International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-5, June 2019

Counting Number of Girth 6 for Sparse Quasi Cyclic Low Density Parity Check Codes using Gallager Approach

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Abstract: This manuscript presents two approaches for counting the number of girth 6, these are based on Gallager construction of sparse QC-LDPC (Quasi Cyclic Low Density Parity Check codes). The Sparse QC-LDPC matrix has been constructed through counter shifting, permutation, circulant shifting, creates generator matrix, sub-matrix and basic construction of Gallager technique. It performs the 6 cycles check algorithm with constant row weight 3 and column weight 6 on various codes of half code rate. Simulation results show that the constructed sparse regular QC-LDPC codes outperforms to number of girth 6 counting using these two approaches that compared to Existing results.

Index Terms: Gallager Construction regular QC-LDPC, Girth 6, Mac and QC codes, 1/2 code rate.

I. INTRODUCTION

A Low Density Parity Check codes are basically error detecting and correcting codes, which introduce low complexity encoding and decoding techniques. The circulant shifting technique is used to construct Quasi Cyclic-LDPC codes. The Graphical representation of QC-LDPC codes is presented by bipartite graph or Tanner Graph. In these graphs the length of shortest cycle is defined as girth. The performance of QC-LDPC codes is depends on number of girths. There are several approaches to constructing regular Quasi Cyclic-LDPC codes, which have different girths such as 4, 6, 8, 10 and 12 [1, 2]. The single-edge tree-apex sub-graph based algorithm is used for determining the girth of regular and irregular LDPC codes in Tanner graphs [3]. QC-LDPC codes are recently constructed through affine permutation matrix (APM) with girth 6,8,10 using explicit construction methods [4]. The method for counting number of 4, 6, 8 and 10 cycles of LDPC codes using all possible combination of rows in the matrix is presented [5]. The explicitly constructed regular type-I QC-LDPC codes has been analysed with girth 12 [6]. The Guohua Zhang is constructed Type-II QC-LDPC codes from Sidon sequences of perfect cyclic of different set, while possessing a large amount of circulant permutation matrix (CPM) [7].
Another approach is represented to construct QC-LDPC codes with girth 6 and 8 using combinatorial design based circulant parity check matrix [8, 9].

Manuscript published on 30 June 2019.
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The approach given by Hang Tang and Jun Xu is basically presents three algebraic methods for constructing LDPC codes, first method is represented classes of Gallager codes, second method is to two classes of circulant LDPC codes and third approach is two-step hybrid method [10]. Cyclic structure of QC-LDPC is obtained for shortest code with given degree of distribution and girth [11].
The constructed polynomial parity check matrix is represented an efficient method for locating the girth of QC-LDPC Codes [12].
The graph-theoretic method is based on linear congruence for constructing QC-LDPC codes with girth 12 is presented by Long-Jiang Jin and Jin-Le Lin [13]. The method is represented for counting number of g-cycles in LDPC codes [14]. The approach is based on mapping of Hierarchical QC-LDPC codes with girth 8 and 10 presented [15]. Well-structured block designed approach is presented to construct regular and irregular QC-LDPC codes with Girth 20 [16]. The approach derives to generate QC-LDPC code of column weight 2 with a girth of 36 has been analysed [17]. The QC-LDPC code is based on sub-graph patterns of Protographs having inevitable cycles of length 2i [18]. QC Protographs LDPC code is constructed with Girth 8 using cyclic lifting technique [19]. Improved Message Passing Algorithm uses integer addition and subtractions to compute message at the nodes of Bipartite graph for counting no. of short cycles for LDPC codes [20]. The technique is given to construct QC-LDPC codes based on base matrix and exponent matrix represented with joint iterative decoding [21].
In this manuscript, the parity check matrix have been constructed using Gallager approach and construct Quasi-Cyclic LDPC code using two methods, such as Approach-I and Approach-II. These codes are converted into QC-LDPC codes with girth 6 using circulant shifting, counter shifting and XORing techniques. In Approach-I number of 1's in each column is represented by C_{WI}. The column weight of LDPC codes is 3. The number of 1's in each row is represented by R_{wI} with row weight of LDPC codes is 6. In Approach-II number of 1's in each column is represented by C_{wII} and its column weight of codes is 3. The no. of 1's in each row is represented by R_{wII} with row weight of codes is 6. This arrangement of weight (3, 6) is called regular LDPC code, otherwise called irregular LDPC code.
In this paper, the proposed construction for Regular Quasi Cyclic-LDPC codes based on single row of circulant shifting technique. There is also exists a set and two counters shifting technique with interleave mapping, randomization and setxor in Approach-I have been applied. The Approach-II is given to constructs QC-LDPC codes using generation and permutation of basic sub-matrix.

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In this manuscript, the planned sparse Quasi Cyclic-LDPC codes is constructed for counting the number of girth 6 on different codes such as Mac(96,48), Mac(1080,540), (512,256), QC(108,54), QC(1074,537) and (1024,512) for half code rate.
The remainder of the paper is organized as follows: Section II presents the girth 6 representation through Tanner graph. In Section III the design of algorithm for new Gallager based constructed Sparse QC-LDPC with Approach-I and Approach-II is discussed. In section IV girth 6 counting Method for Sparse QC-LDPC codes is represented. In section V simulation Results are presented. Section VI is conclusion.

II. GIRTH 6 REPRESENTATIONS THROUGH TANNER GRAPH

The Gallager approach based PCM (Parity Check Matrix) is constructed by using Approach-I and Approach-II having weight (3, 6) of regular LDPC codes. It represents the girth 6 using bipartite graph. It is also called a tanner Graph, the graphics shown in Fig.1.
For example: we have consider PCM to construct LDPC codes for (M=4, N=8) size with code rate 1/2 is represented by H. Here M=no. of rows and N= no. of Columns in H.
The constructed PCM is preceded for enormous code lengths using Gallager based construction technique.

$$H_{G1} = \begin{bmatrix} 1\,1\,1\,1\,1\,1\,0\,0 \\ 0\,1\,1\,1\,1\,1\,1\,0 \\ 0\,0\,0\,0\,0\,0\,0\,0 \\ 1\,1\,0\,1\,0\,1\,1\,1 \end{bmatrix} \quad (1)$$

There is H_{G1}=Parity check matrix of LDPC codes with dimension (4, 8) of Gallager construction Approach-I

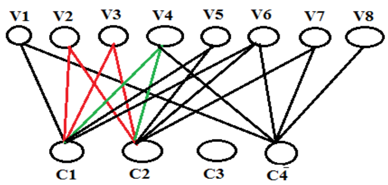

Fig.1: Tanner Graph representation of HG1 (PCM)

When n numbers of variable nodes is given by V and m denote number of check nodes C. The graphical representation of parity check matrix using Tanner graph is G= (V U C, E) of H.
E represents set of edges in Tanner Graph.
Here V= {1, 2, 3…n} and C= {1, 2, 3…….m}

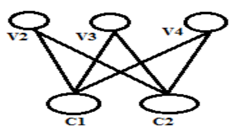

Fig. 2: Girth 6 representation in Tanner graph of HG1 matrix using Approach-I

The length of the shortest cycle in the Tanner graph between variable node V and check node C is called girth g [22, 23].
i.e. (E ∩V) × C, with edge (C_i, V_j) € E, when $h_{i,j}$≠0, where $h_{i,j}$ is the no. of 1's in i[th] row and j[th] column of gallager based parity check matrix H.
Another Parity check matrix H_{G2} for LDPC codes having similar dimensions (4, 8) using Gallager based construction Approach-II is given by:

$$H_{G2} = \begin{bmatrix} 1\,1\,1\,1\,1\,1\,0\,0 \\ 1\,1\,1\,1\,0\,1\,0\,1 \\ 0\,0\,0\,0\,0\,0\,0\,0 \\ 1\,1\,0\,1\,1\,0\,1\,1 \end{bmatrix} \quad (2)$$

H_{G2}= PCM of LDPC codes is obtain by using Gallager construction Approach-II
Fig.3 shows that Tanner Graph representation of parity check matrix H_{G2} constructs for LDPC codes.

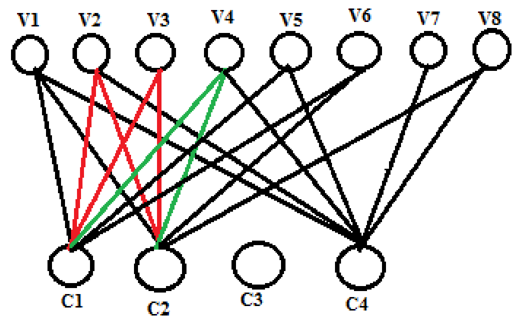

Fig. 3: Tanner Graph representation of HG2 (PCM)

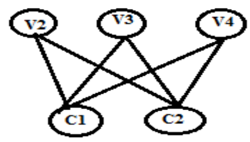

Fig. 4: Girth 6 representation in Tanner graph of H_{G2} matrix using Approach-II

6-cycle must be given in three rows are shown in the Tanner graph of Fig.4. It is allied with the newH for construction of QC-LDPC matrix based on Gallager technique using Approach-I and Approach-II. Number of girth 6 in Parity check matrix of QC-LDPC codes is given by:

$$N(g) = \sum_{i=1}^{M-1} P(i) + \sum_{j=1}^{N-1} P(j) \quad (3)$$

Where, M= no. of rows in parity check matrix H and
N= no. of columns in H, here 0≤i≤M-1, 0≤j≤N-1
P (i) =C_M^3 and P (j) =C_N^3 (for girth 6)
No. of rows required for girth 6 of QC-LDPC codes in tanner graph are three.

III. DESIGN OF ALGORITHM FOR NEW GALLAGER CONSTRUCTION BASED SPARSE QC-LDPC USING APPROACH-I AND APPROACH-II

In 1962 Gallager introduced LDPC codes, then further implemented with various approaches to construct regular or irregular LDPC codes [24]. In this paper, Approach-I represent recent Gallager approach to construct girth 6 based LDPC codes using counter shifting and interleave mapping, and then it becomes QC-LDPC codes using circulant & counter shifting techniques.
Approach-II represents another Gallager technique to construct LDPC codes with girth 6 using Basic and permutation sub matrix. It is also converted into Quasi Cyclic-LDPC codes with girth 6 using similar techniques.

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A. Gallager Construction Sparse QC-LDPC using Approach-I

A binary regular LDPC codes is defined by column length N and no. of rows M= (C_{wI}×N)/R_{wI} for sparse parity check matrix H. The constant column weight is C_{wI}=3 and constant row weight is R_{wI}=6, respectively H of dimension (R_{wI}, C_{wI}) for regular LDPC code with constant weight in each column and row. An LDPC code is called irregular if its parity check matrix H has varying column and row weight.

Algorithm for Construction of LDPC codes using Approach-I:

When C_{wI}=3, R_{wI}=6 and M is no. of rows, N is no. of columns in H, then counter_1 iterate between 1 to N/R_{wI} and shifted array is incremented by 1 and decremented by 1.
After that, another counter_2 is iterate between 2 to C_{wI}, then obtain interleave mapping with arrangement of array and randomization technique. It should also counter shifted by 1. This algorithm constructs regular LDPC code using Gallager based construction method of Approach-I.
QC-LDPC: Let the Gallager construction parity check matrix using Approach-I, it represents another method to construct QC-LDPC code is given by:

$$H = \begin{bmatrix} H_{1,1} & H_{1,2} & \dots \dots H_{1,M} \\ H_{2,1} & H_{2,2} & \dots \dots H_{2,M} \\ & \vdots \vdots & \\ & \dots \dots & \\ H_{N,1} & H_{N,2} & \dots \dots H_{N,M} \end{bmatrix} \quad (4)$$

Where M and N are two positive integers of y×y circulant matrices is represented by E. If there is y=m, then binary elements of this rows are set to zero. At y= C_{wI}, the y-1 is given to cyclic shifting of each column based circulant matrix is obtained.
Algorithm to construct QC-LDPC for Approach-I:
Inputs given are R_{wI}=6 (constant row weight), C_{wI}=3 (constant column weigh), M= {M_1, M2, M3…..M_C) and N= {N_1, N2, N3……..N_V). Set the value of prime between 1 to N and steps of Algorithm are given below:

1. for y = 1 to M **do**
2. Counter ($E_{y,1}$) =0
3. for y from 1 to C_{wI} **do**
4. for $\sum_{t=1}^{y-1} N(t) + 1$ to $\sum_{t=1}^{y} N(t)$
5. $E_{Y,N}$=0
6. for a is given from 1 to R_{wI} and b is from 2 to C_{wI}
7. If a=1, then cyclic shifting (b, a) is to round element of array
8. If b=1, then find x1 to set exclusive OR of two array elements and shifting array element cyclically to round approach.
9. for d from b to -1 to 3 and e from a-1 to -1 to 1 **do**
10. Cyclic shift array (b, e) is to obtained d1 and d2 through shifting (d-1, a), (d-1, e) after subtract array elements
11. for i from 1 to R_{wI} and y from 1 to C_{wI} **do** then circulant shifting (y, i) with subtract array element from 1 in each row and column
12. for b from 1 to N and y from 2 to C_{wI} **do** then connect (i, y-1) with rows (b)
13. for b from 1 to C_{wI} and z from 1 to N **do** the shift value to create connection in sub-matrix and counter +1 shifted for C_{wI} -1

B. Gallager Construction Sparse QC-LDPC using Approach-II

A binary regular LDPC codes is defined as column length n and no. of rows k = (n×C_{wII})/R_{wII} for sparse parity check matrix H. The constant column weight is C_{wII}=3 and constant row weight is R_{wII}=6, respectively weight of H (6, 3) for regular LDPC code with constant weight in each column and row.

Algorithm for Gallager based LDPC construction using Approach-II:
Let i is the positive integer greater than 1. The PCM is constructed using gallager based Approach-II, it's represent in the form of (i×C_{wII}) × (i×R_{wII}) matrix. It consists of C_{wII} sub matrices of H_1, H_2, H_3, ...H_{CwII}. The given first basic sub-matrix H_1 is constructing for 1≤i≤j, the i_{th} row is containing all its R_{wII} is 1 to entry in each column from (i-1) R_{wII} +1 to i×R_{wII}. Then the C_{wII} -1 based sub matrices are simply obtained by permuting the column of H_1. Then parity check matrix of Gallager based LDPC code is given by:

$$H_{G2} = \begin{bmatrix} H_1 \\ H_2 \\ H_3 \\ \vdots \\ \vdots \\ H_{Cw} \end{bmatrix} \quad (5)$$

Algorithm to construct QC-LDPC using Approach-II:
Inputs given are: R_{wII}=6 (constant row weight), C_{wII}=3 (constant column weigh), k={k_1,k_2,k_3…..k_C) and n={n_1,n_2,n_3……..n_V). Set the value of prime between 1 to n and empty-set is [ ].
Output: we follow similar techniques as already discussed in previous algorithm to construction of QC-LDPC codes using Approach-I.

IV. DISCUSS NUMBER OF GIRTH 6 COUNTING ALGORITHM

The number of girth 6 counting for constructed QC-LDPC codes is to be done using following algorithm or steps are given in below:

1. for i from M-1, j from N-1 and s from 1 to M **do**
2. if newH (i, j)==1, x1=i and y1=j and z1=s
3. for j1 from j+1 to N **do**
4. if newH (i, j1)==1 and x2=i and y2= j1 and z2=s
5. for s1 from s+1 to M **do**
6. if newH (i, s1)==1 and x=i, y=s1 and z=j
7. for i1 from i+1 to M **do**
8. if newH (i1, j1)==1, then x3=i1, y3=j1 and z3=s1
9. If newH (i1, j)==1 and another newH (i1, s1)==1, then x4=i1, y4=j, z4=s and x5=i1, y5=j1, z5=s1

Count the number of 6-girths in constructed Sparse QC-LDPC codes.

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V. SIMULATION RESULTS AND COUNTING NUMBER OF 6 GIRTHS FOR SPARSE QC-LDPC CODES

The following results are obtaining using MATLAB simulation is to be represented efficient counting of no. of girth 6 for constructed Sparse QC-LDPC codes. It is constructed using two Gallager based techniques such as Approach-I and Approach-II. The results are given in Table1 on various code lengths with code rate 1/2.

The Table2 represented already published results on no. of 4 and 6 girths counting using different approaches to construct LDPC codes by the Authors. After comparing the results, the Gallager based construction technique for QC-LDPC codes using Approach-II is counting more no. of girth 6 that compare to Approach-I for various code length of 1/2 code rate. Here newH is equal to sparse parity check matrix of QC-LDPC with girth-6.

The mesh fig. 5 represents graphical view of no. of counting girth 6 for constructed QC-LDPC codes of Mac (96, 48) using Approach-I and showing the no. of 830 spikes of girth 6 for this code. Another mesh fig. 6 is represents graphical view of no. of counting 6 girths for constructed QC-LDPC codes of Mac (96, 48) using Approach-II and showing no. of 1531 spikes of 6 girths for this code. The comparatively Approach-II is efficient for counting 6-girths in QC-LDPC codes.

S. No.	Size of Code	No. of 6-girth count using Approach-I	No. of 6-girth count using Approach-II
01	Mac(96,48)	830	1531
02	QC(108,54)	1015	1528
03	Mac(1080,540)	7085	9869
04	QC(1074,537)	12097	16424
05	(512,256)	5116	3268
06	(1024,512)	11479	10413

Table1: No. of 6-girth counting results for Gallager approach based Sparse QC-LDPC codes using Approach-I & II

S.No	Size of Code	Type of girth	No. of girth count Calculated by Umar-Faruk and Jun Fan [3, 5]
01	Mac(96,48)	4	0
02	QC(108,54)	4	0
03	(512,256)	6	2122
04	(1024,512)	6	4716
05	Mac(96,48)	6	191
06	QC(108,54)	6	0

Table2: No. of 4-girth and 6-girth counting results are being published in [3] and [5].

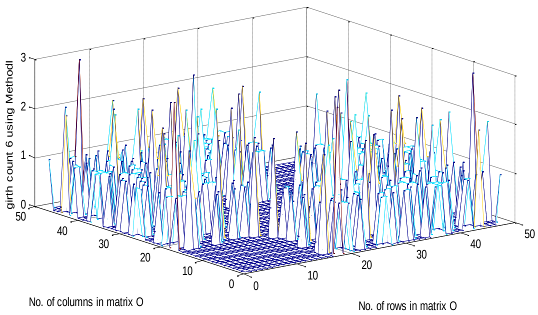

Fig. 5: Sparse Parity Check Matrix O of QC-LDPC codes with girth 6 using Gallager's Construction Approach-I for code Mac (96, 48)

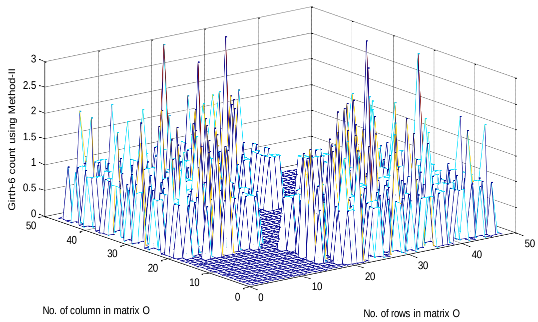

Fig. 6: Sparse Parity Check Matrix O of QC-LDPC codes with girth 6 using Gallager's Construction Approach-II for code Mac (96, 48)

We are proposed more efficient algorithms to construct QC-LDPC codes and also counting no. of more girth 6 that compare to previous results are given in Table2. The regular LDPC code of (512, 256) and (1024, 512) for counting girth-6 is 59% better than previous approach.

VI. CONCLUSION

In this paper, an proposed algorithm is to be constructed for Gallager Approach based sparse QC-LDPC codes with girth 6. These approaches represent most appropriate techniques to counting number of girths 6 in bipartite graph or Tanner graph of Sparse Quasi Cyclic-LDPC codes. These approaches are based on generation and transformation of basic sub-matrix, counter shifting, circular shifting, XORing, row and column combination of matrix to represent efficient method for counting no. of 6 girths in constructed QC-LDPC codes. The generation and permutation of basic sub-matrix using Gallager approach-II is performing more efficient no. of counting the girth 6 comparatively with counter shifting construction based approach-I for sparse PCM. These approaches can be used to reduce the complexity of QC-LDPC encoder and decoder to perform more effective error detection and correction for the larger data size. The constructed LDPC code can decreases the Bit error rate and Frame error rate of various digital video broadcasting. This girth counting approach can further be implemented for the calculation of 8,10,12,14 and 16 girths of LDPC codes.

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REFERENCES

1. Jun Fan, Yang Xiao, and Kiseon "Design LDPC Codes without of Length 4 and 6" in Hindawi Publishing Corporation, Article ID 354137, Volume 2008.
2. Guohua Zhang and Rudolf Mathar, "Explicit construction for Type-1 QC-LDPC Codes with Girth 12" in IEEE Communication Letters, Vol. 21, No. 3, March 2017.
3. Umar-Faruk Abdu-Aguye, Marcel Adrian and Martin Tomlinson "An Efficient Algorithm for Determining the Girth and ACE Distributions in LDPC Code Tanner Graphs" in IEEE Transaction on information theory, March 2016.
4. Mohammad Gholami and Masoumeh Alinia "Explicit APM-LDPC Codes with Girths 6, 8, and 10" in IEEE Signal Processing Letters, vol. 24, no. 6, June 2017.
5. Jun Fan, Yang Xiao "A Method of counting the Number of Cycles in LDPC Codes" IEEE Trans. Inf. Theory, ICSP2006 Proceedings, May 2006.
6. S.kim, H.Chung and D-J Shin "On the girth of tanner (3,5) quasi cyclic LDPC codes" IEEE Trans. Inf. Theory, vol. 52, no. 4, pp. 381–389, Jun. 2007.
7. Guohua Zhang "Type-II quasi cyclic low-density parity-check codes from Sidon sequences" in IET Electronic Letters on communication, vol. 52, no. 5, March 2016.
8. Sina Vafi and Narges Rezwani Majid, "A new scheme of high performance Quasi-cyclic LDPC codes with Girth 6" in IEEE Communication Letters, Vol. 19, No. 10, Oct 2015.
9. 9. Alireza Tasdighi, Amir H. Banihashemi, and Mohammad-Reza Sadeghi "Symmetrical Construction for Regular girth-8 QC-LDPC codes" in IEEE Transaction on communication,Vol.14, No.8, Oct 2016.
10. Hang Tang, June Xu, Yu Kou, Shun Lin and Khaled Abdel- Ghaffar "On algebraic construction of Gallager and circulant LDPC codes" in IEEE Trans. On information theory,Vol. 50, No. 6, June 2004.
11. Alireza Tasdighi, Amir H. Banihashemi and Mohammad Reza Sadeghi "Efficient search of girth optimal QC-LDPC codes" in IEEE Trans. on information theory,Vol. 14, No. 8, Jan 2016.
12. Xiaofu Wu, Xiaohu You, and Chunming Zhao "An efficient Girth Locating Algorithm for Quasi-Cyclic LDPC Codes" in IEEE Communication Society, 2006.
13. Long-Jiang Jing, Jing-Li Lin and Wie-Le Zhu "Design of Quasi-Cyclic Low Density Parity Check codes with Large Girth" in ETRI Journal, Volume 29, Number 3, June 2007.
14. H. Dahghani, M. Ahmadi, S.Alikhani and R. Hasni "calculation of girth of Tanner Graph in LDPC codes" in Trends in Applied Sciences and research, 929-934, 2012.
15. Yige Wang, Stark C. Draper and Jonathan S.Yedidia "Hierarchical and High Girth QC-LDPC codes" in IEEE Transcations on Information Theory, Vol. 59, No. 7, July 2013.
16. Mohmmad Gholami, Mehdi Samadieh and Gaffar Raeisi "Column weight three QC-LDPC Codes with Girth 20" in IEEE Communication Letters, Vol. 17, No. 7, July 2013.
17. Xiongfei Tao, Lixin Zheng, Weizhong Liu, and Dongsheng Liu "Recursive design of High Girth (2, k) LDPC codes from (k, k) LDPC Codes" in IEEE Communication Letters, Vol. 15, No. 1, Jan 2011.
18. Sunghwan Kim, Jong seon-No, Habong Chung and Dong-Joon Shin "Cycle Analysis and Construction of Photographs for QC-LDPC Codes with Girth Larger than 12" in IEEE Communication Society, 29 June 2007.
19. Mehdi Karimi and Amir H. Banihashemi "On the Girth of Quasi-Cyclic Photographs LDPC Codes" in IEEE Transcation on information theory, Vol. 59, No. 7, July 2013.
20. Juane Li, Shu Lin, and Khaled Abdel-Ghaffar "Improved message passing Algorithm for counting short cycles in Bipartite Graphs" in IEEE Transcation on information theory, July 2015.
21. Shunwai Zhang, Fengfan Yang, Lei Tang, Saqib Ejaz, Lin Lu and B.T. Maharaj "On the Girth of Quasi-Cyclic Photographs LDPC Codes" in Taylors & Francis Group IJE, May 2015.
22. Mehdi Karimi and Amir H. Banihashemi "Counting short cycles of Quasi cyclic protograph LDPC codes" in IEEE Communication Letters, Vol. 16, No. 3, March 2012.
23. Lingjun Kong, Yang Xiao"A new algorithm of counting the no. of small stopping sets and girth in QC-LDPC codes" in ICSP Proceedings, 2008.
24. Sarah J. Johnson and Steven R. Weller "Construction of Low Density Parity check codes from Kirkman Triple system" in IEEE Trans. on information theory, Vol. 11, No. 15, Jan 2001.

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