D85130210421

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International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075, Volume-10 Issue-4, February 2021

Even-odd Harmonious Labeling of Some Graphs

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Abstract: *Let $G = (V,E)$ be a graph, with $m = |V(G)|$ and $n = |E(G)|$. An injective mapping $f: V(G) \rightarrow \{1,3,5,\dots,2m-1\}$ is called an even-odd harmonious labeling of the graph G, if $\exists$ an induced edge mapping $f^*: E(G) \rightarrow \{0,2,4,\dots,2(n-1)\}$ such that (i) f^* is bijective mapping (ii) $f^*(e = pq) = (f(p) + f(q))(mod\ 2n)$. The graph acquired from this labeling is called even-odd harmonious graph. In this paper, we discovered some interesting results like H-graph, comb graph, bistar graph and $< k_{1,n}^{(1)}, k_{1,n}^{(2)}, k_{1,n}^{(3)} >$ graph for even-odd harmonious labeling.*

***Keywords**: Comb graph, Even-odd harmonious labeling, H-graph, Injective mapping*

I. INTRODUCTION

Graph labeling is an engrossing and sizable research in the arena of graph theory. It trades in how vertices and edges of a graph are labelled corresponding to certain mathematical condition[1]. From Galian[5], the neoteric research development in the sphere of graph labeling is taken. The pioneer of graph labeling was A. Rosa[10]. Books of Harary[2] and D.B.west[8] are being used for the ideas and basic knowledge. The harmonius graph have instigated [3] in 1980. Z.liang etl[8] set forth the odd harmonious graphs in 2009 and in 2011 P.B.sarasijia etal [10] investigated the even harmonious graphs. Further Adalin Beatress and Sarasijia in [2] set forth the even odd harmonious graphs. We have manifested distinct graphs, as we have collected distinct types of graphs in forms of even - odd harmonious labeling.

II. BASIC TERMINOLOGY

Definition([6]) 2.1: A graph $G = (V(G), E(G))$ with n edges is called a harmonious, if there is an injective function $f: V(G) \rightarrow Z_n$ such that when each edge uv is alloted the label $\{f(u) + f(v)\}(mod\ n)$, the resulting edge labels are different. When the graph G is tree, exactly one edge label may be used on two vertices.

Definition([7]) 2.2: Let G = (V,E) be a graph, with $m = |V(G)|\ and\ n = |E(G)|$. $f: V(G) \rightarrow \{1,3,5,\dots,2m-1\}$ is said to be an even-odd harmonious labeling of the graph G if $\exists$ an induced edge mapping $f^*: E(G) \rightarrow \{0,2,4,\dots,2(n-1)\}$ such that (i) f^* is bijective mapping (ii) $f^*(e = pq) = (f(p) + f(q))(mod\ 2n)$. The graph acquired from this labeling is called even-odd harmonious graph.

Definition([8]) 2.3: The H-graph of a path P_m is the graph secured from two copies of path P_m with vertices $u_1, u_2, u_3, \dots, u_m$ and $v_1, v_2, v_3, \dots, v_m$ by attaching the vertices $u_{\frac{m+1}{2}}$ and $v_{\frac{m+1}{2}}$ if m is odd and the vertices $u_{\frac{m}{2}+1}$ and $v_{\frac{m}{2}}$ if m is even.

Definition([8]) 2.4: A comb graph is a graph obtained by attaching a single pendent edge to each vertex of a path. The comb graph is defined as $P_m \odot K_1$. Where $P_m = \{v_1, \dots, v_m\}$ be the path **with** m vertices which contains $2m$ vertices and $2m-1$ edges.

Definition([9]) 2.5: The bistar graph $B_{m,n}$ is a graph acquired from a path P_2 by attaching the root of stars S_m and S_n at the terminal vertices of P_2, the bistar graph is denoted by $B_{m,n}$.

Remark: In this paper, we use "EOHL" instead of "even-odd harmonious labeling", for the simplicity.

III. EVEN-ODD HARMONIOUS LABELING OF ACYCLIC GRAPH

Theorem 3.1: The H-graph of path P_n is an even-odd harmonious graph.

Proof: Let $G = H_n$ be the H -graph. Let $u_1, u_2, \dots, u_n, v_1, v_2, \dots, v_n$ be the vertices of graph G and

$$E(H_n) = \{u_i u_{i+1}, v_i v_{i+1} \mid i = 1,2,\dots,n-1\} \cup \{u_{\frac{n+1}{2}} v_{\frac{n+1}{2}} \text{ if } n \equiv 1(mod\ 2)\} (\text{or}) \cup \{u_{\frac{n}{2}+1} v_{\frac{n}{2}} \text{ if } n \equiv 0(mod\ 2)\}$$

Note that, $p = |V(G)| = 2n$ and $q = |E(G)| = 2n-1$.

Define an injective function $f: V(G) \longrightarrow \{1,3,5,\dots,4n-1\}$ such that

Case-1: - When $n \equiv 1(mod\ 2)$

$$f(u_i) = \begin{cases} i & ; i \equiv 1(mod\ 2) \\ 2n+i-1 ; & i \equiv 0(mod\ 2) \end{cases} \quad \text{and}$$

$$f(v_i) = \begin{cases} 3n+i-1 & ; i \equiv 1(mod\ 2) \\ n+i & ; i \equiv 0(mod\ 2) \end{cases}$$

Case-2: - When $n \equiv 0(mod\ 2)$

$$f(u_i) = \begin{cases} i & ; i \equiv 1(mod\ 2) \\ 2n+i-1 ; & i \equiv 0(mod\ 2) \end{cases} \quad \text{and}$$

$$f(v_i) = \begin{cases} 2n-i & ; i \equiv 1(mod\ 2) \\ 4n-i+1 & ; i \equiv 0(mod\ 2) \end{cases}$$

and an induced edge function $f^*: E(G) \longrightarrow \{0,2,4,\dots,4n-4\}$ such that

Case-1: - When $n \equiv 1(mod\ 2)$

$f^*(e_i) = f^*(u_i u_{i+1}) = (2n+2i)(mod\ 2q), 1 \le i \le n-1$

$f^*(e_j) = f^*(v_j v_{j+1}) = 2(2n+i)(mod\ 2q), 1 \le j \le n-1$

and

$$f^*(e') = f^*\left(u_{\frac{n+1}{2}} v_{\frac{n+1}{2}}\right) = (2q+2)(mod\ 2q).$$

Manuscript received on February 01, 2021.
Revised Manuscript received on February 13, 2021.
Manuscript published on February 28, 2021.

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Case-2: - When $n \equiv 0(mod\ 2)$

$f^*(e_i) = f^*(u_iu_{i+1}) = (2n + 2i)(mod\ 2q), 1 \le i \le n-1$

$f^*(e_j) = f^*(v_jv_{j+1}) = (5n - 2(i-1) + 4)(mod\ 2q),$

$1 \le j \le n-1$ and

$f^*(e') = f^*\left(u_{\frac{n}{2}+1} v_{\frac{n}{2}}\right) = (2q + 2)(mod\ 2q).$

The above labeling pattern give rise EOHL to the graph G, as f is an injective mapping and f^* is one-one and onto. Thus, the H-graph is even-odd harmonious graph.

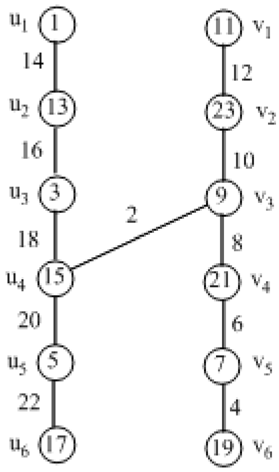

Fig.1 EOHL of H_6

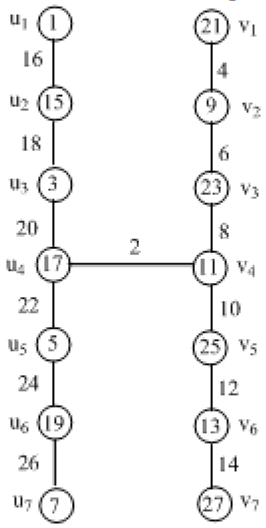

Fig.2 EOHL of H_7

Theorem 3.2: The comb graph C_{bn} is an even-odd harmonious graph, when $n \equiv 1(mod\ 2)$.

Proof: Let $G = C_{bn}$ be a comb graph, where $n \equiv 1(mod\ 2)$. Let $u_1, u_2, \ldots, u_n, v_1, v_2, \ldots, v_n$ be the vertices of the graph G.

Also, $E(G) = \{ u_iv_i | i = 1,2, \ldots, n \} \cup \{ u_iu_{i+1} \mid i = 1,2, \ldots, n-1 \}$.

Here, $p = |V(G)| = 2n$ and $q = |E(G)| = 2n - 1$.

Define an injective function $f: V(G) \longrightarrow \{1, 3, 5, \ldots, 4n - 1\}$ by

$f(u_i) = \begin{cases} i & ; i \equiv 1(mod\ 2) \\ n + i & ; i \equiv 0(mod\ 2) \end{cases}$ and

$f(v_i) = \begin{cases} 3n + i - 1 & ; i \equiv 1(mod\ 2) \\ 2n + i - 1 & ; i \equiv 0(mod\ 2) \end{cases}$

and the corresponding induced edge function $f^*: E(G) \longrightarrow \{0, 2, 4, \ldots, 4n - 4\}$ by

$f^*(u_iu_{i+1}) = (n + 2i + 1)(mod\ 2q), 1 \le i \le n - 1$

$f^*(u_iv_i) = (5n + 2i - 1)(mod\ 2q), 1 \le i \le n - 1$

therefore, the function f^* is bijective. Thus, the graph $G = C_{bn}(n \equiv 1(mod\ 2))$ admits an EOHL and hence it is an even-odd harmonious graph.

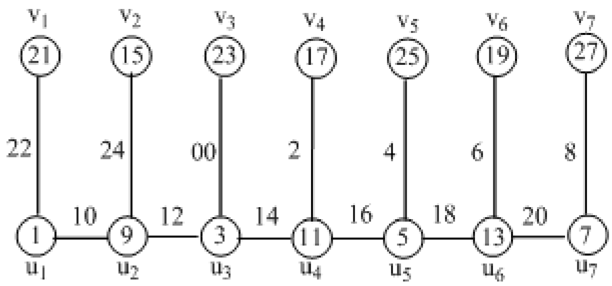

Fig.3 EOHL of comb graph C_{b7}

Theorem 3.3: The bistar graph $B_{m,n}$ is an even-odd harmonious graph.

Proof: Let $G = B_{m,n}$ be a bistar graph.

We know that, in bistar graph, $p = |V(G)| = m + n + 2$ and $q = |E(G)| = m + n + 1$.

Let $u_1, u_2, \ldots, u_m, v_1, v_2, \ldots, v_n$ be the vertices of the graph G.

Also,

$E(G) = \{ uu_i \mid 1 \le i \le m \} \cup \{ uv \} \cup \{ vv_j \mid 1 \le j \le n \}$.

Now, an injective function $f: V(G) \longrightarrow \{ 1, 3, 5, \ldots, 2m + 2n - 3 \}$ is defined as follows:

$f(u) = 1, \qquad f(v) = 2p - 1$

$f(u_i) = 2i + 1, 1 \le i \le m$

$f(v_j) = 2m + 2j + 1, 1 \le j \le n$

and the corresponding edge labeling function $f^*: E(G) \longrightarrow \{ 0, 2, 4, \ldots, 2m + 2n \}$ is defined as follows:

$f^*(e) = f^*(uv) = 2q + 2(mod\ 2q)$

$f^*(e_i) = f^*(uu_i) = 2(i + 1)(mod\ 2q), i \in \{1, 2, \ldots, m\}$

$f^*(e_j') = f^*(vv_j) = m + n + 2j(mod\ 2q), j \in \{1, 2, \ldots, n\}$

The above labeling pattern give rise EOHL to the graph $B_{m,n}$, as f is an injective mapping and f^* is one-one and onto function. Thus, the bistar graph $B_{m,n}$ is an even-odd harmonious graph.

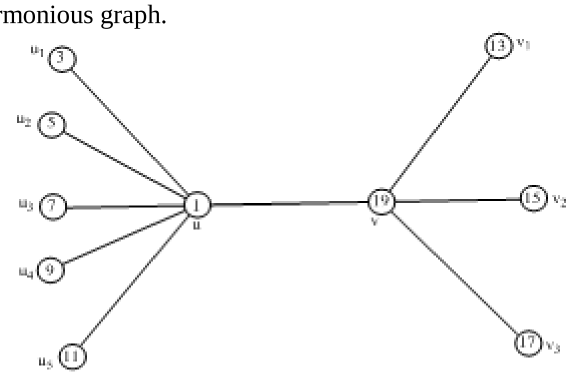

Fig.4 EOHL of the bistar graph $B_{5,3}$

Theorem 3.4: The graph $< k_{1,n}^{(1)}, k_{1,n}^{(2)}, k_{1,n}^{(3)} >$ is an even odd harmonious graph.

Proof: Let $G =< k_{1,n}^{(1)}, k_{1,n}^{(2)}, k_{1,n}^{(3)} >$. Let u_i be the apex vertex of $k_{1,n}^{(i)}$; $1 \le i \le 3$ and $v_1^{(i)}, v_2^{(i)}, \ldots, v_n^{(i)}$ be the pendent vertices of $k_{1,n}^{(i)}$ for $1 \le i \le 3$.

Retrieval Number: 100.1/ijitee.D85130210421
DOI: 10.35940/ijitee.D8513.0210421

Published By:
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Here, apex vertices u_1 and u_2 are adjacent to the vertex w_1, u_1 and u_3 are adjacent to the vertex w_2.
So $p = |V(G)| = 3n + 5$ and $q = |E(G)| = 3n + 4$
Define an injective function $f : V(G) \rightarrow \{1,3,5,\dots,3(2n+3)\}$ such that
$f(u_i) = 2i - 1; i = 1,2,3$
$f(w_i) = 2i + 2^i n + 5; i = 1,2$
$f\left(v_j^{(i)}\right) = (2i + 3) + 2n(i - 2) + 2j; j = 1,2,\dots,n; i = 1,2,3$
and the corresponding edge labeling function is defined as follows:
$f^*(u_i w_j) = 2j + 5 + 2^j n + (2i - 1)(mod 2q)$; where $1 \le i \le 3, j = 1,2$
$f^*\left(u_i v_j^{(i)}\right) = 2(2i + 1) + 2n(i - 2) + 2j(mod\ 2q)$; where $1 \le i \le 3, 1 \le j \le n$
Hence f^* is bijective. Thus, the graph $G = < k_{1,n}^{(1)}, k_{1,n}^{(2)}, k_{1,n}^{(3)} >$ admits an EOHL, hence the graph $< k_{1,n}^{(1)}, k_{1,n}^{(2)}, k_{1,n}^{(3)} >$ is an even odd harmonious graph.

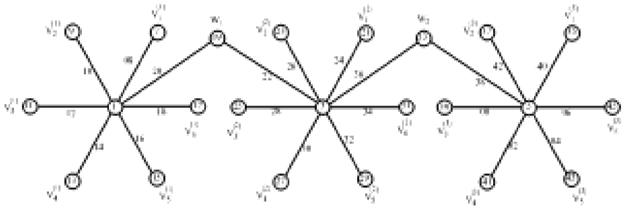

Fig.5 EOHL of $< k_{1,6}^{(1)}, k_{1,6}^{(2)}, k_{1,6}^{(3)} >$

IV. CONCLUSION

In this paper we investigated some bunch of graphs of acyclic graphs such as H-graph, comb graph, bistar graph and the graph $< k_{1,n}^{(1)}, k_{1,n}^{(2)}, k_{1,n}^{(3)} >$ which all are even-odd harmonious labeling. Also, we have proved that, comb graph C_{bn} is an even-odd harmonious graph, when n is even.

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