)-R9_9(1)))^2)+ ((norm(r(2*t)-
R9_9(2)))^2)); Q(9,t1)=1;
        u9_10(t1)= (((norm(r(2*t-1)-R9_10(1)))^2)+((norm(r(2*t)-
R9_10(2)))^2));Q(10,t1)=1;
        u9_11(t1)= (((norm(r(2*t-1)-R9_11(1)))^2)+((norm(r(2*t)-
R9_11(2)))^2));Q(11,t1)=1;
        u9_12(t1)= (((norm(r(2*t-1)-R9_12(1)))^2)+((norm(r(2*t)-
R9_12(2)))^2));Q(12,t1)=1;
        u9_13(t1)= (((norm(r(2*t-1)-R9_13(1)))^2)+((norm(r(2*t)-
R9_13(2)))^2));Q(13,t1)=1;
        u9_14(t1)= (((norm(r(2*t-1)-R9_14(1)))^2)+((norm(r(2*t)-
R9_14(2)))^2));Q(14,t1)=1;
        u9_15(t1)= (((norm(r(2*t-1)-R9_15(1)))^2)+((norm(r(2*t)-
R9_15(2)))^2));Q(15,t1)=1;

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APPENDIX G (Continued)

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        u9_16(t1)=(((norm(r(2*t-1)-R9_16(1)))^2)+((norm(r(2*t)-
R9_16(2)))^2));Q(16,t1)=1;
    end

    if Q(10,t)==1
        u10_1(t1)=(((norm(r(2*t-1)-R10_1(1)))^2)+((norm(r(2*t)-
R10_1(2)))^2));Q(1,t1)=1;
        u10_2(t1)=(((norm(r(2*t-1)-R10_2(1)))^2)+((norm(r(2*t)-
R10_2(2)))^2));Q(2,t1)=1;
        u10_3(t1)=(((norm(r(2*t-1)-R10_3(1)))^2)+((norm(r(2*t)-
R10_3(2)))^2));Q(3,t1)=1;
        u10_4(t1)=(((norm(r(2*t-1)-R10_4(1)))^2)+((norm(r(2*t)-
R10_4(2)))^2));Q(4,t1)=1;
        u10_5(t1)=(((norm(r(2*t-1)-R10_5(1)))^2)+((norm(r(2*t)-
R10_5(2)))^2));Q(5,t1)=1;
        u10_6(t1)=(((norm(r(2*t-1)-R10_6(1)))^2)+((norm(r(2*t)-
R10_6(2)))^2));Q(6,t1)=1;
        u10_7(t1)=(((norm(r(2*t-1)-R10_7(1)))^2)+((norm(r(2*t)-
R10_7(2)))^2));Q(7,t1)=1;
        u10_8(t1)=(((norm(r(2*t-1)-R10_8(1)))^2)+((norm(r(2*t)-
R10_8(2)))^2));Q(8,t1)=1;
        u10_9(t1)=(((norm(r(2*t-1)-R10_9(1)))^2)+((norm(r(2*t)-
R10_9(2)))^2));Q(9,t1)=1;
        u10_10(t1)=(((norm(r(2*t-1)-R10_10(1)))^2)+((norm(r(2*t)-
R10_10(2)))^2));Q(10,t1)=1;
        u10_11(t1)=(((norm(r(2*t-1)-R10_11(1)))^2)+((norm(r(2*t)-
R10_11(2)))^2));Q(11,t1)=1;
        u10_12(t1)=(((norm(r(2*t-1)-R10_12(1)))^2)+((norm(r(2*t)-
R10_12(2)))^2));Q(12,t1)=1;
        u10_13(t1)=(((norm(r(2*t-1)-R10_13(1)))^2)+((norm(r(2*t)-
R10_13(2)))^2));Q(13,t1)=1;
        u10_14(t1)=(((norm(r(2*t-1)-R10_14(1)))^2)+((norm(r(2*t)-
R10_14(2)))^2));Q(14,t1)=1;
        u10_15(t1)=(((norm(r(2*t-1)-R10_15(1)))^2)+((norm(r(2*t)-
R10_15(2)))^2));Q(15,t1)=1;
        u10_16(t1)=(((norm(r(2*t-1)-R10_16(1)))^2)+((norm(r(2*t)-
R10_16(2)))^2));Q(16,t1)=1;
    end

    if Q(11,t)==1
        u11_1(t1)=(((norm(r(2*t-1)-R11_1(1)))^2)+((norm(r(2*t)-
R11_1(2)))^2));Q(1,t1)=1;
        u11_2(t1)=(((norm(r(2*t-1)-R11_2(1)))^2)+((norm(r(2*t)-
R11_2(2)))^2));Q(2,t1)=1;
        u11_3(t1)=(((norm(r(2*t-1)-R11_3(1)))^2)+((norm(r(2*t)-
R11_3(2)))^2));Q(3,t1)=1;
        u11_4(t1)=(((norm(r(2*t-1)-R11_4(1)))^2)+((norm(r(2*t)-
R11_4(2)))^2));Q(4,t1)=1;
        u11_5(t1)=(((norm(r(2*t-1)-R11_5(1)))^2)+((norm(r(2*t)-
R11_5(2)))^2));Q(5,t1)=1;
        u11_6(t1)=(((norm(r(2*t-1)-R11_6(1)))^2)+((norm(r(2*t)-
R11_6(2)))^2));Q(6,t1)=1;
        u11_7(t1)=(((norm(r(2*t-1)-R11_7(1)))^2)+((norm(r(2*t)-
R11_7(2)))^2));Q(7,t1)=1;

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APPENDIX G (Continued)

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        u11_8(t1)= ((norm(r(2*t-1)-R11_8(1)))^2)+ ((norm(r(2*t)-
R11_8(2)))^2)); Q(8,t1)=1;
        u11_9(t1)= ((norm(r(2*t-1)-R11_9(1)))^2)+ ((norm(r(2*t)-
R11_9(2)))^2)); Q(9,t1)=1;
        u11_10(t1)=((norm(r(2*t-1)-R11_10(1)))^2)+((norm(r(2*t)-
R11_10(2)))^2));Q(10,t1)=1;
        u11_11(t1)=((norm(r(2*t-1)-R11_11(1)))^2)+((norm(r(2*t)-
R11_11(2)))^2));Q(11,t1)=1;
        u11_12(t1)=((norm(r(2*t-1)-R11_12(1)))^2)+((norm(r(2*t)-
R11_12(2)))^2));Q(12,t1)=1;
        u11_13(t1)=((norm(r(2*t-1)-R11_13(1)))^2)+((norm(r(2*t)-
R11_13(2)))^2));Q(13,t1)=1;
        u11_14(t1)=((norm(r(2*t-1)-R11_14(1)))^2)+((norm(r(2*t)-
R11_14(2)))^2));Q(14,t1)=1;
        u11_15(t1)=((norm(r(2*t-1)-R11_15(1)))^2)+((norm(r(2*t)-
R11_15(2)))^2));Q(15,t1)=1;
        u11_16(t1)=((norm(r(2*t-1)-R11_16(1)))^2)+((norm(r(2*t)-
R11_16(2)))^2));Q(16,t1)=1;
    end

    if Q(12,t)==1
        u12_1(t1)= ((norm(r(2*t-1)-R12_1(1)))^2)+ ((norm(r(2*t)-
R12_1(2)))^2)); Q(1,t1)=1;
        u12_2(t1)= ((norm(r(2*t-1)-R12_2(1)))^2)+ ((norm(r(2*t)-
R12_2(2)))^2)); Q(2,t1)=1;
        u12_3(t1)= ((norm(r(2*t-1)-R12_3(1)))^2)+ ((norm(r(2*t)-
R12_3(2)))^2)); Q(3,t1)=1;
        u12_4(t1)= ((norm(r(2*t-1)-R12_4(1)))^2)+ ((norm(r(2*t)-
R12_4(2)))^2)); Q(4,t1)=1;
        u12_5(t1)= ((norm(r(2*t-1)-R12_5(1)))^2)+ ((norm(r(2*t)-
R12_5(2)))^2)); Q(5,t1)=1;
        u12_6(t1)= ((norm(r(2*t-1)-R12_6(1)))^2)+ ((norm(r(2*t)-
R12_6(2)))^2)); Q(6,t1)=1;
        u12_7(t1)= ((norm(r(2*t-1)-R12_7(1)))^2)+ ((norm(r(2*t)-
R12_7(2)))^2)); Q(7,t1)=1;
        u12_8(t1)= ((norm(r(2*t-1)-R12_8(1)))^2)+ ((norm(r(2*t)-
R12_8(2)))^2)); Q(8,t1)=1;
        u12_9(t1)= ((norm(r(2*t-1)-R12_9(1)))^2)+ ((norm(r(2*t)-
R12_9(2)))^2)); Q(9,t1)=1;
        u12_10(t1)=((norm(r(2*t-1)-R12_10(1)))^2)+((norm(r(2*t)-
R12_10(2)))^2));Q(10,t1)=1;
        u12_11(t1)=((norm(r(2*t-1)-R12_11(1)))^2)+((norm(r(2*t)-
R12_11(2)))^2));Q(11,t1)=1;
        u12_12(t1)=((norm(r(2*t-1)-R12_12(1)))^2)+((norm(r(2*t)-
R12_12(2)))^2));Q(12,t1)=1;
        u12_13(t1)=((norm(r(2*t-1)-R12_13(1)))^2)+((norm(r(2*t)-
R12_13(2)))^2));Q(13,t1)=1;
        u12_14(t1)=((norm(r(2*t-1)-R12_14(1)))^2)+((norm(r(2*t)-
R12_14(2)))^2));Q(14,t1)=1;
        u12_15(t1)=((norm(r(2*t-1)-R12_15(1)))^2)+((norm(r(2*t)-
R12_15(2)))^2));Q(15,t1)=1;
        u12_16(t1)=((norm(r(2*t-1)-R12_16(1)))^2)+((norm(r(2*t)-
R12_16(2)))^2));Q(16,t1)=1;

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APPENDIX G (Continued)

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end

    if Q(13,t)==1
        u13_1(t1)= ((norm(r(2*t-1)-R13_1(1)))^2)+ ((norm(r(2*t)-
R13_1(2)))^2)); Q(1,t1)=1;
        u13_2(t1)= ((norm(r(2*t-1)-R13_2(1)))^2)+ ((norm(r(2*t)-
R13_2(2)))^2)); Q(2,t1)=1;
        u13_3(t1)= ((norm(r(2*t-1)-R13_3(1)))^2)+ ((norm(r(2*t)-
R13_3(2)))^2)); Q(3,t1)=1;
        u13_4(t1)= ((norm(r(2*t-1)-R13_4(1)))^2)+ ((norm(r(2*t)-
R13_4(2)))^2)); Q(4,t1)=1;
        u13_5(t1)= ((norm(r(2*t-1)-R13_5(1)))^2)+ ((norm(r(2*t)-
R13_5(2)))^2)); Q(5,t1)=1;
        u13_6(t1)= ((norm(r(2*t-1)-R13_6(1)))^2)+ ((norm(r(2*t)-
R13_6(2)))^2)); Q(6,t1)=1;
        u13_7(t1)= ((norm(r(2*t-1)-R13_7(1)))^2)+ ((norm(r(2*t)-
R13_7(2)))^2)); Q(7,t1)=1;
        u13_8(t1)= ((norm(r(2*t-1)-R13_8(1)))^2)+ ((norm(r(2*t)-
R13_8(2)))^2)); Q(8,t1)=1;
        u13_9(t1)= ((norm(r(2*t-1)-R13_9(1)))^2)+ ((norm(r(2*t)-
R13_9(2)))^2)); Q(9,t1)=1;
        u13_10(t1)=((norm(r(2*t-1)-R13_10(1)))^2)+((norm(r(2*t)-
R13_10(2)))^2));Q(10,t1)=1;
        u13_11(t1)=((norm(r(2*t-1)-R13_11(1)))^2)+((norm(r(2*t)-
R13_11(2)))^2));Q(11,t1)=1;
        u13_12(t1)=((norm(r(2*t-1)-R13_12(1)))^2)+((norm(r(2*t)-
R13_12(2)))^2));Q(12,t1)=1;
        u13_13(t1)=((norm(r(2*t-1)-R13_13(1)))^2)+((norm(r(2*t)-
R13_13(2)))^2));Q(13,t1)=1;
        u13_14(t1)=((norm(r(2*t-1)-R13_14(1)))^2)+((norm(r(2*t)-
R13_14(2)))^2));Q(14,t1)=1;
        u13_15(t1)=((norm(r(2*t-1)-R13_15(1)))^2)+((norm(r(2*t)-
R13_15(2)))^2));Q(15,t1)=1;
        u13_16(t1)=((norm(r(2*t-1)-R13_16(1)))^2)+((norm(r(2*t)-
R13_16(2)))^2));Q(16,t1)=1;
    end

    if Q(14,t)==1
        u14_1(t1)= ((norm(r(2*t-1)-R14_1(1)))^2)+ ((norm(r(2*t)-
R14_1(2)))^2)); Q(1,t1)=1;
        u14_2(t1)= ((norm(r(2*t-1)-R14_2(1)))^2)+ ((norm(r(2*t)-
R14_2(2)))^2)); Q(2,t1)=1;
        u14_3(t1)= ((norm(r(2*t-1)-R14_3(1)))^2)+ ((norm(r(2*t)-
R14_3(2)))^2)); Q(3,t1)=1;
        u14_4(t1)= ((norm(r(2*t-1)-R14_4(1)))^2)+ ((norm(r(2*t)-
R14_4(2)))^2)); Q(4,t1)=1;
        u14_5(t1)= ((norm(r(2*t-1)-R14_5(1)))^2)+ ((norm(r(2*t)-
R14_5(2)))^2)); Q(5,t1)=1;
        u14_6(t1)= ((norm(r(2*t-1)-R14_6(1)))^2)+ ((norm(r(2*t)-
R14_6(2)))^2)); Q(6,t1)=1;
        u14_7(t1)= ((norm(r(2*t-1)-R14_7(1)))^2)+ ((norm(r(2*t)-
R14_7(2)))^2)); Q(7,t1)=1;
        u14_8(t1)= ((norm(r(2*t-1)-R14_8(1)))^2)+ ((norm(r(2*t)-
R14_8(2)))^2)); Q(8,t1)=1;

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APPENDIX G (Continued)

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        u14_9(t1)= (((norm(r(2*t-1)-R14_9(1)))^2)+ ((norm(r(2*t)-
R14_9(2)))^2)); Q(9,t1)=1;
        u14_10(t1)= (((norm(r(2*t-1)-R14_10(1)))^2)+ ((norm(r(2*t)-
R14_10(2)))^2)); Q(10,t1)=1;
        u14_11(t1)= (((norm(r(2*t-1)-R14_11(1)))^2)+ ((norm(r(2*t)-
R14_11(2)))^2)); Q(11,t1)=1;
        u14_12(t1)= (((norm(r(2*t-1)-R14_12(1)))^2)+ ((norm(r(2*t)-
R14_12(2)))^2)); Q(12,t1)=1;
        u14_13(t1)= (((norm(r(2*t-1)-R14_13(1)))^2)+ ((norm(r(2*t)-
R14_13(2)))^2)); Q(13,t1)=1;
        u14_14(t1)= (((norm(r(2*t-1)-R14_14(1)))^2)+ ((norm(r(2*t)-
R14_14(2)))^2)); Q(14,t1)=1;
        u14_15(t1)= (((norm(r(2*t-1)-R14_15(1)))^2)+ ((norm(r(2*t)-
R14_15(2)))^2)); Q(15,t1)=1;
        u14_16(t1)= (((norm(r(2*t-1)-R14_16(1)))^2)+ ((norm(r(2*t)-
R14_16(2)))^2)); Q(16,t1)=1;
    end

    if Q(15,t)==1
        u15_1(t1)= (((norm(r(2*t-1)-R15_1(1)))^2)+ ((norm(r(2*t)-
R15_1(2)))^2)); Q(1,t1)=1;
        u15_2(t1)= (((norm(r(2*t-1)-R15_2(1)))^2)+ ((norm(r(2*t)-
R15_2(2)))^2)); Q(2,t1)=1;
        u15_3(t1)= (((norm(r(2*t-1)-R15_3(1)))^2)+ ((norm(r(2*t)-
R15_3(2)))^2)); Q(3,t1)=1;
        u15_4(t1)= (((norm(r(2*t-1)-R15_4(1)))^2)+ ((norm(r(2*t)-
R15_4(2)))^2)); Q(4,t1)=1;
        u15_5(t1)= (((norm(r(2*t-1)-R15_5(1)))^2)+ ((norm(r(2*t)-
R15_5(2)))^2)); Q(5,t1)=1;
        u15_6(t1)= (((norm(r(2*t-1)-R15_6(1)))^2)+ ((norm(r(2*t)-
R15_6(2)))^2)); Q(6,t1)=1;
        u15_7(t1)= (((norm(r(2*t-1)-R15_7(1)))^2)+ ((norm(r(2*t)-
R15_7(2)))^2)); Q(7,t1)=1;
        u15_8(t1)= (((norm(r(2*t-1)-R15_8(1)))^2)+ ((norm(r(2*t)-
R15_8(2)))^2)); Q(8,t1)=1;
        u15_9(t1)= (((norm(r(2*t-1)-R15_9(1)))^2)+ ((norm(r(2*t)-
R15_9(2)))^2)); Q(9,t1)=1;
        u15_10(t1)= (((norm(r(2*t-1)-R15_10(1)))^2)+ ((norm(r(2*t)-
R15_10(2)))^2)); Q(10,t1)=1;
        u15_11(t1)= (((norm(r(2*t-1)-R15_11(1)))^2)+ ((norm(r(2*t)-
R15_11(2)))^2)); Q(11,t1)=1;
        u15_12(t1)= (((norm(r(2*t-1)-R15_12(1)))^2)+ ((norm(r(2*t)-
R15_12(2)))^2)); Q(12,t1)=1;
        u15_13(t1)= (((norm(r(2*t-1)-R15_13(1)))^2)+ ((norm(r(2*t)-
R15_13(2)))^2)); Q(13,t1)=1;
        u15_14(t1)= (((norm(r(2*t-1)-R15_14(1)))^2)+ ((norm(r(2*t)-
R15_14(2)))^2)); Q(14,t1)=1;
        u15_15(t1)= (((norm(r(2*t-1)-R15_15(1)))^2)+ ((norm(r(2*t)-
R15_15(2)))^2)); Q(15,t1)=1;
        u15_16(t1)= (((norm(r(2*t-1)-R15_16(1)))^2)+ ((norm(r(2*t)-
R15_16(2)))^2)); Q(16,t1)=1;
    end

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APPENDIX G (Continued)

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        if Q(16,t)==1
            u16_1(t1)= ((norm(r(2*t-1)-R16_1(1)))^2)+ ((norm(r(2*t)-
R16_1(2)))^2)); Q(1,t1)=1;
            u16_2(t1)= ((norm(r(2*t-1)-R16_2(1)))^2)+ ((norm(r(2*t)-
R16_2(2)))^2)); Q(2,t1)=1;
            u16_3(t1)= ((norm(r(2*t-1)-R16_3(1)))^2)+ ((norm(r(2*t)-
R16_3(2)))^2)); Q(3,t1)=1;
            u16_4(t1)= ((norm(r(2*t-1)-R16_4(1)))^2)+ ((norm(r(2*t)-
R16_4(2)))^2)); Q(4,t1)=1;
            u16_5(t1)= ((norm(r(2*t-1)-R16_5(1)))^2)+ ((norm(r(2*t)-
R16_5(2)))^2)); Q(5,t1)=1;
            u16_6(t1)= ((norm(r(2*t-1)-R16_6(1)))^2)+ ((norm(r(2*t)-
R16_6(2)))^2)); Q(6,t1)=1;
            u16_7(t1)= ((norm(r(2*t-1)-R16_7(1)))^2)+ ((norm(r(2*t)-
R16_7(2)))^2)); Q(7,t1)=1;
            u16_8(t1)= ((norm(r(2*t-1)-R16_8(1)))^2)+ ((norm(r(2*t)-
R16_8(2)))^2)); Q(8,t1)=1;
            u16_9(t1)= ((norm(r(2*t-1)-R16_9(1)))^2)+ ((norm(r(2*t)-
R16_9(2)))^2)); Q(9,t1)=1;
            u16_10(t1)=((norm(r(2*t-1)-R16_10(1)))^2)+((norm(r(2*t)-
R16_10(2)))^2));Q(10,t1)=1;
            u16_11(t1)=((norm(r(2*t-1)-R16_11(1)))^2)+((norm(r(2*t)-
R16_11(2)))^2));Q(11,t1)=1;
            u16_12(t1)=((norm(r(2*t-1)-R16_12(1)))^2)+((norm(r(2*t)-
R16_12(2)))^2));Q(12,t1)=1;
            u16_13(t1)=((norm(r(2*t-1)-R16_13(1)))^2)+((norm(r(2*t)-
R16_13(2)))^2));Q(13,t1)=1;
            u16_14(t1)=((norm(r(2*t-1)-R16_14(1)))^2)+((norm(r(2*t)-
R16_14(2)))^2));Q(14,t1)=1;
            u16_15(t1)=((norm(r(2*t-1)-R16_15(1)))^2)+((norm(r(2*t)-
R16_15(2)))^2));Q(15,t1)=1;
            u16_16(t1)=((norm(r(2*t-1)-R16_16(1)))^2)+((norm(r(2*t)-
R16_16(2)))^2));Q(16,t1)=1;
        end

```

```

        if t1==2
            u2_1(2)=u1_1(2);u3_1(2)=u1_1(2);u4_1(2)=u1_1(2);
            u5_1(2)=u1_1(2);u6_1(2)=u1_1(2);u7_1(2)=u1_1(2);
            u8_1(2)=u1_1(2);u9_1(2)=u1_1(2);u10_1(2)=u1_1(2);
            u11_1(2)=u1_1(2);u12_1(2)=u1_1(2);u13_1(2)=u1_1(2);
            u14_1(2)=u1_1(2);u15_1(2)=u1_1(2);u16_1(2)=u1_1(2);

            u2_2(2)=u1_2(2);u3_2(2)=u1_2(2);u4_2(2)=u1_2(2);
            u5_2(2)=u1_2(2);u6_2(2)=u1_2(2);u7_2(2)=u1_2(2);
            u8_2(2)=u1_2(2);u9_2(2)=u1_2(2);u10_2(2)=u1_2(2);
            u11_2(2)=u1_2(2);u12_2(2)=u1_2(2);u13_2(2)=u1_2(2);
            u14_2(2)=u1_2(2);u15_2(2)=u1_2(2);u16_2(2)=u1_2(2);

            u2_3(2)=u1_3(2);u3_3(2)=u1_3(2);u4_3(2)=u1_3(2);
            u5_3(2)=u1_3(2);u6_3(2)=u1_3(2);u7_3(2)=u1_3(2);
            u8_3(2)=u1_3(2);u9_3(2)=u1_3(2);u10_3(2)=u1_3(2);

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APPENDIX G (Continued)

$u_{11_3}(2)=u_{1_3}(2); u_{12_3}(2)=u_{1_3}(2); u_{13_3}(2)=u_{1_3}(2);$
 $u_{14_3}(2)=u_{1_3}(2); u_{15_3}(2)=u_{1_3}(2); u_{16_3}(2)=u_{1_3}(2);$

$u_{2_4}(2)=u_{1_4}(2); u_{3_4}(2)=u_{1_4}(2); u_{4_4}(2)=u_{1_4}(2);$
 $u_{5_4}(2)=u_{1_4}(2); u_{6_4}(2)=u_{1_4}(2); u_{7_4}(2)=u_{1_4}(2);$
 $u_{8_4}(2)=u_{1_4}(2); u_{9_4}(2)=u_{1_4}(2); u_{10_4}(2)=u_{1_4}(2);$
 $u_{11_4}(2)=u_{1_4}(2); u_{12_4}(2)=u_{1_4}(2); u_{13_4}(2)=u_{1_4}(2);$
 $u_{14_4}(2)=u_{1_4}(2); u_{15_4}(2)=u_{1_4}(2); u_{16_4}(2)=u_{1_4}(2);$

$u_{2_5}(2)=u_{1_5}(2); u_{3_5}(2)=u_{1_5}(2); u_{4_5}(2)=u_{1_5}(2);$
 $u_{5_5}(2)=u_{1_5}(2); u_{6_5}(2)=u_{1_5}(2); u_{7_5}(2)=u_{1_5}(2);$
 $u_{8_5}(2)=u_{1_5}(2); u_{9_5}(2)=u_{1_5}(2); u_{10_5}(2)=u_{1_5}(2);$
 $u_{11_5}(2)=u_{1_5}(2); u_{12_5}(2)=u_{1_5}(2); u_{13_5}(2)=u_{1_5}(2);$
 $u_{14_5}(2)=u_{1_5}(2); u_{15_5}(2)=u_{1_5}(2); u_{16_5}(2)=u_{1_5}(2);$

$u_{2_6}(2)=u_{1_6}(2); u_{3_6}(2)=u_{1_6}(2); u_{4_6}(2)=u_{1_6}(2);$
 $u_{5_6}(2)=u_{1_6}(2); u_{6_6}(2)=u_{1_6}(2); u_{7_6}(2)=u_{1_6}(2);$
 $u_{8_6}(2)=u_{1_6}(2); u_{9_6}(2)=u_{1_6}(2); u_{10_6}(2)=u_{1_6}(2);$
 $u_{11_6}(2)=u_{1_6}(2); u_{12_6}(2)=u_{1_6}(2); u_{13_6}(2)=u_{1_6}(2);$
 $u_{14_6}(2)=u_{1_6}(2); u_{15_6}(2)=u_{1_6}(2); u_{16_6}(2)=u_{1_6}(2);$

$u_{2_7}(2)=u_{1_7}(2); u_{3_7}(2)=u_{1_7}(2); u_{4_7}(2)=u_{1_7}(2);$
 $u_{5_7}(2)=u_{1_7}(2); u_{6_7}(2)=u_{1_7}(2); u_{7_7}(2)=u_{1_7}(2);$
 $u_{8_7}(2)=u_{1_7}(2); u_{9_7}(2)=u_{1_7}(2); u_{10_7}(2)=u_{1_7}(2);$
 $u_{11_7}(2)=u_{1_7}(2); u_{12_7}(2)=u_{1_7}(2); u_{13_7}(2)=u_{1_7}(2);$
 $u_{14_7}(2)=u_{1_7}(2); u_{15_7}(2)=u_{1_7}(2); u_{16_7}(2)=u_{1_7}(2);$

$u_{2_8}(2)=u_{1_8}(2); u_{3_8}(2)=u_{1_8}(2); u_{4_8}(2)=u_{1_8}(2);$
 $u_{5_8}(2)=u_{1_8}(2); u_{6_8}(2)=u_{1_8}(2); u_{7_8}(2)=u_{1_8}(2);$
 $u_{8_8}(2)=u_{1_8}(2); u_{9_8}(2)=u_{1_8}(2); u_{10_8}(2)=u_{1_8}(2);$
 $u_{11_8}(2)=u_{1_8}(2); u_{12_8}(2)=u_{1_8}(2); u_{13_8}(2)=u_{1_8}(2);$
 $u_{14_8}(2)=u_{1_8}(2); u_{15_8}(2)=u_{1_8}(2); u_{16_8}(2)=u_{1_8}(2);$

$u_{2_9}(2)=u_{1_9}(2); u_{3_9}(2)=u_{1_9}(2); u_{4_9}(2)=u_{1_9}(2);$
 $u_{5_9}(2)=u_{1_9}(2); u_{6_9}(2)=u_{1_9}(2); u_{7_9}(2)=u_{1_9}(2);$
 $u_{8_9}(2)=u_{1_9}(2); u_{9_9}(2)=u_{1_9}(2); u_{10_9}(2)=u_{1_9}(2);$
 $u_{11_9}(2)=u_{1_9}(2); u_{12_9}(2)=u_{1_9}(2); u_{13_9}(2)=u_{1_9}(2);$
 $u_{14_9}(2)=u_{1_9}(2); u_{15_9}(2)=u_{1_9}(2); u_{16_9}(2)=u_{1_9}(2);$

$u_{2_10}(2)=u_{1_10}(2); u_{3_10}(2)=u_{1_10}(2); u_{4_10}(2)=u_{1_10}(2);$
 $u_{5_10}(2)=u_{1_10}(2); u_{6_10}(2)=u_{1_10}(2); u_{7_10}(2)=u_{1_10}(2);$
 $u_{8_10}(2)=u_{1_10}(2); u_{9_10}(2)=u_{1_10}(2); u_{10_10}(2)=u_{1_10}(2);$
 $u_{11_10}(2)=u_{1_10}(2); u_{12_10}(2)=u_{1_10}(2); u_{13_10}(2)=u_{1_10}(2);$
 $u_{14_10}(2)=u_{1_10}(2); u_{15_10}(2)=u_{1_10}(2); u_{16_10}(2)=u_{1_10}(2);$

$u_{2_11}(2)=u_{1_11}(2); u_{3_11}(2)=u_{1_11}(2); u_{4_11}(2)=u_{1_11}(2);$
 $u_{5_11}(2)=u_{1_11}(2); u_{6_11}(2)=u_{1_11}(2); u_{7_11}(2)=u_{1_11}(2);$
 $u_{8_11}(2)=u_{1_11}(2); u_{9_11}(2)=u_{1_11}(2); u_{10_11}(2)=u_{1_11}(2);$
 $u_{11_11}(2)=u_{1_11}(2); u_{12_11}(2)=u_{1_11}(2); u_{13_11}(2)=u_{1_11}(2);$
 $u_{14_11}(2)=u_{1_11}(2); u_{15_11}(2)=u_{1_11}(2); u_{16_11}(2)=u_{1_11}(2);$

$u_{2_12}(2)=u_{1_12}(2); u_{3_12}(2)=u_{1_12}(2); u_{4_12}(2)=u_{1_12}(2);$

APPENDIX G (Continued)

```

u5_12(2)=u1_12(2);u6_12(2)=u1_12(2);u7_12(2)=u1_12(2);
u8_12(2)=u1_12(2);u9_12(2)=u1_12(2);u10_12(2)=u1_12(2);
u11_12(2)=u1_12(2);u12_12(2)=u1_12(2);u13_12(2)=u1_12(2);
u14_12(2)=u1_12(2);u15_12(2)=u1_12(2);u16_12(2)=u1_12(2);

```

```

u2_13(2)=u1_13(2);u3_13(2)=u1_13(2);u4_13(2)=u1_13(2);
u5_13(2)=u1_13(2);u6_13(2)=u1_13(2);u7_13(2)=u1_13(2);
u8_13(2)=u1_13(2);u9_13(2)=u1_13(2);u10_13(2)=u1_13(2);
u11_13(2)=u1_13(2);u12_13(2)=u1_13(2);u13_13(2)=u1_13(2);
u14_13(2)=u1_13(2);u15_13(2)=u1_13(2);u16_13(2)=u1_13(2);

```

```

u2_14(2)=u1_14(2);u3_14(2)=u1_14(2);u4_14(2)=u1_14(2);
u5_14(2)=u1_14(2);u6_14(2)=u1_14(2);u7_14(2)=u1_14(2);
u8_14(2)=u1_14(2);u9_14(2)=u1_14(2);u10_14(2)=u1_14(2);
u11_14(2)=u1_14(2);u12_14(2)=u1_14(2);u13_14(2)=u1_14(2);
u14_14(2)=u1_14(2);u15_14(2)=u1_14(2);u16_14(2)=u1_14(2);

```

```

u2_15(2)=u1_15(2);u3_15(2)=u1_15(2);u4_15(2)=u1_15(2);
u5_15(2)=u1_15(2);u6_15(2)=u1_15(2);u7_15(2)=u1_15(2);
u8_15(2)=u1_15(2);u9_15(2)=u1_15(2);u10_15(2)=u1_15(2);
u11_15(2)=u1_15(2);u12_15(2)=u1_15(2);u13_15(2)=u1_15(2);
u14_15(2)=u1_15(2);u15_15(2)=u1_15(2);u16_15(2)=u1_15(2);

```

```

u2_16(2)=u1_16(2);u3_16(2)=u1_16(2);u4_16(2)=u1_16(2);
u5_16(2)=u1_16(2);u6_16(2)=u1_16(2);u7_16(2)=u1_16(2);
u8_16(2)=u1_16(2);u9_16(2)=u1_16(2);u10_16(2)=u1_16(2);
u11_16(2)=u1_16(2);u12_16(2)=u1_16(2);u13_16(2)=u1_16(2);
u14_16(2)=u1_16(2);u15_16(2)=u1_16(2);u16_16(2)=u1_16(2);

```

end

```

jh1=[mu1(t)+u1_1(t1) mu2(t)+u2_1(t1) mu3(t)+u3_1(t1)
mu4(t)+u4_1(t1) mu5(t)+u5_1(t1) mu6(t)+u6_1(t1) mu7(t)+u7_1(t1)
mu8(t)+u8_1(t1) mu9(t)+u9_1(t1) mu10(t)+u10_1(t1) mu11(t)+u11_1(t1)
mu12(t)+u12_1(t1) mu13(t)+u13_1(t1) mu14(t)+u14_1(t1) mu15(t)+u15_1(t1)
mu16(t)+u16_1(t1)];

```

```

jh2=[mu1(t)+u1_2(t1) mu2(t)+u2_2(t1) mu3(t)+u3_2(t1)
mu4(t)+u4_2(t1) mu5(t)+u5_2(t1) mu6(t)+u6_2(t1) mu7(t)+u7_2(t1)
mu8(t)+u8_2(t1) mu9(t)+u9_2(t1) mu10(t)+u10_2(t1) mu11(t)+u11_2(t1)
mu12(t)+u12_2(t1) mu13(t)+u13_2(t1) mu14(t)+u14_2(t1) mu15(t)+u15_2(t1)
mu16(t)+u16_2(t1)];

```

```

jh3=[mu1(t)+u1_3(t1) mu2(t)+u2_3(t1) mu3(t)+u3_3(t1)
mu4(t)+u4_3(t1) mu5(t)+u5_3(t1) mu6(t)+u6_3(t1) mu7(t)+u7_3(t1)
mu8(t)+u8_3(t1) mu9(t)+u9_3(t1) mu10(t)+u10_3(t1) mu11(t)+u11_3(t1)
mu12(t)+u12_3(t1) mu13(t)+u13_3(t1) mu14(t)+u14_3(t1) mu15(t)+u15_3(t1)
mu16(t)+u16_3(t1)];

```

```

jh4=[mu1(t)+u1_4(t1) mu2(t)+u2_4(t1) mu3(t)+u3_4(t1)
mu4(t)+u4_4(t1) mu5(t)+u5_4(t1) mu6(t)+u6_4(t1) mu7(t)+u7_4(t1)
mu8(t)+u8_4(t1) mu9(t)+u9_4(t1) mu10(t)+u10_4(t1) mu11(t)+u11_4(t1)

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APPENDIX G (Continued)

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mu12(t)+u12_4(t1) mu13(t)+u13_4(t1) mu14(t)+u14_4(t1) mu15(t)+u15_4(t1)
mu16(t)+u16_4(t1)];
      jh5=[mu1(t)+u1_5(t1) mu2(t)+u2_5(t1) mu3(t)+u3_5(t1)
mu4(t)+u4_5(t1) mu5(t)+u5_5(t1) mu6(t)+u6_5(t1) mu7(t)+u7_5(t1)
mu8(t)+u8_5(t1) mu9(t)+u9_5(t1) mu10(t)+u10_5(t1) mu11(t)+u11_5(t1)
mu12(t)+u12_5(t1) mu13(t)+u13_5(t1) mu14(t)+u14_5(t1) mu15(t)+u15_5(t1)
mu16(t)+u16_5(t1)];
      jh6=[mu1(t)+u1_6(t1) mu2(t)+u2_6(t1) mu3(t)+u3_6(t1)
mu4(t)+u4_6(t1) mu5(t)+u5_6(t1) mu6(t)+u6_6(t1) mu7(t)+u7_6(t1)
mu8(t)+u8_6(t1) mu9(t)+u9_6(t1) mu10(t)+u10_6(t1) mu11(t)+u11_6(t1)
mu12(t)+u12_6(t1) mu13(t)+u13_6(t1) mu14(t)+u14_6(t1) mu15(t)+u15_6(t1)
mu16(t)+u16_6(t1)];
      jh7=[mu1(t)+u1_7(t1) mu2(t)+u2_7(t1) mu3(t)+u3_7(t1)
mu4(t)+u4_7(t1) mu5(t)+u5_7(t1) mu6(t)+u6_7(t1) mu7(t)+u7_7(t1)
mu8(t)+u8_7(t1) mu9(t)+u9_7(t1) mu10(t)+u10_7(t1) mu11(t)+u11_7(t1)
mu12(t)+u12_7(t1) mu13(t)+u13_7(t1) mu14(t)+u14_7(t1) mu15(t)+u15_7(t1)
mu16(t)+u16_7(t1)];
      jh8=[mu1(t)+u1_8(t1) mu2(t)+u2_8(t1) mu3(t)+u3_8(t1)
mu4(t)+u4_8(t1) mu5(t)+u5_8(t1) mu6(t)+u6_8(t1) mu7(t)+u7_8(t1)
mu8(t)+u8_8(t1) mu9(t)+u9_8(t1) mu10(t)+u10_8(t1) mu11(t)+u11_8(t1)
mu12(t)+u12_8(t1) mu13(t)+u13_8(t1) mu14(t)+u14_8(t1) mu15(t)+u15_8(t1)
mu16(t)+u16_8(t1)];
      jh9=[mu1(t)+u1_9(t1) mu2(t)+u2_9(t1) mu3(t)+u3_9(t1)
mu4(t)+u4_9(t1) mu5(t)+u5_9(t1) mu6(t)+u6_9(t1) mu7(t)+u7_9(t1)
mu8(t)+u8_9(t1) mu9(t)+u9_9(t1) mu10(t)+u10_9(t1) mu11(t)+u11_9(t1)
mu12(t)+u12_9(t1) mu13(t)+u13_9(t1) mu14(t)+u14_9(t1) mu15(t)+u15_9(t1)
mu16(t)+u16_9(t1)];
      jh10=[mu1(t)+u1_10(t1) mu2(t)+u2_10(t1) mu3(t)+u3_10(t1)
mu4(t)+u4_10(t1) mu5(t)+u5_10(t1) mu6(t)+u6_10(t1) mu7(t)+u7_10(t1)
mu8(t)+u8_10(t1) mu9(t)+u9_10(t1) mu10(t)+u10_10(t1) mu11(t)+u11_10(t1)
mu12(t)+u12_10(t1) mu13(t)+u13_10(t1) mu14(t)+u14_10(t1) mu15(t)+u15_10(t1)
mu16(t)+u16_10(t1)];
      jh11=[mu1(t)+u1_11(t1) mu2(t)+u2_11(t1) mu3(t)+u3_11(t1)
mu4(t)+u4_11(t1) mu5(t)+u5_11(t1) mu6(t)+u6_11(t1) mu7(t)+u7_11(t1)
mu8(t)+u8_11(t1) mu9(t)+u9_11(t1) mu10(t)+u10_11(t1) mu11(t)+u11_11(t1)
mu12(t)+u12_11(t1) mu13(t)+u13_11(t1) mu14(t)+u14_11(t1) mu15(t)+u15_11(t1)
mu16(t)+u16_11(t1)];
      jh12=[mu1(t)+u1_12(t1) mu2(t)+u2_12(t1) mu3(t)+u3_12(t1)
mu4(t)+u4_12(t1) mu5(t)+u5_12(t1) mu6(t)+u6_12(t1) mu7(t)+u7_12(t1)
mu8(t)+u8_12(t1) mu9(t)+u9_12(t1) mu10(t)+u10_12(t1) mu11(t)+u11_12(t1)
mu12(t)+u12_12(t1) mu13(t)+u13_12(t1) mu14(t)+u14_12(t1) mu15(t)+u15_12(t1)
mu16(t)+u16_12(t1)];
      jh13=[mu1(t)+u1_13(t1) mu2(t)+u2_13(t1) mu3(t)+u3_13(t1)
mu4(t)+u4_13(t1) mu5(t)+u5_13(t1) mu6(t)+u6_13(t1) mu7(t)+u7_13(t1)
mu8(t)+u8_13(t1) mu9(t)+u9_13(t1) mu10(t)+u10_13(t1) mu11(t)+u11_13(t1)
mu12(t)+u12_13(t1) mu13(t)+u13_13(t1) mu14(t)+u14_13(t1) mu15(t)+u15_13(t1)
mu16(t)+u16_13(t1)];
      jh14=[mu1(t)+u1_14(t1) mu2(t)+u2_14(t1) mu3(t)+u3_14(t1)
mu4(t)+u4_14(t1) mu5(t)+u5_14(t1) mu6(t)+u6_14(t1) mu7(t)+u7_14(t1)
mu8(t)+u8_14(t1) mu9(t)+u9_14(t1) mu10(t)+u10_14(t1) mu11(t)+u11_14(t1)
mu12(t)+u12_14(t1) mu13(t)+u13_14(t1) mu14(t)+u14_14(t1) mu15(t)+u15_14(t1)
mu16(t)+u16_14(t1)];
      jh15=[mu1(t)+u1_15(t1) mu2(t)+u2_15(t1) mu3(t)+u3_15(t1)
mu4(t)+u4_15(t1) mu5(t)+u5_15(t1) mu6(t)+u6_15(t1) mu7(t)+u7_15(t1)

```

APPENDIX G (Continued)

```
mu8(t)+u8_15(t1) mu9(t)+u9_15(t1) mu10(t)+u10_15(t1) mu11(t)+u11_15(t1)
mu12(t)+u12_15(t1) mu13(t)+u13_15(t1) mu14(t)+u14_15(t1) mu15(t)+u15_15(t1)
mu16(t)+u16_15(t1)];
```

```
jh16=[mu1(t)+u1_16(t1) mu2(t)+u2_16(t1) mu3(t)+u3_16(t1)
mu4(t)+u4_16(t1) mu5(t)+u5_16(t1) mu6(t)+u6_16(t1) mu7(t)+u7_16(t1)
mu8(t)+u8_16(t1) mu9(t)+u9_16(t1) mu10(t)+u10_16(t1) mu11(t)+u11_16(t1)
mu12(t)+u12_16(t1) mu13(t)+u13_16(t1) mu14(t)+u14_16(t1) mu15(t)+u15_16(t1)
mu16(t)+u16_16(t1)];
```

```
mu1(t1)=min(jh1);mu2(t1)=min(jh2);mu3(t1)=min(jh3);mu4(t1)=min(jh4);mu5(t1)=m
in(jh5);mu6(t1)=min(jh6);mu7(t1)=min(jh7);mu8(t1)=min(jh8);
```

```
mu9(t1)=min(jh9);mu10(t1)=min(jh10);mu11(t1)=min(jh11);mu12(t1)=min(jh12);mu1
3(t1)=min(jh13);mu14(t1)=min(jh14);mu15(t1)=min(jh15);mu16(t1)=min(jh16);
```

```
%go1
if mu1(t1)==mu1(t)+u1_1(t1)
    go1(t)=1;
elseif mu1(t1)==mu2(t)+u2_1(t1)
    go1(t)=2;
elseif mu1(t1)==mu3(t)+u3_1(t1)
    go1(t)=3;
elseif mu1(t1)==mu4(t)+u4_1(t1)
    go1(t)=4;
elseif mu1(t1)==mu5(t)+u5_1(t1)
    go1(t)=5;
elseif mu1(t1)==mu6(t)+u6_1(t1)
    go1(t)=6;
elseif mu1(t1)==mu7(t)+u7_1(t1)
    go1(t)=7;
elseif mu1(t1)==mu8(t)+u8_1(t1)
    go1(t)=8;
elseif mu1(t1)==mu9(t)+u9_1(t1)
    go1(t)=9;
elseif mu1(t1)==mu10(t)+u10_1(t1)
    go1(t)=10;
elseif mu1(t1)==mu11(t)+u11_1(t1)
    go1(t)=11;
elseif mu1(t1)==mu12(t)+u12_1(t1)
    go1(t)=12;
elseif mu1(t1)==mu13(t)+u13_1(t1)
    go1(t)=13;
elseif mu1(t1)==mu14(t)+u14_1(t1)
    go1(t)=14;
elseif mu1(t1)==mu15(t)+u15_1(t1)
    go1(t)=15;
elseif mu1(t1)==mu16(t)+u16_1(t1)
    go1(t)=16;
```

```
end
%go2
if mu2(t1)==mu1(t)+u1_2(t1)
    go2(t)=1;
elseif mu2(t1)==mu2(t)+u2_2(t1)
```

APPENDIX G (Continued)

```
    go2(t)=2;
elseif mu2(t1)==mu3(t)+u3_2(t1)
    go2(t)=3;
elseif mu2(t1)==mu4(t)+u4_2(t1)
    go2(t)=4;
elseif mu2(t1)==mu5(t)+u5_2(t1)
    go2(t)=5;
elseif mu2(t1)==mu6(t)+u6_2(t1)
    go2(t)=6;
elseif mu2(t1)==mu7(t)+u7_2(t1)
    go2(t)=7;
elseif mu2(t1)==mu8(t)+u8_2(t1)
    go2(t)=8;
elseif mu2(t1)==mu9(t)+u9_2(t1)
    go2(t)=9;
elseif mu2(t1)==mu10(t)+u10_2(t1)
    go2(t)=10;
elseif mu2(t1)==mu11(t)+u11_2(t1)
    go2(t)=11;
elseif mu2(t1)==mu12(t)+u12_2(t1)
    go2(t)=12;
elseif mu2(t1)==mu13(t)+u13_2(t1)
    go2(t)=13;
elseif mu2(t1)==mu14(t)+u14_2(t1)
    go2(t)=14;
elseif mu2(t1)==mu15(t)+u15_2(t1)
    go2(t)=15;
elseif mu2(t1)==mu16(t)+u16_2(t1)
    go2(t)=16;
end
```

```
%go3
if mu3(t1)==mu1(t)+u1_3(t1)
    go3(t)=1;
elseif mu3(t1)==mu2(t)+u2_3(t1)
    go3(t)=2;
elseif mu3(t1)==mu3(t)+u3_3(t1)
    go3(t)=3;
elseif mu3(t1)==mu4(t)+u4_3(t1)
    go3(t)=4;
elseif mu3(t1)==mu5(t)+u5_3(t1)
    go3(t)=5;
elseif mu3(t1)==mu6(t)+u6_3(t1)
    go3(t)=6;
elseif mu3(t1)==mu7(t)+u7_3(t1)
    go3(t)=7;
elseif mu3(t1)==mu8(t)+u8_3(t1)
    go3(t)=8;
elseif mu3(t1)==mu9(t)+u9_3(t1)
    go3(t)=9;
elseif mu3(t1)==mu10(t)+u10_3(t1)
    go3(t)=10;
elseif mu3(t1)==mu11(t)+u11_3(t1)
    go3(t)=11;
```

APPENDIX G (Continued)

```
elseif mu3(t1)==mu12(t)+u12_3(t1)
    go3(t)=12;
elseif mu3(t1)==mu13(t)+u13_3(t1)
    go3(t)=13;
elseif mu3(t1)==mu14(t)+u14_3(t1)
    go3(t)=14;
elseif mu3(t1)==mu15(t)+u15_3(t1)
    go3(t)=15;
elseif mu3(t1)==mu16(t)+u16_3(t1)
    go3(t)=16;
end
```

```
%go4
if mu4(t1)==mu1(t)+u1_4(t1)
    go4(t)=1;
elseif mu4(t1)==mu2(t)+u2_4(t1)
    go4(t)=2;
elseif mu4(t1)==mu3(t)+u3_4(t1)
    go4(t)=3;
elseif mu4(t1)==mu4(t)+u4_4(t1)
    go4(t)=4;
elseif mu4(t1)==mu5(t)+u5_4(t1)
    go4(t)=5;
elseif mu4(t1)==mu6(t)+u6_4(t1)
    go4(t)=6;
elseif mu4(t1)==mu7(t)+u7_4(t1)
    go4(t)=7;
elseif mu4(t1)==mu8(t)+u8_4(t1)
    go4(t)=8;
elseif mu4(t1)==mu9(t)+u9_4(t1)
    go4(t)=9;
elseif mu4(t1)==mu10(t)+u10_4(t1)
    go4(t)=10;
elseif mu4(t1)==mu11(t)+u11_4(t1)
    go4(t)=11;
elseif mu4(t1)==mu12(t)+u12_4(t1)
    go4(t)=12;
elseif mu4(t1)==mu13(t)+u13_4(t1)
    go4(t)=13;
elseif mu4(t1)==mu14(t)+u14_4(t1)
    go4(t)=14;
elseif mu4(t1)==mu15(t)+u15_4(t1)
    go4(t)=15;
elseif mu4(t1)==mu16(t)+u16_4(t1)
    go4(t)=16;
end
```

```
%go5
if mu5(t1)==mu1(t)+u1_5(t1)
    go5(t)=1;
elseif mu5(t1)==mu2(t)+u2_5(t1)
    go5(t)=2;
elseif mu5(t1)==mu3(t)+u3_5(t1)
    go5(t)=3;
```

APPENDIX G (Continued)

```
elseif mu5(t1)==mu4(t)+u4_5(t1)
    go5(t)=4;
elseif mu5(t1)==mu5(t)+u5_5(t1)
    go5(t)=5;
elseif mu5(t1)==mu6(t)+u6_5(t1)
    go5(t)=6;
elseif mu5(t1)==mu7(t)+u7_5(t1)
    go5(t)=7;
elseif mu5(t1)==mu8(t)+u8_5(t1)
    go5(t)=8;
elseif mu5(t1)==mu9(t)+u9_5(t1)
    go5(t)=9;
elseif mu5(t1)==mu10(t)+u10_5(t1)
    go5(t)=10;
elseif mu5(t1)==mu11(t)+u11_5(t1)
    go5(t)=11;
elseif mu5(t1)==mu12(t)+u12_5(t1)
    go5(t)=12;
elseif mu5(t1)==mu13(t)+u13_5(t1)
    go5(t)=13;
elseif mu5(t1)==mu14(t)+u14_5(t1)
    go5(t)=14;
elseif mu5(t1)==mu15(t)+u15_5(t1)
    go5(t)=15;
elseif mu5(t1)==mu16(t)+u16_5(t1)
    go5(t)=16;
end

%go6
if mu6(t1)==mu1(t)+u1_6(t1)
    go6(t)=1;
elseif mu6(t1)==mu2(t)+u2_6(t1)
    go6(t)=2;
elseif mu6(t1)==mu3(t)+u3_6(t1)
    go6(t)=3;
elseif mu6(t1)==mu4(t)+u4_6(t1)
    go6(t)=4;
elseif mu6(t1)==mu5(t)+u5_6(t1)
    go6(t)=5;
elseif mu6(t1)==mu6(t)+u6_6(t1)
    go6(t)=6;
elseif mu6(t1)==mu7(t)+u7_6(t1)
    go6(t)=7;
elseif mu6(t1)==mu8(t)+u8_6(t1)
    go6(t)=8;
elseif mu6(t1)==mu9(t)+u9_6(t1)
    go6(t)=9;
elseif mu6(t1)==mu10(t)+u10_6(t1)
    go6(t)=10;
elseif mu6(t1)==mu11(t)+u11_6(t1)
    go6(t)=11;
elseif mu6(t1)==mu12(t)+u12_6(t1)
    go6(t)=12;
elseif mu6(t1)==mu13(t)+u13_6(t1)
```

APPENDIX G (Continued)

```
    go6(t)=13;
elseif mu6(t1)==mu14(t)+u14_6(t1)
    go6(t)=14;
elseif mu6(t1)==mu15(t)+u15_6(t1)
    go6(t)=15;
elseif mu6(t1)==mu16(t)+u16_6(t1)
    go6(t)=16;
end
```

```
%go7
if mu7(t1)==mu1(t)+u1_7(t1)
    go7(t)=1;
elseif mu7(t1)==mu2(t)+u2_7(t1)
    go7(t)=2;
elseif mu7(t1)==mu3(t)+u3_7(t1)
    go7(t)=3;
elseif mu7(t1)==mu4(t)+u4_7(t1)
    go7(t)=4;
elseif mu7(t1)==mu5(t)+u5_7(t1)
    go7(t)=5;
elseif mu7(t1)==mu6(t)+u6_7(t1)
    go7(t)=6;
elseif mu7(t1)==mu7(t)+u7_7(t1)
    go7(t)=7;
elseif mu7(t1)==mu8(t)+u8_7(t1)
    go7(t)=8;
elseif mu7(t1)==mu9(t)+u9_7(t1)
    go7(t)=9;
elseif mu7(t1)==mu10(t)+u10_7(t1)
    go7(t)=10;
elseif mu7(t1)==mu11(t)+u11_7(t1)
    go7(t)=11;
elseif mu7(t1)==mu12(t)+u12_7(t1)
    go7(t)=12;
elseif mu7(t1)==mu13(t)+u13_7(t1)
    go7(t)=13;
elseif mu7(t1)==mu14(t)+u14_7(t1)
    go7(t)=14;
elseif mu7(t1)==mu15(t)+u15_7(t1)
    go7(t)=15;
elseif mu7(t1)==mu16(t)+u16_7(t1)
    go7(t)=16;
end
```

```
%go8
if mu8(t1)==mu1(t)+u1_8(t1)
    go8(t)=1;
elseif mu8(t1)==mu2(t)+u2_8(t1)
    go8(t)=2;
elseif mu8(t1)==mu3(t)+u3_8(t1)
    go8(t)=3;
elseif mu8(t1)==mu4(t)+u4_8(t1)
    go8(t)=4;
elseif mu8(t1)==mu5(t)+u5_8(t1)
```

APPENDIX G (Continued)

```
    go8(t)=5;
elseif mu8(t1)==mu6(t)+u6_8(t1)
    go8(t)=6;
elseif mu8(t1)==mu7(t)+u7_8(t1)
    go8(t)=7;
elseif mu8(t1)==mu8(t)+u8_8(t1)
    go8(t)=8;
elseif mu8(t1)==mu9(t)+u9_8(t1)
    go8(t)=9;
elseif mu8(t1)==mu10(t)+u10_8(t1)
    go8(t)=10;
elseif mu8(t1)==mu11(t)+u11_8(t1)
    go8(t)=11;
elseif mu8(t1)==mu12(t)+u12_8(t1)
    go8(t)=12;
elseif mu8(t1)==mu13(t)+u13_8(t1)
    go8(t)=13;
elseif mu8(t1)==mu14(t)+u14_8(t1)
    go8(t)=14;
elseif mu8(t1)==mu15(t)+u15_8(t1)
    go8(t)=15;
elseif mu8(t1)==mu16(t)+u16_8(t1)
    go8(t)=16;
end
```

```
%go9
if mu9(t1)==mu1(t)+u1_9(t1)
    go9(t)=1;
elseif mu9(t1)==mu2(t)+u2_9(t1)
    go9(t)=2;
elseif mu9(t1)==mu3(t)+u3_9(t1)
    go9(t)=3;
elseif mu9(t1)==mu4(t)+u4_9(t1)
    go9(t)=4;
elseif mu9(t1)==mu5(t)+u5_9(t1)
    go9(t)=5;
elseif mu9(t1)==mu6(t)+u6_9(t1)
    go9(t)=6;
elseif mu9(t1)==mu7(t)+u7_9(t1)
    go9(t)=7;
elseif mu9(t1)==mu8(t)+u8_9(t1)
    go9(t)=8;
elseif mu9(t1)==mu9(t)+u9_9(t1)
    go9(t)=9;
elseif mu9(t1)==mu10(t)+u10_9(t1)
    go9(t)=10;
elseif mu9(t1)==mu11(t)+u11_9(t1)
    go9(t)=11;
elseif mu9(t1)==mu12(t)+u12_9(t1)
    go9(t)=12;
elseif mu9(t1)==mu13(t)+u13_9(t1)
    go9(t)=13;
elseif mu9(t1)==mu14(t)+u14_9(t1)
    go9(t)=14;
```


APPENDIX G (Continued)

```
elseif mu9(t1)==mu15(t)+u15_9(t1)
    go9(t)=15;
elseif mu9(t1)==mu16(t)+u16_9(t1)
    go9(t)=16;
end

%go10
if mu10(t1)==mu1(t)+u1_10(t1)
    go10(t)=1;
elseif mu10(t1)==mu2(t)+u2_10(t1)
    go10(t)=2;
elseif mu10(t1)==mu3(t)+u3_10(t1)
    go10(t)=3;
elseif mu10(t1)==mu4(t)+u4_10(t1)
    go10(t)=4;
elseif mu10(t1)==mu5(t)+u5_10(t1)
    go10(t)=5;
elseif mu10(t1)==mu6(t)+u6_10(t1)
    go10(t)=6;
elseif mu10(t1)==mu7(t)+u7_10(t1)
    go10(t)=7;
elseif mu10(t1)==mu8(t)+u8_10(t1)
    go10(t)=8;
elseif mu10(t1)==mu9(t)+u9_10(t1)
    go10(t)=9;
elseif mu10(t1)==mu10(t)+u10_10(t1)
    go10(t)=10;
elseif mu10(t1)==mu11(t)+u11_10(t1)
    go10(t)=11;
elseif mu10(t1)==mu12(t)+u12_10(t1)
    go10(t)=12;
elseif mu10(t1)==mu13(t)+u13_10(t1)
    go10(t)=13;
elseif mu10(t1)==mu14(t)+u14_10(t1)
    go10(t)=14;
elseif mu10(t1)==mu15(t)+u15_10(t1)
    go10(t)=15;
elseif mu10(t1)==mu16(t)+u16_10(t1)
    go10(t)=16;
end

%go11
if mu11(t1)==mu1(t)+u1_11(t1)
    go11(t)=1;
elseif mu11(t1)==mu2(t)+u2_11(t1)
    go11(t)=2;
elseif mu11(t1)==mu3(t)+u3_11(t1)
    go11(t)=3;
elseif mu11(t1)==mu4(t)+u4_11(t1)
    go11(t)=4;
elseif mu11(t1)==mu5(t)+u5_11(t1)
    go11(t)=5;
elseif mu11(t1)==mu6(t)+u6_11(t1)
    go11(t)=6;
```

APPENDIX G (Continued)

```
elseif mu11(t1)==mu7(t)+u7_11(t1)
    go11(t)=7;
elseif mu11(t1)==mu8(t)+u8_11(t1)
    go11(t)=8;
elseif mu11(t1)==mu9(t)+u9_11(t1)
    go11(t)=9;
elseif mu11(t1)==mu10(t)+u10_11(t1)
    go11(t)=10;
elseif mu11(t1)==mu11(t)+u11_11(t1)
    go11(t)=11;
elseif mu11(t1)==mu12(t)+u12_11(t1)
    go11(t)=12;
elseif mu11(t1)==mu13(t)+u13_11(t1)
    go11(t)=13;
elseif mu11(t1)==mu14(t)+u14_11(t1)
    go11(t)=14;
elseif mu11(t1)==mu15(t)+u15_11(t1)
    go11(t)=15;
elseif mu11(t1)==mu16(t)+u16_11(t1)
    go11(t)=16;
end
```

```
%go12
if mu12(t1)==mu1(t)+u1_12(t1)
    go12(t)=1;
elseif mu12(t1)==mu2(t)+u2_12(t1)
    go12(t)=2;
elseif mu12(t1)==mu3(t)+u3_12(t1)
    go12(t)=3;
elseif mu12(t1)==mu4(t)+u4_12(t1)
    go12(t)=4;
elseif mu12(t1)==mu5(t)+u5_12(t1)
    go12(t)=5;
elseif mu12(t1)==mu6(t)+u6_12(t1)
    go12(t)=6;
elseif mu12(t1)==mu7(t)+u7_12(t1)
    go12(t)=7;
elseif mu12(t1)==mu8(t)+u8_12(t1)
    go12(t)=8;
elseif mu12(t1)==mu9(t)+u9_12(t1)
    go12(t)=9;
elseif mu12(t1)==mu10(t)+u10_12(t1)
    go12(t)=10;
elseif mu12(t1)==mu11(t)+u11_12(t1)
    go12(t)=11;
elseif mu12(t1)==mu12(t)+u12_12(t1)
    go12(t)=12;
elseif mu12(t1)==mu13(t)+u13_12(t1)
    go12(t)=13;
elseif mu12(t1)==mu14(t)+u14_12(t1)
    go12(t)=14;
elseif mu12(t1)==mu15(t)+u15_12(t1)
    go12(t)=15;
```

APPENDIX G (Continued)

```
elseif mu12(t1)==mu16(t)+u16_12(t1)
    go12(t)=16;
end
```

```
%go13
if mu13(t1)==mu1(t)+u1_13(t1)
    go13(t)=1;
elseif mu13(t1)==mu2(t)+u2_13(t1)
    go13(t)=2;
elseif mu13(t1)==mu3(t)+u3_13(t1)
    go13(t)=3;
elseif mu13(t1)==mu4(t)+u4_13(t1)
    go13(t)=4;
elseif mu13(t1)==mu5(t)+u5_13(t1)
    go13(t)=5;
elseif mu13(t1)==mu6(t)+u6_13(t1)
    go13(t)=6;
elseif mu13(t1)==mu7(t)+u7_13(t1)
    go13(t)=7;
elseif mu13(t1)==mu8(t)+u8_13(t1)
    go13(t)=8;
elseif mu13(t1)==mu9(t)+u9_13(t1)
    go13(t)=9;
elseif mu13(t1)==mu10(t)+u10_13(t1)
    go13(t)=10;
elseif mu13(t1)==mu11(t)+u11_13(t1)
    go13(t)=11;
elseif mu13(t1)==mu12(t)+u12_13(t1)
    go13(t)=12;
elseif mu13(t1)==mu13(t)+u13_13(t1)
    go13(t)=13;
elseif mu13(t1)==mu14(t)+u14_13(t1)
    go13(t)=14;
elseif mu13(t1)==mu15(t)+u15_13(t1)
    go13(t)=15;
elseif mu13(t1)==mu16(t)+u16_13(t1)
    go13(t)=16;
end
```

```
%go14
if mu14(t1)==mu1(t)+u1_14(t1)
    go14(t)=1;
elseif mu14(t1)==mu2(t)+u2_14(t1)
    go14(t)=2;
elseif mu14(t1)==mu3(t)+u3_14(t1)
    go14(t)=3;
elseif mu14(t1)==mu4(t)+u4_14(t1)
    go14(t)=4;
elseif mu14(t1)==mu5(t)+u5_14(t1)
    go14(t)=5;
elseif mu14(t1)==mu6(t)+u6_14(t1)
    go14(t)=6;
elseif mu14(t1)==mu7(t)+u7_14(t1)
    go14(t)=7;
```

APPENDIX G (Continued)

```
elseif mu14(t1)==mu8(t)+u8_14(t1)
    go14(t)=8;
elseif mu14(t1)==mu9(t)+u9_14(t1)
    go14(t)=9;
elseif mu14(t1)==mu10(t)+u10_14(t1)
    go14(t)=10;
elseif mu14(t1)==mu11(t)+u11_14(t1)
    go14(t)=11;
elseif mu14(t1)==mu12(t)+u12_14(t1)
    go14(t)=12;
elseif mu14(t1)==mu13(t)+u13_14(t1)
    go14(t)=13;
elseif mu14(t1)==mu14(t)+u14_14(t1)
    go14(t)=14;
elseif mu14(t1)==mu15(t)+u15_14(t1)
    go14(t)=15;
elseif mu14(t1)==mu16(t)+u16_14(t1)
    go14(t)=16;
end

%go15
if mu15(t1)==mu1(t)+u1_15(t1)
    go15(t)=1;
elseif mu15(t1)==mu2(t)+u2_15(t1)
    go15(t)=2;
elseif mu15(t1)==mu3(t)+u3_15(t1)
    go15(t)=3;
elseif mu15(t1)==mu4(t)+u4_15(t1)
    go15(t)=4;
elseif mu15(t1)==mu5(t)+u5_15(t1)
    go15(t)=5;
elseif mu15(t1)==mu6(t)+u6_15(t1)
    go15(t)=6;
elseif mu15(t1)==mu7(t)+u7_15(t1)
    go15(t)=7;
elseif mu15(t1)==mu8(t)+u8_15(t1)
    go15(t)=8;
elseif mu15(t1)==mu9(t)+u9_15(t1)
    go15(t)=9;
elseif mu15(t1)==mu10(t)+u10_15(t1)
    go15(t)=10;
elseif mu15(t1)==mu11(t)+u11_15(t1)
    go15(t)=11;
elseif mu15(t1)==mu12(t)+u12_15(t1)
    go15(t)=12;
elseif mu15(t1)==mu13(t)+u13_15(t1)
    go15(t)=13;
elseif mu15(t1)==mu14(t)+u14_15(t1)
    go15(t)=14;
elseif mu15(t1)==mu15(t)+u15_15(t1)
    go15(t)=15;
elseif mu15(t1)==mu16(t)+u16_15(t1)
    go15(t)=16;
end
```

APPENDIX G (Continued)

```

%go16
if mu16(t1)==mu1(t)+u1_16(t1)
    go16(t)=1;
elseif mu16(t1)==mu2(t)+u2_16(t1)
    go16(t)=2;
elseif mu16(t1)==mu3(t)+u3_16(t1)
    go16(t)=3;
elseif mu16(t1)==mu4(t)+u4_16(t1)
    go16(t)=4;
elseif mu16(t1)==mu5(t)+u5_16(t1)
    go16(t)=5;
elseif mu16(t1)==mu6(t)+u6_16(t1)
    go16(t)=6;
elseif mu16(t1)==mu7(t)+u7_16(t1)
    go16(t)=7;
elseif mu16(t1)==mu8(t)+u8_16(t1)
    go16(t)=8;
elseif mu16(t1)==mu9(t)+u9_16(t1)
    go16(t)=9;
elseif mu16(t1)==mu10(t)+u10_16(t1)
    go16(t)=10;
elseif mu16(t1)==mu11(t)+u11_16(t1)
    go16(t)=11;
elseif mu16(t1)==mu12(t)+u12_16(t1)
    go16(t)=12;
elseif mu16(t1)==mu13(t)+u13_16(t1)
    go16(t)=13;
elseif mu16(t1)==mu14(t)+u14_16(t1)
    go16(t)=14;
elseif mu16(t1)==mu15(t)+u15_16(t1)
    go16(t)=15;
elseif mu16(t1)==mu16(t)+u16_16(t1)
    go16(t)=16;
end
end
%
=====
go(1,:)=go1;
go(2,:)=go2;
go(3,:)=go3;
go(4,:)=go4;
go(5,:)=go5;
go(6,:)=go6;
go(7,:)=go7;
go(8,:)=go8;
go(9,:)=go9;
go(10,:)=go10;
go(11,:)=go11;
go(12,:)=go12;
go(13,:)=go13;
go(14,:)=go14;
go(15,:)=go15;
go(16,:)=go16;

```

APPENDIX G (Continued)

```
Last=[mu1(11) mu2(11) mu3(11) mu4(11) mu5(11) mu6(11) mu7(11)
mu8(11) mu9(11) mu10(11) mu11(11) mu12(11) mu13(11) mu14(11) mu15(11)
mu16(11)];
start=min>Last);

if start==mu1(11)
    l1(length(go1)+1)=1;
    state(2*length(go1)-
1)=1/sqrt(2);state(2*length(go1))=1/sqrt(2); %==last state infor
    l1(length(go1))=go(1,length(go1));
    for t2=length(go1):-1:2
        l1(t2-1)=go(l1(t2),t2-1);

        if l1(t2)==1
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==2
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==3
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==4
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

        elseif l1(t2)==5
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==6
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==7
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==8
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-i/sqrt(2);

        elseif l1(t2)==9
            state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==10
            state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==11
            state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==12
            state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

        elseif l1(t2)==13
            state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==14
            state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==15
            state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==16
            state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-i/sqrt(2);
        end
    end
end
```

APPENDIX G (Continued)

```

elseif start==mu2(l1)
    l1(length(go1)+1)=2;
    state(2*length(go1)-
1)=1/sqrt(2);state(2*length(go1))=i/sqrt(2);
    l1(length(go1))=go(2,length(go1));
    for t2=length(go1):-1:2
        l1(t2-1)=go(l1(t2),t2-1);

        if l1(t2)==1
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==2
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==3
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==4
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

        elseif l1(t2)==5
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==6
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==7
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==8
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-i/sqrt(2);

        elseif l1(t2)==9
            state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==10
            state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==11
            state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==12
            state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

        elseif l1(t2)==13
            state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==14
            state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==15
            state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==16
            state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-i/sqrt(2);
        end
    end

elseif start==mu3(l1)
    l1(length(go1)+1)=3;
    state(2*length(go1)-1)=1/sqrt(2);state(2*length(go1))=-
1/sqrt(2);
    l1(length(go1))=go(3,length(go1));
    for t2=length(go1):-1:2
        l1(t2-1)=go(l1(t2),t2-1);

```

APPENDIX G (Continued)

```

if l1(t2)==1
    state(2*t2-3)=1/sqrt(2);state(2*t2-2)=1/sqrt(2);
elseif l1(t2)==2
    state(2*t2-3)=1/sqrt(2);state(2*t2-2)=i/sqrt(2);
elseif l1(t2)==3
    state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
elseif l1(t2)==4
    state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

elseif l1(t2)==5
    state(2*t2-3)=i/sqrt(2);state(2*t2-2)=1/sqrt(2);
elseif l1(t2)==6
    state(2*t2-3)=i/sqrt(2);state(2*t2-2)=i/sqrt(2);
elseif l1(t2)==7
    state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
elseif l1(t2)==8
    state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-i/sqrt(2);

elseif l1(t2)==9
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=1/sqrt(2);
elseif l1(t2)==10
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=i/sqrt(2);
elseif l1(t2)==11
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
elseif l1(t2)==12
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

elseif l1(t2)==13
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=1/sqrt(2);
elseif l1(t2)==14
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=i/sqrt(2);
elseif l1(t2)==15
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
elseif l1(t2)==16
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-i/sqrt(2);
end
end

elseif start==mu4(l1)
    l1(length(go1)+1)=4;
    state(2*length(go1)-1)=1/sqrt(2);state(2*length(go1))=-
i/sqrt(2);

    l1(length(go1))=go(4,length(go1));
    for t2=length(go1):-1:2
        l1(t2-1)=go(l1(t2),t2-1);

        if l1(t2)==1
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==2
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==3
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-1/sqrt(2);

```


APPENDIX G (Continued)

```
elseif l1(t2)==4
    state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

elseif l1(t2)==5
    state(2*t2-3)=i/sqrt(2);state(2*t2-2)=1/sqrt(2);
elseif l1(t2)==6
    state(2*t2-3)=i/sqrt(2);state(2*t2-2)=i/sqrt(2);
elseif l1(t2)==7
    state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
elseif l1(t2)==8
    state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-i/sqrt(2);

elseif l1(t2)==9
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=1/sqrt(2);
elseif l1(t2)==10
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=i/sqrt(2);
elseif l1(t2)==11
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
elseif l1(t2)==12
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

elseif l1(t2)==13
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=1/sqrt(2);
elseif l1(t2)==14
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=i/sqrt(2);
elseif l1(t2)==15
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
elseif l1(t2)==16
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-i/sqrt(2);
end
end

elseif start==mu5(l1)
    l1(length(go1)+1)=5;
    state(2*length(go1)-
1)=i/sqrt(2);state(2*length(go1))=1/sqrt(2);
    l1(length(go1))=go(5,length(go1));
    for t2=length(go1):-1:2
        l1(t2-1)=go(l1(t2),t2-1);

        if l1(t2)==1
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==2
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==3
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==4
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

        elseif l1(t2)==5
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==6
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=i/sqrt(2);
```

APPENDIX G (Continued)

```
elseif l1(t2)==7
    state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
elseif l1(t2)==8
    state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-i/sqrt(2);

elseif l1(t2)==9
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=1/sqrt(2);
elseif l1(t2)==10
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=i/sqrt(2);
elseif l1(t2)==11
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
elseif l1(t2)==12
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

elseif l1(t2)==13
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=1/sqrt(2);
elseif l1(t2)==14
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=i/sqrt(2);
elseif l1(t2)==15
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
elseif l1(t2)==16
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-i/sqrt(2);
end
end

elseif start==mu6(l1)
    l1(length(gol)+1)=6;
    state(2*length(gol)-
1)=i/sqrt(2);state(2*length(gol))=i/sqrt(2);
    l1(length(gol))=go(6,length(gol));
    for t2=length(gol):-1:2
        l1(t2-1)=go(l1(t2),t2-1);

        if l1(t2)==1
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==2
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==3
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==4
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

        elseif l1(t2)==5
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==6
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==7
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==8
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-i/sqrt(2);

        elseif l1(t2)==9
            state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=1/sqrt(2);
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APPENDIX G (Continued)

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elseif l1(t2)==10
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=i/sqrt(2);
elseif l1(t2)==11
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
elseif l1(t2)==12
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

elseif l1(t2)==13
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=1/sqrt(2);
elseif l1(t2)==14
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=i/sqrt(2);
elseif l1(t2)==15
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
elseif l1(t2)==16
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-i/sqrt(2);
end
end
elseif start==mu7(l1)
    l1(length(go1)+1)=7;
    state(2*length(go1)-1)=i/sqrt(2);state(2*length(go1))=-
1/sqrt(2);
    l1(length(go1))=go(7,length(go1));
    for t2=length(go1):-1:2
        l1(t2-1)=go(l1(t2),t2-1);

        if l1(t2)==1
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==2
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==3
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==4
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

        elseif l1(t2)==5
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==6
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==7
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==8
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-i/sqrt(2);

        elseif l1(t2)==9
            state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==10
            state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==11
            state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==12
            state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

        elseif l1(t2)==13

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APPENDIX G (Continued)

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        state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=1/sqrt(2);
elseif l1(t2)==14
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=i/sqrt(2);
elseif l1(t2)==15
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
elseif l1(t2)==16
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-i/sqrt(2);
end
end

elseif start==mu8(l1)
    l1(length(go1)+1)=8;
    state(2*length(go1)-1)=i/sqrt(2);state(2*length(go1))=-
i/sqrt(2);
    l1(length(go1))=go(8,length(go1));
    for t2=length(go1):-1:2
        l1(t2-1)=go(l1(t2),t2-1);

        if l1(t2)==1
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==2
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==3
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==4
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

        elseif l1(t2)==5
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==6
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==7
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==8
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-i/sqrt(2);

        elseif l1(t2)==9
            state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==10
            state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==11
            state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==12
            state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

        elseif l1(t2)==13
            state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==14
            state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==15
            state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==16
            state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-i/sqrt(2);

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APPENDIX G (Continued)

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        end
    end

    elseif start==mu9(l1)
        l1(length(go1)+1)=9;
        state(2*length(go1)-1)=-
1/sqrt(2);state(2*length(go1))=1/sqrt(2);
        l1(length(go1))=go(9,length(go1));
        for t2=length(go1):-1:2
            l1(t2-1)=go(l1(t2),t2-1);

            if l1(t2)==1
                state(2*t2-3)=1/sqrt(2);state(2*t2-2)=1/sqrt(2);
            elseif l1(t2)==2
                state(2*t2-3)=1/sqrt(2);state(2*t2-2)=i/sqrt(2);
            elseif l1(t2)==3
                state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
            elseif l1(t2)==4
                state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

            elseif l1(t2)==5
                state(2*t2-3)=i/sqrt(2);state(2*t2-2)=1/sqrt(2);
            elseif l1(t2)==6
                state(2*t2-3)=i/sqrt(2);state(2*t2-2)=i/sqrt(2);
            elseif l1(t2)==7
                state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
            elseif l1(t2)==8
                state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-i/sqrt(2);

            elseif l1(t2)==9
                state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=1/sqrt(2);
            elseif l1(t2)==10
                state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=i/sqrt(2);
            elseif l1(t2)==11
                state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
            elseif l1(t2)==12
                state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

            elseif l1(t2)==13
                state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=1/sqrt(2);
            elseif l1(t2)==14
                state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=i/sqrt(2);
            elseif l1(t2)==15
                state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
            elseif l1(t2)==16
                state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-i/sqrt(2);
            end
        end

    elseif start==mu10(l1)
        l1(length(go1)+1)=10;
        state(2*length(go1)-1)=-
1/sqrt(2);state(2*length(go1))=i/sqrt(2);

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APPENDIX G (Continued)

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l1(length(go1))=go(10,length(go1));
for t2=length(go1):-1:2
    l1(t2-1)=go(l1(t2),t2-1);

    if l1(t2)==1
        state(2*t2-3)=1/sqrt(2);state(2*t2-2)=1/sqrt(2);
    elseif l1(t2)==2
        state(2*t2-3)=1/sqrt(2);state(2*t2-2)=i/sqrt(2);
    elseif l1(t2)==3
        state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
    elseif l1(t2)==4
        state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

    elseif l1(t2)==5
        state(2*t2-3)=i/sqrt(2);state(2*t2-2)=1/sqrt(2);
    elseif l1(t2)==6
        state(2*t2-3)=i/sqrt(2);state(2*t2-2)=i/sqrt(2);
    elseif l1(t2)==7
        state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
    elseif l1(t2)==8
        state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-i/sqrt(2);

    elseif l1(t2)==9
        state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=1/sqrt(2);
    elseif l1(t2)==10
        state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=i/sqrt(2);
    elseif l1(t2)==11
        state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
    elseif l1(t2)==12
        state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

    elseif l1(t2)==13
        state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=1/sqrt(2);
    elseif l1(t2)==14
        state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=i/sqrt(2);
    elseif l1(t2)==15
        state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
    elseif l1(t2)==16
        state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-i/sqrt(2);
    end
end

elseif start==mul1(l1)
    l1(length(go1)+1)=11;
    state(2*length(go1)-1)=-1/sqrt(2);state(2*length(go1))=-
1/sqrt(2);

    l1(length(go1))=go(11,length(go1));
    for t2=length(go1):-1:2
        l1(t2-1)=go(l1(t2),t2-1);

        if l1(t2)==1
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==2

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APPENDIX G (Continued)

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        state(2*t2-3)=1/sqrt(2);state(2*t2-2)=i/sqrt(2);
elseif l1(t2)==3
    state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
elseif l1(t2)==4
    state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

elseif l1(t2)==5
    state(2*t2-3)=i/sqrt(2);state(2*t2-2)=1/sqrt(2);
elseif l1(t2)==6
    state(2*t2-3)=i/sqrt(2);state(2*t2-2)=i/sqrt(2);
elseif l1(t2)==7
    state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
elseif l1(t2)==8
    state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-i/sqrt(2);

elseif l1(t2)==9
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=1/sqrt(2);
elseif l1(t2)==10
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=i/sqrt(2);
elseif l1(t2)==11
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
elseif l1(t2)==12
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

elseif l1(t2)==13
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=1/sqrt(2);
elseif l1(t2)==14
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=i/sqrt(2);
elseif l1(t2)==15
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
elseif l1(t2)==16
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-i/sqrt(2);
end
end

elseif start==mul2(l1)
    l1(length(go1)+1)=12;
    state(2*length(go1)-1)=-1/sqrt(2);state(2*length(go1))=-
i/sqrt(2);

    l1(length(go1))=go(12,length(go1));
    for t2=length(go1):-1:2
        l1(t2-1)=go(l1(t2),t2-1);

        if l1(t2)==1
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==2
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==3
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==4
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

        elseif l1(t2)==5

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APPENDIX G (Continued)

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        state(2*t2-3)=i/sqrt(2);state(2*t2-2)=1/sqrt(2);
elseif l1(t2)==6
    state(2*t2-3)=i/sqrt(2);state(2*t2-2)=i/sqrt(2);
elseif l1(t2)==7
    state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
elseif l1(t2)==8
    state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-i/sqrt(2);

elseif l1(t2)==9
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=1/sqrt(2);
elseif l1(t2)==10
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=i/sqrt(2);
elseif l1(t2)==11
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
elseif l1(t2)==12
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

elseif l1(t2)==13
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=1/sqrt(2);
elseif l1(t2)==14
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=i/sqrt(2);
elseif l1(t2)==15
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
elseif l1(t2)==16
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-i/sqrt(2);
end
end

elseif start==mul3(l1)
    l1(length(go1)+1)=13;
    state(2*length(go1)-1)=-
i/sqrt(2);state(2*length(go1))=1/sqrt(2);
    l1(length(go1))=go(13,length(go1));
    for t2=length(go1):-1:2
        l1(t2-1)=go(l1(t2),t2-1);

        if l1(t2)==1
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==2
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==3
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==4
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

        elseif l1(t2)==5
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==6
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==7
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==8
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-i/sqrt(2);

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APPENDIX G (Continued)

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elseif l1(t2)==9
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=1/sqrt(2);
elseif l1(t2)==10
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=i/sqrt(2);
elseif l1(t2)==11
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
elseif l1(t2)==12
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

elseif l1(t2)==13
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=1/sqrt(2);
elseif l1(t2)==14
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=i/sqrt(2);
elseif l1(t2)==15
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
elseif l1(t2)==16
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-i/sqrt(2);
end
end

elseif start==mul4(l1)
    l1(length(go1)+1)=14;
    state(2*length(go1)-1)=-
i/sqrt(2);state(2*length(go1))=i/sqrt(2);
    l1(length(go1))=go(14,length(go1));
    for t2=length(go1):-1:2
        l1(t2-1)=go(l1(t2),t2-1);

    if l1(t2)==1
        state(2*t2-3)=1/sqrt(2);state(2*t2-2)=1/sqrt(2);
    elseif l1(t2)==2
        state(2*t2-3)=1/sqrt(2);state(2*t2-2)=i/sqrt(2);
    elseif l1(t2)==3
        state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
    elseif l1(t2)==4
        state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

    elseif l1(t2)==5
        state(2*t2-3)=i/sqrt(2);state(2*t2-2)=1/sqrt(2);
    elseif l1(t2)==6
        state(2*t2-3)=i/sqrt(2);state(2*t2-2)=i/sqrt(2);
    elseif l1(t2)==7
        state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
    elseif l1(t2)==8
        state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-i/sqrt(2);

    elseif l1(t2)==9
        state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=1/sqrt(2);
    elseif l1(t2)==10
        state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=i/sqrt(2);
    elseif l1(t2)==11
        state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
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APPENDIX G (Continued)

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elseif l1(t2)==12
    state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

elseif l1(t2)==13
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=1/sqrt(2);
elseif l1(t2)==14
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=i/sqrt(2);
elseif l1(t2)==15
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
elseif l1(t2)==16
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-i/sqrt(2);
end
end

elseif start==mul5(l1)
    l1(length(go1)+1)=15;
    state(2*length(go1)-1)=-i/sqrt(2);state(2*length(go1))=-
1/sqrt(2);
    l1(length(go1))=go(15,length(go1));
    for t2=length(go1):-1:2
        l1(t2-1)=go(l1(t2),t2-1);

        if l1(t2)==1
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==2
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==3
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==4
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

        elseif l1(t2)==5
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==6
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==7
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==8
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-i/sqrt(2);

        elseif l1(t2)==9
            state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==10
            state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==11
            state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==12
            state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

        elseif l1(t2)==13
            state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==14
            state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=i/sqrt(2);

```

APPENDIX G (Continued)

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elseif l1(t2)==15
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
elseif l1(t2)==16
    state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-i/sqrt(2);
end
end

elseif start==mul6(l1)
    l1(length(go1)+1)=16;
    state(2*length(go1)-1)=-i/sqrt(2);state(2*length(go1))=-
i/sqrt(2);

    l1(length(go1))=go(16,length(go1));
    for t2=length(go1):-1:2
        l1(t2-1)=go(l1(t2),t2-1);

        if l1(t2)==1
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==2
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==3
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==4
            state(2*t2-3)=1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

        elseif l1(t2)==5
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==6
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==7
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==8
            state(2*t2-3)=i/sqrt(2);state(2*t2-2)=-i/sqrt(2);

        elseif l1(t2)==9
            state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==10
            state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==11
            state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==12
            state(2*t2-3)=-1/sqrt(2);state(2*t2-2)=-i/sqrt(2);

        elseif l1(t2)==13
            state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=1/sqrt(2);
        elseif l1(t2)==14
            state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=i/sqrt(2);
        elseif l1(t2)==15
            state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-1/sqrt(2);
        elseif l1(t2)==16
            state(2*t2-3)=-i/sqrt(2);state(2*t2-2)=-i/sqrt(2);
        end
    end
end
end

```

APPENDIX G (Continued)

```

for num_s=1:length(state)

    if state(num_s)==1/sqrt(2)
        m(2*num_s-1)=0;m(2*num_s)=0;
    elseif state(num_s)==-1/sqrt(2)
        m(2*num_s-1)=1;m(2*num_s)=1;
    elseif state(num_s)==i/sqrt(2)
        m(2*num_s-1)=0;m(2*num_s)=1;
    elseif state(num_s)==-i/sqrt(2)
        m(2*num_s-1)=1;m(2*num_s)=0;
    end

end

for num_m=1:(k/2)

    if m(2*num_m-1)==0 && m(2*num_m)==0
        msg_m(num_m)=1;
    elseif m(2*num_m-1)==0 && m(2*num_m)==1
        msg_m(num_m)=i;
    elseif m(2*num_m-1)==1 && m(2*num_m)==1
        msg_m(num_m)=-1;
    elseif m(2*num_m-1)==1 && m(2*num_m)==0
        msg_m(num_m)=-i;
    end

    error(SNR)=nnz(msg_mod-msg_m);

end

reset1=error+reset1;
end
avg_er=reset1/ci;

semilogy(SNRindB,avg_er/length(msg_m), '-r+');
grid on
hold on

```