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SD-Prime Cordial Labeling of Subdivision of Snake Graphs

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ABSTRACT:

Let $f : V(G) \rightarrow \{1,2, \ldots ,|V(G)|\}$ be a bijection, and let us denote $S = f(u) + f(v)$ and $D = |f(u) - f(v)|$ for every edge uv in $E(G)$. Let f' be the induced edge labeling, induced by the vertex labeling f, defined as $f' : E(G) \rightarrow \{0,1\}$ such that for any edge uv in $E(G)$, $f'(uv) = 1$ if $gcd(S, D) = 1$, and $f'(uv) = 0$ otherwise. Let $e_{f'}(0)$ and $e_{f'}(1)$ be the number of edges labeled with 0 and 1 respectively. Then f is said to be SD-prime cordial labeling if $|e_{f'}(0) - e_{f'}(1)| \leq 1$ and G is said to be SD-prime cordial graph if it admits SD-prime cordial labeling. In this paper, we investigate the SD-prime cordial labeling behaviour of subdivision of some snake graphs, namely subdivision of: triangular snake, alternate triangular snake, quadrilateral snake, alternate quadrilateral snake.

AMS Subject Classification (2010): 05C78.

KEYWORDS: SD-prime cordial graph, triangular snake, subdivision of alternate triangular snake, subdivision of quadrilateral snake, subdivision of alternate quadrilateral snake.

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INTRODUCTION:

Let $G = (V(G), E(G))$ be a simple, finite and undirected graph of order $|V(G)| = p$ and size $|E(G)| = q$. For standard terminology of Graph Theory, we used[1]. For all detailed survey of graph labeling we refer[2]. Lau, Chu, Suhadak, Foo, and Ng[3] have introduced SD-prime cordial labeling and they proved behaviour of several graphs like path, complete bipartite graph, star, double star, wheel, fan, double fan and ladder. Lourdusamy and Patrick[4] proved that $S'(K_{1,n})$, $D_2(K_{1,n})$, $S(K_{1,n})$, $DS(K_{1,n})$, $S'(B_{n,n})$, $D_2(B_{n,n})$, TL_n, $DS(B_{n,n})$, $S(B_{n,n})$, $K_{1,3} \star K_{1,n}$, CH_n, Fl_n, P_n^2, $T(P_n)$, $T(C_n), Q_n, A(T_n), J_n, P_n \odot K_1$and $C_n \odot K_1$the graph obtained by duplication of each vertex of path and cycle by an edge are SD-prime cordial. Lourdusamy, Wency and Patrick[5] proved that the union of star and path graphs, subdivision of comb graph, subdivision of ladder graph and the graph obtained by attaching star graph at one end of the path are SD-prime cordial graphs. They proved that the union of two SD-prime cordial graphs need not be SD-prime cordial graph. Also, they proved that given a positive integer n, there is SD-prime cordial graph G with n vertices. Prajapati and Vantiya[6] proved that $T_n (n \neq 3), A(T_n), Q_n, A(Q_n), DT_n, DA(T_n), DQ_n$ and $DA(Q_n)$ are SD-prime cordial.

Definition 1: If the vertices or edges or both of a graph are assigned values subject to certain conditions then it is known as *vertex or edge or total labeling* respectively.

Definition 2: [3] A bijection $f: V(G) \rightarrow \{1, 2, \dots, |V(G)|\}$ induces an edge labeling $f': E(G) \rightarrow \{0, 1\}$ such that for any edge uv in G, $f'(uv) = 1$ if $gcd(S, D) = 1$, and $f'(uv) = 0$ otherwise, where $S = f(u) + f(v)$ and $D = |f(u) - f(v)|$ for every edge uv in $E(G)$. The labeling f is called SD-prime cordial labeling if $|e_{f'}(0) - e'_f(1)| \leq 1$. G is called SD-prime cordial graph if it admits SD-prime cordial labeling.

Definition 3: [1] The *subdivision graph*$S(G)$ is obtained from G by subdividing each edge of G by a vertex.

Definition 4: [2] A *triangular snake*T_n is obtained from the path P_n by replacing every edge of a path by a triangle C_3. That is, it is obtained from a path $u_1, u_2, \dots, u_n$ by joining u_i and u_{i+1} to a new vertex w_i for $i = 1, 2, \dots, n-1$.

Definition 5: [2] An *alternate triangular snake*$A(T_n)$ is obtained from the path P_n by replacing every alternate edge of a path by a triangle C_3. That is, it is obtained from a path $u_1, u_2, \dots, u_n$ by joining u_i and u_{i+1} (alternately) to a new vertex w_i for $i = 1, 2, \dots, n-1$.

Definition 6: [2] An *alternate quadrilateral snake* $A(Q_n)$ is obtained from the path $P_n = u_1, u_2, \dots, u_n$ by replacing every alternate edge of a path by a cycle C_4, in such a way that each pair of vertices (u_i, u_{i+1}) remains adjacent. That is, it is obtained from a path $P_n = u_1, u_2, \dots, u_n$ by joining u_i and u_{i+1} (alternately) to new vertices v_i and w_i respectively, and then joining v_i and w_i by an edge, for $i = 1, 2, \dots, n-1$.

Notation: Throughout this paper, a path $P_n = u_1, u_2, \dots, u_n$, where $n > 1$.

MAIN RESULTS:

Theorem 1: The graph $S(T_n)$ is SD-prime cordial.

Proof: Let $V(S(T_n)) = V(P_n) \cup \{u_i', w_i, w_i', w_i'' : 1 \le i \le n-1\}$ and

$E(S(T_n)) = \{u_i u_i', u_i' u_{i+1}, u_i w_i', w_i' w_i, w_i w_i'', w_i'' u_{i+1} : 1 \le i \le n-1\}$. Therefore, $S(T_n)$ is of order $5n-4$ and size $6n-6$.

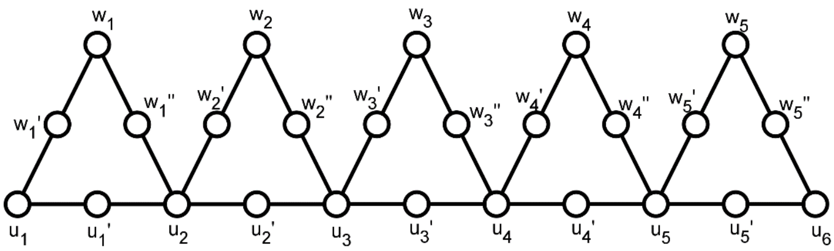

Figure 1: $S(T_6)$

Define $f: V(S(T_n)) \to \{1, 2, \dots, 5n-4\}$ as follows:

$$f(u_i) = 5i - 4 \quad if\ 1 \le i \le n;$$

$$f(u_i') = \begin{cases} 5i & if\ i \not\equiv 0 (mod\ 3), 1 \le i \le n-1; \\ 5i - 1 & if\ i \equiv 0 (mod\ 3), 1 \le i \le n-1; \end{cases}$$

$$f(w_i) = \begin{cases} 5i - 3 & if\ i \not\equiv 0 (mod\ 3), 1 \le i \le n-1; \\ 5i & if\ i \equiv 0 (mod\ 3), 1 \le i \le n-1; \end{cases}$$

$$f(w_i') = \begin{cases} 5i - 1 & if\ i \not\equiv 0 (mod\ 3), 1 \le i \le n-1; \\ 5i - 3 & if\ i \equiv 0 (mod\ 3), 1 \le i \le n-1; \end{cases}$$

$$f(w_i'') = 5i - 2 \quad if\ 1 \le i \le n-1.$$

Therefore, $e_{f'}(0) = e_{f'}(1) = 3n - 3$.

Thus $|e_{f'}(0) - e_{f'}(1)| \le 1$. Hence $S(T_n)$ is SD-prime cordial.

Theorem 2: The graph $S(A(T_n))$ is SD-prime cordial.

Proof:

Case-1: Let the first triangle C_3 be starts from u_1 and the last triangle be ends at u_n:

In this case, n will be an even number.

Let $V\left(S\left(A(T_n)\right)\right) = V(P_n) \cup \{u_i': 1 \leq i \leq n-1\} \cup \{w_i, w_i', w_i'': i\ is\ odd\ and\ 1 \leq i \leq n-1\}$ and $E\left(S\left(A(T_n)\right)\right) = \{u_i u_i', u_i' u_{i+1}: 1 \leq i \leq n-1\} \cup \{u_i w_i', w_i' w_i, w_i w_i'', w_i'' u_{i+1}: i\ is\ odd\ and\ 1 \leq i \leq n-1\}$. Therefore, in this case, $S\left(A(T_n)\right)$ is of order $\frac{7n-2}{2}$ and size $4n-2$.

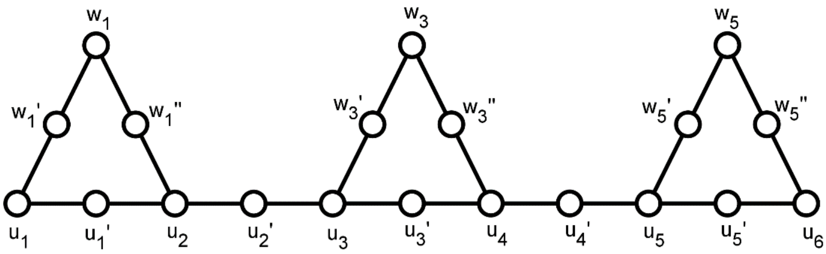

Figure 2: $S(A(T_6))$

Define $f: V\left(S\left(A(T_n)\right)\right) \rightarrow \left\{1, 2, \ldots, \frac{7n-2}{2}\right\}$ as follows:

$$f(u_i) = \frac{14i - 9 + (-1)^i}{4} \quad if\ 1 \leq i \leq n;$$

$$f(u_i') = \frac{14i - 3 + 3(-1)^i}{4} \quad if\ 1 \leq i \leq n-1;$$

$$f(w_i) = \frac{7i + 5}{2} \quad if\ i\ is\ odd\ and\ 1 \leq i \leq n-1;$$

$$f(w_i') = \frac{7i + 1}{2} \quad if\ i\ is\ odd\ and\ 1 \leq i \leq n-1;$$

$$f(w_i'') = \frac{7i - 1}{2} \quad if\ i\ is\ odd\ and\ 1 \leq i \leq n-1.$$

Therefore, if $e_{f'}(0) = e_{f'}(1) = 2n - 1$.

Case-2: Let the first triangle C_3 be starts from u_1 and the last triangle be ends at u_{n-1}.

In this case, n will be an odd number. Let $n > 1$. Define $V\left(S\left(A(T_n)\right)\right)$ and $E\left(S\left(A(T_n)\right)\right)$ as per Case-1. Therefore, in this case, $S\left(A(T_n)\right)$ is of order $\frac{7n-5}{2}$ and size $4n-4$.

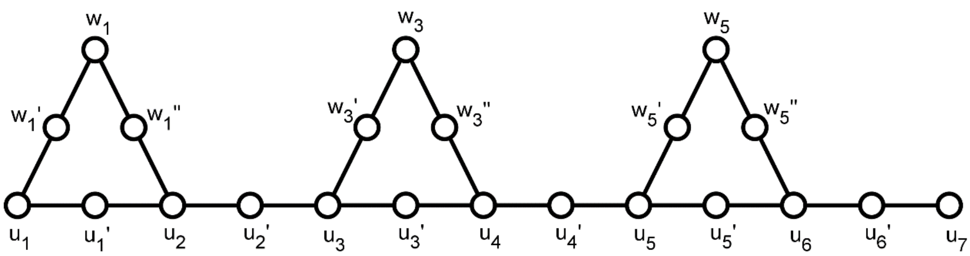

Figure 3: $S(A(T_7))$

Define $f: V\left(S\left(A(T_n)\right)\right) \rightarrow \left\{1, 2, \ldots, \frac{7n-5}{2}\right\}$ as per the case-1.

Therefore, $e_{f'}(0) = e_{f'}(1) = 2n - 2$.

Remark: Note that, the graphs of case-2 and case-3 are isomorphic graphs, so it is enough to prove that any one of these two graphs is SD-prime cordial. But here we have given separate labelings for both the cases.

Case-3: Let the first triangle C_3 be starts from u_2 and the last triangle be ends at u_n.

In this case, n will be an odd number. Let $n > 2$.

Let $V\left(S\big(A(T_n)\big)\right) = V(P_n) \cup \{u_i' : 1 \le i \le n-1\} \cup \{w_i, w_i', w_i'' : i \text{ is even and } 1 \le i \le n-1\}$ and $E\left(S\big(A(T_n)\big)\right) = \{u_iu_i', u_i'u_{i+1} : 1 \le i \le n-1\} \cup \{u_iw_i', w_i'w_i, w_iw_i'', w_i''u_{i+1} : i \text{ is even and } 1 \le i \le n-1\}$. Therefore, in this case, $S\big(A(T_n)\big)$ is of order $\frac{7n-5}{2}$ and size $4n-4$.

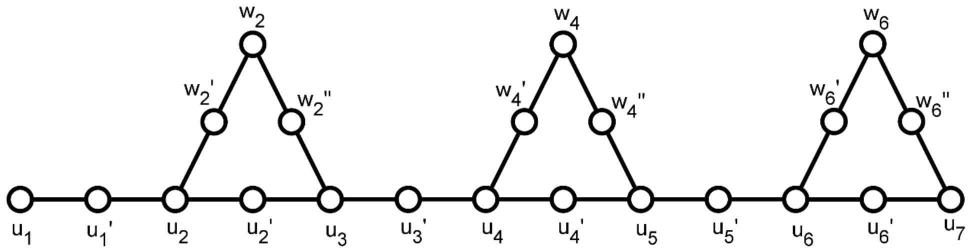

Figure 4: $S\big(A(T_7)\big)$

Define $f: V\left(S\big(A(T_n)\big)\right) \to \left\{1, 2, \dots, \frac{7n-5}{2}\right\}$ as follows:

$$f(u_1) = 2, f(u_1') = 1,$$

$$f(u_i) = \frac{14i - 15 - (-1)^i}{4} \quad if\ 2 \le i \le n;$$

$$f(u_i') = \frac{14i - 9 - 3(-1)^i}{4} \quad if\ 2 \le i \le n-1;$$

$$f(w_i) = \frac{7i+2}{2} \quad if\ i\ is\ even\ and\ 1 \le i \le n-1;$$

$$f(w_i') = \frac{7i-2}{2} \quad if\ i\ is\ even\ and\ 1 \le i \le n-1;$$

$$f(w_i'') = \frac{7i-4}{2} \quad if\ i\ is\ even\ and\ 1 \le i \le n-1.$$

Therefore, $e_{f'}(0) = e_{f'}(1) = 2n-2$.

Case-4: Let the first triangle C_3 be starts from u_2 and the last triangle be ends at u_{n-1}.

In this case, n will be an even number. Let $n > 2$. Define $V\left(S\big(A(T_n)\big)\right)$ and $E\left(S\big(A(T_n)\big)\right)$ as per Case-3. Therefore, in this case, $S\big(A(T_n)\big)$ is of order $\frac{7n-8}{2}$ and size $4n-6$.

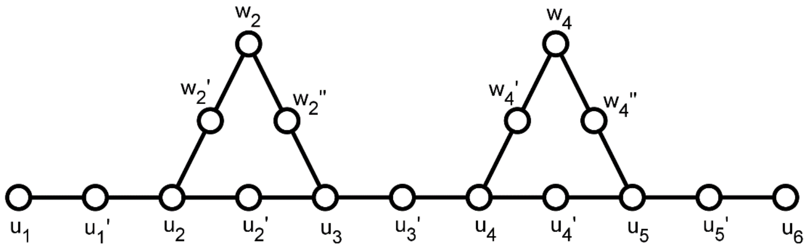

Figure 5: $S(A(T_6))$

Define $f: V\left(S(A(T_n))\right) \rightarrow \left\{1, 2, \dots, \frac{7n-8}{2}\right\}$ as per the Case-3.

Therefore, $e_{f'}(0) = e_{f'}(1) = 2n - 3$.

Thus in all cases $|e_{f'}(0) - e_{f'}(1)| \leq 1$. Hence $S(A(T_n))$ is SD-prime cordial.

Theorem 3: The graph $S(Q_n)$ is SD-prime cordial.

Proof: Let $V(S(Q_n)) = V(P_n) \cup \{u_i', w_i, v_i, w_i', v_i', w_i'': 1 \leq i \leq n-1\}$ and $E(S(Q_n)) = \{u_iu_i', u_i'u_{i+1}, u_iv_i', v_i'v_i, v_iw_i'', w_i''w_i, w_iw_i', w_i'u_{i+1}: 1 \leq i \leq n-1\}$. Therefore, $S(Q_n)$ is of order $7n - 6$ and size $8n - 8$.

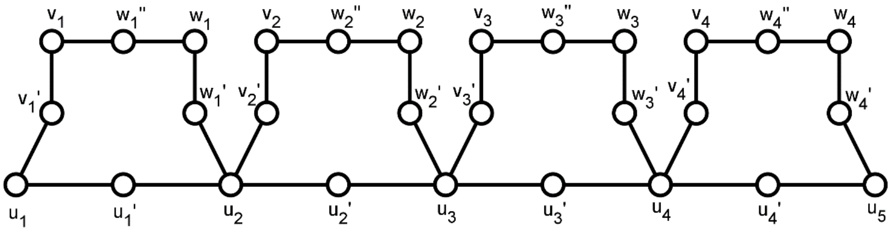

Figure 6: $S(Q_5)$

Define $f: V(S(Q_n)) \rightarrow \{1, 2, \dots, 7n - 6\}$ as follows:

$$f(u_i) = 7i - 6 \quad if\ 1 \leq i \leq n;$$
$$f(u_i') = 7i \quad if\ 1 \leq i \leq n-1;$$
$$f(v_i) = 7i - 5 \quad if\ 1 \leq i \leq n-1;$$
$$f(w_i) = 7i - 2 \quad if\ 1 \leq i \leq n-1;$$
$$f(v_i') = 7i - 4 \quad if\ 1 \leq i \leq n-1;$$
$$f(w_i') = 7i - 1 \quad if\ 1 \leq i \leq n-1;$$
$$f(w_i'') = 7i - 3 \quad if\ 1 \leq i \leq n-1.$$

Therefore, $e_{f'}(0) = e_{f'}(1) = 4n - 4$.

Thus $|e_{f'}(0) - e_{f'}(1)| \leq 1$. Hence $S(Q_n)$ is SD-prime cordial.

Theorem 4: The graph $S(A(Q_n))$ is SD-prime cordial.

Proof: Case-1: Let the first cycle C_4 be starts from u_1 and the last cycle C_4 be ends at u_n.

In this case, n will be an even number.

Let $V\left(S\left(A(Q_n)\right)\right) = V(P_n) \cup \{u_i' : 1 \le i \le n-1\} \cup \{w_i, v_i, w_i', v_i', w_i'' : i \text{ is odd and } 1 \le i \le n-1\}$ and $E\left(S\left(A(Q_n)\right)\right) = \{u_i u_i', u_i' u_{i+1} : 1 \le i \le n-1\} \cup \{u_i v_i', v_i' v_i, v_i w_i'', w_i'' w_i, w_i w_i', w_i' u_{i+1} : i \text{ is odd and } 1 \le i \le n-1\}$. Therefore, in this case, $S\left(A(Q_n)\right)$ is of order $\frac{9n-2}{2}$ and size $5n-2$.

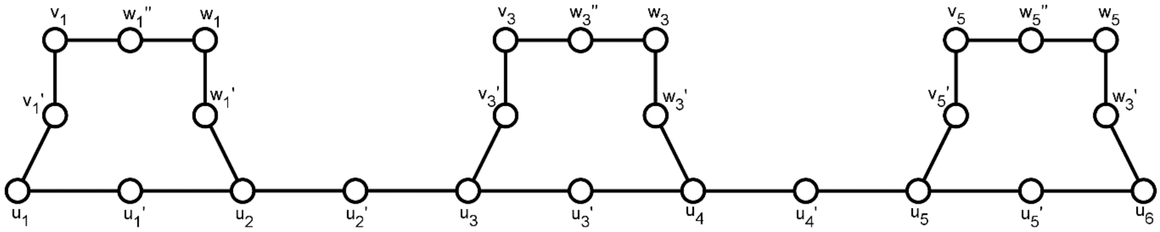

Figure 7: $S\left(A(Q_6)\right)$ *: Case – 1*

Define $f: V\left(S\left(A(Q_n)\right)\right) \to \left\{1, 2, \ldots, \frac{9n-2}{2}\right\}$ as follows:

$$f(u_i) = \begin{cases} \dfrac{18i - 9 + 5(-1)^i}{4} & \text{if } i \equiv 1 (mod\ 4) \text{ or } i \equiv 2 (mod\ 4) \text{ and } 1 \le i \le n; \\ \dfrac{18i - 13 + 5(-1)^i}{4} & \text{if } i \equiv 3 (mod\ 4) \text{ or } i \equiv 0 (mod\ 4) \text{ and } 1 \le i \le n; \end{cases}$$

$$f(u_i') = \begin{cases} \dfrac{18i + 7 - 3(-1)^i}{4} & \text{if } i \equiv 1 (mod\ 4) \text{ or } i \equiv 2 (mod\ 4) \text{ and } 1 \le i \le n-1; \\ \dfrac{18i + 7 - 7(-1)^i}{4} & \text{if } i \equiv 3 (mod\ 4) \text{ or } i \equiv 0 (mod\ 4) \text{ and } 1 \le i \le n-1; \end{cases}$$

$$f(v_i) = \begin{cases} \dfrac{9i - 5}{2} & \text{if } i \equiv 1 (mod\ 4) \text{ and } 1 \le i \le n-1; \\ \dfrac{9i - 3}{2} & \text{if } i \equiv 3 (mod\ 4) \text{ and } 1 \le i \le n-1; \end{cases}$$

$$f(w_i) = \begin{cases} \dfrac{9i + 1}{2} & \text{if } i \equiv 1 (mod\ 4) \text{ and } 1 \le i \le n-1; \\ \dfrac{9i - 1}{2} & \text{if } i \equiv 3 (mod\ 4) \text{ and } 1 \le i \le n-1; \end{cases}$$

$$f(v_i') = \begin{cases} \dfrac{9i - 3}{2} & \text{if } i \equiv 1 (mod\ 4) \text{ and } 1 \le i \le n-1; \\ \dfrac{9i - 5}{2} & \text{if } i \equiv 3 (mod\ 4) \text{ and } 1 \le i \le n-1; \end{cases}$$

$$f(w_i') = \frac{9i + 3}{2} \quad \text{if } i \text{ is odd and } 1 \le i \le n-1;$$

$$f(w_i'') = \begin{cases} \dfrac{9i - 1}{2} & \text{if } i \equiv 1 (mod\ 4) \text{ and } 1 \le i \le n-1; \\ \dfrac{9i + 1}{2} & \text{if } i \equiv 3 (mod\ 4) \text{ and } 1 \le i \le n-1. \end{cases}$$

Therefore, $e_{f'}(0) = e_{f'}(1) = \frac{5n-2}{2}$.

Case-2: Let the first cycle C_4 be starts from u_1 and the last cycle C_4 be ends at u_{n-1}.

In this case, n will be an odd number. Let $n > 1$. Define $V\left(S\big(A(Q_n)\big)\right)$ and $E\left(S\big(A(Q_n)\big)\right)$ as per the Case-1. Therefore, in this case, $S\big(A(Q_n)\big)$ is of order $\frac{9n-7}{2}$ and size $5n-5$.

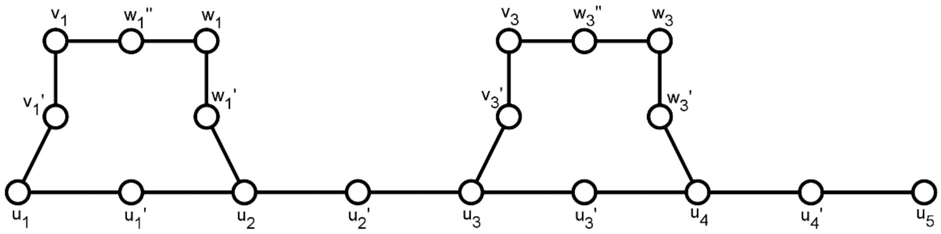

Figure 8: $S\big(A(Q_5)\big)$ *: Case − 2*

Define $f: V\left(S\big(A(Q_n)\big)\right) \rightarrow \left\{1, 2, \ldots, \frac{9n-7}{2}\right\}$ asper the case-1.

Therefore, $e_{f'}(0) = e_{f'}(1) = \frac{5n-5}{2}$.

Case-3: Let the first cycle C_4 be starts from u_2 and the last cycle C_4 be ends at u_n.

In this case, n will be an odd number. Let $n > 2$.

Let $V\left(S\big(A(Q_n)\big)\right) = V(P_n) \cup \{u_i': 1 \le i \le n-1\} \cup \{w_i, v_i, w_i', v_i', w_i'': i \text{ is even and } 1 \le i \le n-1\}$ and $E\left(S\big(A(Q_n)\big)\right) = \{u_i u_i', u_i' u_{i+1}: 1 \le i \le n-1\} \cup \{u_i v_i', v_i' v_i, v_i w_i'', w_i'' w_i, w_i w_i', w_i' u_{i+1}: i \text{ is even and } 1 \le i \le n-1\}$. Therefore, in this case, $S\big(A(Q_n)\big)$ is of order $\frac{9n-7}{2}$ and size $5n-5$.

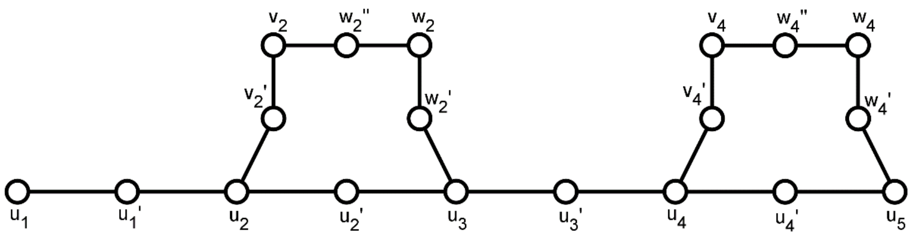

Figure 9: $S\big(A(Q_5)\big)$ *: Case − 3*

Define $f: V\left(S\big(A(Q_n)\big)\right) \rightarrow \left\{1, 2, \ldots, \frac{9n-7}{2}\right\}$ as follows:

$$f(u_i) = \begin{cases} \frac{18i-21-7(-1)^i}{4} & if\ i \equiv 1(mod\ 4)\ or\ i \equiv 2(mod\ 4)\ and\ 1 \le i \le n; \\ \frac{18i-21-3(-1)^i}{4} & if\ i \equiv 3(mod\ 4)\ or\ i \equiv 0(mod\ 4)\ and\ 1 \le i \le n; \end{cases}$$

$$f(u_i') = \begin{cases} \frac{18i-1+5(-1)^i}{4} & if\ i \equiv 1(mod\ 4)\ or\ i \equiv 2(mod\ 4)\ and\ 1 \le i \le n-1; \\ \frac{18i-17-7(-1)^i}{4} & if\ i \equiv 3(mod\ 4)\ or\ i \equiv 0(mod\ 4)\ and\ 1 \le i \le n-1; \end{cases}$$

$$f(v_i) = \begin{cases} \frac{9i-8}{2} & if\ i \equiv 2(mod\ 4)\ and\ 1 \le i \le n-1; \\ \frac{9i-10}{2} & if\ i \equiv 0(mod\ 4)\ and\ 1 \le i \le n-1; \end{cases}$$

$$f(w_i) = \begin{cases} \frac{9i-6}{2} & if\ i \equiv 2(mod\ 4)\ and\ 1 \le i \le n-1; \\ \frac{9i-4}{2} & if\ i \equiv 0(mod\ 4)\ and\ 1 \le i \le n-1; \end{cases}$$

$$f(v_i') = \begin{cases} \frac{9i-10}{2} & if\ i \equiv 2(mod\ 4)\ and\ 1 \le i \le n-1; \\ \frac{9i-8}{2} & if\ i \equiv 0(mod\ 4)\ and\ 1 \le i \le n-1; \end{cases}$$

$$f(w_i') = \frac{9i-2}{2} \quad if\ i\ is\ even\ and\ 1 \le i \le n-1;$$

$$f(w_i'') = \begin{cases} \frac{9i-4}{2} & if\ i \equiv 2(mod\ 4)\ and\ 1 \le i \le n-1; \\ \frac{9i-6}{2} & if\ i \equiv 0(mod\ 4)\ and\ 1 \le i \le n-1. \end{cases}$$

Therefore, $e_{f'}(0) = e_{f'}(1) = \frac{5n-5}{2}$.

Case-4: Let the first cycle C_4 be starts from u_2 and the last cycle C_4 be ends at u_{n-1}.

In this case, n will be an even number. Let $n > 2$. Define $V\left(S(A(Q_n))\right)$ and $E\left(S(A(Q_n))\right)$ as per the Case-3. Therefore, in this case, $S(A(Q_n))$ is of order $\frac{9n-12}{2}$ and size $5n-8$.

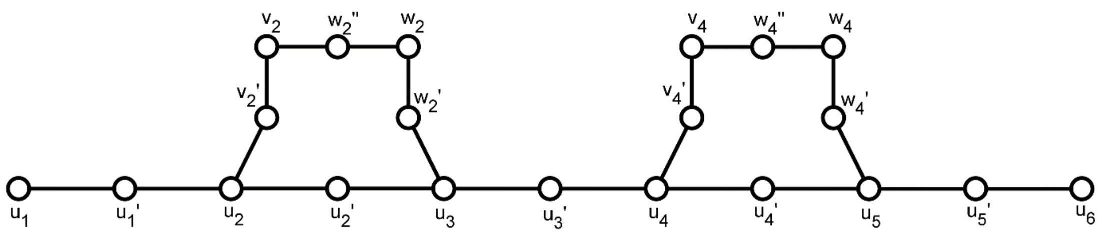

Figure 10: $S(A(Q_6))$ *: Case – 4*

Define $f: V\left(S(A(Q_n))\right) \to \left\{1, 2, \ldots, \frac{9n-12}{2}\right\}$ as per the Case-3.

Therefore, $e_{f'}(0) = e_{f'}(1) = \frac{5n-8}{2}$.

Thus in all cases $|e_{f'}(0) - e_{f'}(1)| \le 1$. Hence $S(A(Q_n))$ is SD-prime cordial.

CONCLUSION:

We have proved that the graphs $S(T_n)$, $S(A(T_n))$, $S(Q_n)$ and $S(A(Q_n))$are SD-prime cordial. Further investigation can be done for subdivision of other graph family.

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