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# LOCATING CONNECTED DOMINATION NUMBER ON SOME OPERATIONS OF GRAPHS

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**Abstract:** In the current era, domination plays a vital role in communication Networks, Security process, locating connected domination reduces the cost of the intender needed for security purpose and also invoke more connection between the circuits in the Network.

In this articles, the locating connected domination number is obtained for Cartesian product of the graphs $P_n \times K_r$ for n = 2,3,4. For the tensor product $P_n \otimes K_r$ of the path $P_n$ and complete graph $K_r$ the locating connected domination number is characterized for n = 3,4. Also the the locating connected domination number for the strong product of the two paths $P_n \boxtimes P_r$ for n = 2,3, and $P_n \boxtimes C_r$ for n =2,3. the locating connected domination number is obtained for Corona product of the graphs $C_n$ $K_r$ ∀ n.

***Keywords:*** Dominating set, locating dominating set, locating connected dominating set, Cartesian product of two graphs.

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## Introduction

A *graph* G = (*N*, *L*) is a combination of a set *N* of nodes and a set L of lines. That is, *L* is a set of unordered pairs {*n*, *l*} of distinct elements from *N*. The *order* and *size* of G is the number of nodes and lines respectively, denoted by *p* and *q*. If $l = n_i n_j \in L(G)$, then $n_i$ and $n_j$ are said to be *adjacent*. Nodes $n_i$ and $n_j$ are said to be *incident* with lines *l*. The *open neighborhood* A(n) of *n* is the set of nodes adjacent to a nodes n in a graph G. The open neighborhood of set *S* of nodes $S \subset N$ (G) is *A*(*S*) = $\bigcup_{n \in S} A(n)$. The closed neighborhood of a set of nodes $S \subset N(G)$ is $A[S] = A(S) \cup S$. The number of lines incident with n is the *degree* of a nodes *n*, denoted by deg(*n*). The minimum and maximum degrees of nodes in *N* (G) are denoted by $\delta(G)$ and $\Delta(G)$, respectively. If $\delta(G) = \Delta(G) = r$, then the graph G is *regular* of degree *r*, or *r - regular*.

A few different types of graphs considered in this article are as follows:

1. *Path* $P_p$ of order $p \geq 2$ has size $q = p - 1$, is connected
2. *Cycle* $C_p$ of order $p \geq 3$ has size $q = p$, is connected and 2 - regular.
3. *Complete graph* $K_p$ has the maximum possible lines $p(p-1)/2$.
4. The *Cartesian product* of two graphs G and *H* are denoted by G × *H* and is described as
    - *N* (G × *H*) = *N* (G) × *N* (*H*)

- Two nodes $(n, n')$ and $(l, l')$ are adjacent in $G \times H$ if and only if any one of the condition holds
- $n = l$ and $n'$ is adjacent to $l'$ in $H$, or
- $n' = l'$ and $n$ is adjacent to $l$ in G.

5. The tensor product is above the first condition hold and
   - Nodes $(n,l)$ and $(l',n')$ are adjacent in $G \times H$ if and only if
   - $n$ is adjacent to $n'$ in G and
   - $l$ is adjacent to $l'$ in $H$.
6. The strong product is above Cartesian product two condition hold and
   - $n$ is adjacent to l and $n'$ is adjacent to l'.
7. The corona graph $G_1 \odot G_2$ of two graphs $G_1$ (with $n_1$ nodes and $n_2$ lines) and $G_2$ (with $n_2$ nodes and $l_2$ lines) is defined as the graph obtained by taking one copy of $G_1$ and $n_1$ copies of $G_2$, and then joining the $i$th nodes of $G_1$ with an lines to every nodes in the $i$th copy of $G_2$.

The tensor product is also called direct product, Kronecker product, Cardinal product, weak direct product. It was introduced by Alfred North Whitehead [3] and Bertrand Russell in their principia Mathematica(1912). It is also equivalent to the Kronecker Product of the adjacency matrices of the graph[3]. The strong product was introduced by Sabidussi in 1960[2]. In that setting, the strong product is contrasted against a "weak" product but the two are different only when applied to infinitely many factors.

A subset S of N(G) is called

i) **Dominating set** if every node in N – S is adjacent to atleast one node in S.

ii) **Connected dominating set**, if the induced subgraph is connected.

iii) **Locating dominating set**, if for every pair of distinct nodes $n_1$ and $n_2$, $A(n_1) \cap S \neq A(n_2) \cap S$.

iv) **Locating connected dominating set**, if both the conditions (ii) and (iii) are satisfied.

The corresponding sets with minimum cardinality of (i), (iii) and (iv) are called $\gamma$ – set, $\gamma_L$ – set, $\gamma_{LCD}$ – set respectively.

A set S which is both connected and locating dominated is called **locating connected domination set** and the corresponding number is denoted by $\gamma_{LCD}(G)$.

## 1. Main Results

**Theorem:2.1**

The Locating connected domination number of the Cartesian product of two graphs $P_2$ and $K_r$ denoted by $P_2 \times K_r$ is given by $\gamma_{LCD}(P_2 \times K_r) = r$, $r \geq 2$.

**Proof:**

Let $K_r$ be the complete graph on r nodes with $N(K_r) = \{a_1', a_2', \ldots a_r'\}$
Take 2 copies of $K_r$ with node set $\{a_1, a_2, \ldots a_r, a_1', a_2', \ldots .a_r'\}$ to the form of the Cartesian product of $P_2$ and $K_r$ with

$G \cong P_2 \times K_r$.

Then the set $S = \{a_1', a_2', \ldots . a_r'\}$ will form a $\gamma_{LCD}$ – set of G.

Since S contains the nodes of the first copy of $K_r$, obviously S is connected.

**claim:** S will form locating dominating set $N - S = \{a_1, a_2, \ldots . a_r\}$

$A(a_i) \cap S = a_i' \ \forall \ i = 1,2, \ldots r$.

Which ensure that all nodes in N – S have distinct neighbours.

Thus S is a Locating dominating set. Again $< S > \cong K_r$, which implies is connected.

Also if any one node is removed from S, then S will no longer be a LCD – set.

Thus $\gamma_{LCD}(P_2 \times K_r) = |S| = r$.

**Illustration:2.2**

For the graph given in Figure 2.3, the $\gamma_{LCD}$ – set is encircled and $\gamma_{LCD}(P_2 \times K_6) \cong 6$.

**$(P_2 \times K_6) \cong$**

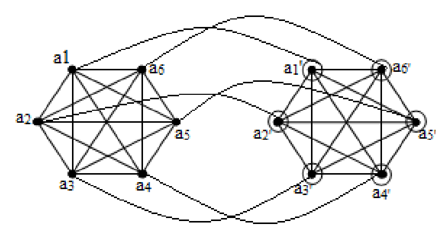


**Figure 2.3**
**$P_6 \times P_2$**

**Theorem:2.4**

The Locating connected domination number of the Cartesian product of two graphs $P_3$ and $K_r$ denoted by $P_3 \times K_r$ is given by $\gamma_{LCD}(P_3 \times K_r) = r + 1, r \geq 2$.

**Proof:**

Let $K_r$ be the complete graph on r nodes with $N(K_r) = \{a_1', a_2', \ldots a_r'\}$

Take 3 copies of $K_r$ with node set $\{a_1, a_2, \ldots a_r, a_1', a_2', \ldots .a_r', a_1'', a_2'', \ldots a_r''\}$ to the form of the Cartesian product of $P_2$ and $K_r$ with

$G \cong P_3 \times K_r$.

Then the set $S = \{a_1', a_2', \ldots . a_r', a_r''\}$ will form a $\gamma_{LCD}$ – set of G.

Since S contains all the nodes of the second copy exactly one node of the third copy of $K_r$, obviously S is connected.

**claim:** S will form locating dominating set $N - S = \{a_1, a_2, \ldots . a_r, a_1'', a_2'' \ldots a_{r-1}''\}$

$A(a_i) \cap S = a_i' \ \forall \ i = 1,2, \ldots r$.

$A(a_i'') \cap S = \{a_i'', a_r\} \ \forall \ i = 1,2, \ldots r$.

Which ensure that all nodes in N – S have distinct neighbours.
Thus S is a Locating dominating set. Again < S > ≅ $K_r$ +1, which implies is connected.

Also if any one node is removed from S, then S will no longer be a LCD – set.
Thus $\gamma_{LCD}(P_3 \times K_r) = |S| = r + 1$.

**Illustration:2.5**

For the graph given in Figure 2.6, the $\gamma_{LCD}$ – set is encircled and $\gamma_{LCD}(P_3 \times K_5) \cong 6$.

**$(P_3 \times K_5) \cong$**

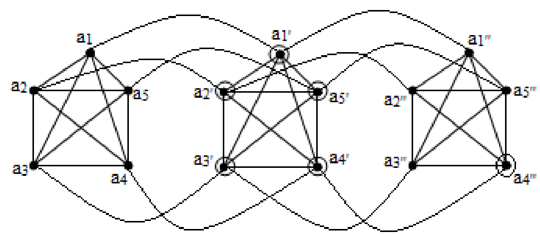


**Figure 2.6**
**$P_3 \times K_5$**

**Theorem:2.7**

The Locating connected domination number of the Cartesian product of two graphs $P_4$ and $K_r$ denoted by $P_4 \times K_r$ is given by $\gamma_{LCD}(P_4 \times K_r) = 2r$, $r \geq 2$.

**Proof:**

Let $K_r$ be the complete graph on r nodes with $N(K_r) = \{a_1', a_2', \ldots a_r'\}$
Take 4 copies of $K_r$ with node set
$N(P_4 \times K_r) = \{a_1, a_2, \ldots a_r, a_1', a_2', \ldots .a_r', a_1'', a_2'', \ldots a_r'', a_1''', a_2''', \ldots a_r'''\}$ to the form of the Cartesian product of $P_4$ and $K_r$ with

$$G \cong P_4 \times K_r.$$

Then the set $S = \{a_1', a_2', \ldots . a_r', a_1'', a_2'', \ldots a_r''\}$ will form a $\gamma_{LCD}$ – set of G.

Since S contains all the nodes of the first copy and second copy of $K_r$, obviously S is connected.

**claim:** S will form locating dominating set $N - S = \{a_1, a_2, \ldots . a_r, a_1''', a_2''' \ldots . a_{r-1}'''\}$

$A(a_i) \cap S = a_i' \quad \forall\, i = 1,2, \ldots r.$
$A(a_i''') \cap S = a_i'' \quad \forall\, i = 1,2, \ldots r.$

Which ensure that all nodes in N – S have distinct neighbours.
Thus S is a Locating dominating set. Again < S > ≅ $2K_r$, which implies is connected.

Also if any one node is removed from S, then S will no longer be a LCD – set.

Thus $\gamma_{LCD}(P_4 \times K_r)$ = |S| = 2r.

**Illustration:2.8**

For the graph given in Figure 2.9, the $\gamma_{LCD}$ – set is encircled and $\gamma_{LCD}(P_3 \times K_r) \cong 6$.

**$P_4 \times K_6 \cong$**

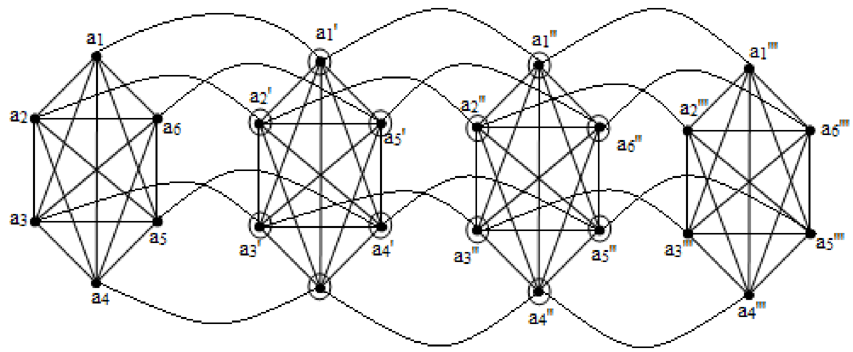


**Figure 2.9**
**$P_3 \times K_6$**

**Theorem:2.10**

The Locating connected domination number of the tensor product of two graphs $P_3$ and $K_r$ denoted by $P_3 \otimes K_r$ is given by $\gamma_{LCD}(P_3 \otimes K_r) = 2r - 1$ , $r \geq 2$.

**Proof:**

Let $K_r$ be the complete graph on r nodes with $N(K_r) = \{a_1, a_2, \ldots a_r\}$

Take the node set of namely $b_1$, $b_2$, $b_3$, and $P_3$ be the path on 3 nodes.

$N(P_3 \otimes K_r) = \{a_1b_1, a_2b_1, \ldots a_rb_1, a_1b_2, a_2b_2, \ldots a_rb_2, a_1b_3, a_2b_3, \ldots a_rb_3\}$ to the form of the Cartesian product of $P_3$ and $K_r$ with

$$G \cong P_3 \otimes K_r.$$

Let $\{a_1, b_1, \ldots a_rb_1\}$ denote the first copy of $K_r$, and $\{a_1b_2, a_2b_2, \ldots a_rb_2\}$ denote the second copy of $K_r$, and $\{a_1b_3, a_2b_3, \ldots a_rb_3\}$ denote the third copy of $K_r$.

Then the set $S = \{a_1b_2, a_2b_2, \ldots a_{r-1}b_2, a_1b_3, a_2b_3, \ldots a_rb_3\}$ will form a $\gamma_{LCD}$ – set of G.

Since S contains all the nodes in second copy except last node and all the nodes in third copy of $K_r$, obviously S is connected.

**claim:** S will form locating dominating set N – S = $\{a_1b_1, a_2b_1, \ldots a_rb_1, a_{r-1}b_2\}$

$A(a_1b_1) \cap S = \{a_2b_2, a_3b_2, \ldots a_{r-1}b_2\}$

$A(a_2b_1) \cap S = \{a_1b_2, a_3b_2, \ldots a_{r-1}b_2\}$

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$A(a_rb_1) \cap S = \{a_1b_2, a_2b_2, \ldots a_{r-1}b_2\}$

$A(a_{r-1}b_2) \cap S = \{a_1b_3, a_2b_3, \ldots a_{r-1}b_3\}$

Which ensure that all nodes in N – S have distinct neighbours.

Thus S is a Locating dominating set. Again $< S > \cong P_r$, which implies is connected.

Suppose we take the nodes in second column of LCD – set, S does not distinct neighbourhood. Also if any one node is removed from S, then S will no longer be a LCD – set.

Thus $\gamma_{LCD}(P_3 \otimes K_r) = |S| = 2r - 1$.

**Illustration:2.9**

For the graph given in Figure 2.10, the $\gamma_{LCD}$ – set is encircled and $\gamma_{LCD}(P_3 \otimes K_r) \cong 6$.

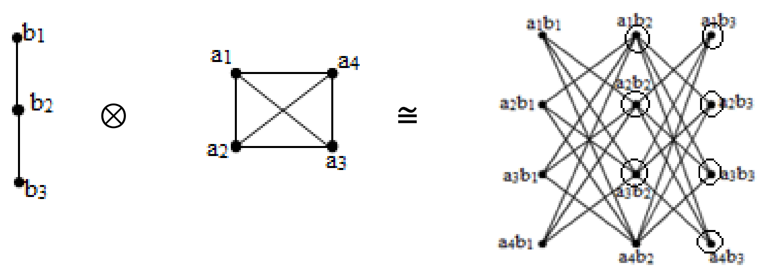


**Figure 2.10**
**$P_3 \otimes K_4$**

**Theorem:2.11**

The Locating connected domination number of the tensor product of two graphs $P_4$ and $K_r$ denoted by $P_4 \otimes K_r$ is given by $\gamma_{LCD}(P_4 \otimes K_r) = 2r$ , $r \geq 3$.

**Proof:**

Let $K_r$ be the complete graph on r nodes with $N(K_r) = \{a_1, a_2, \ldots a_r\}$

$N(P_4 \otimes K_r) = \{a_1b_1, a_2b_1, \ldots a_rb_1, a_1b_2, a_2b_2, \ldots a_rb_2, a_1b_3, a_2b_3, \ldots a_rb_3, a_1b_4, a_2b_4, \ldots a_rb_4\}$ to the form of the Cartesian product of $P_4$ and $K_r$ with

$G \cong P_4 \otimes K_r$.

Let $\{a_1, b_1, \ldots a_rb_1\}$ denote the first copy of $K_r$, and $\{a_1b_2, a_2b_2, \ldots a_rb_2\}$ denote the second copy of $K_r$, and $\{a_1b_3, a_2b_3, \ldots a_rb_3\}$ denote the third copy of $K_r$, and $\{a_1b_4, a_2b_4, \ldots a_rb_4\}$ denote the fourth copy of $K_r$.

Then the set S = $\{a_1b_2, a_2b_2, \ldots a_rb_2, a_1b_3, a_2b_3, \ldots a_rb_3\}$ will form a $\gamma_{LCD}$ – set of G.

Since S contains all the nodes in second column and all the nodes in third column of $K_r$, obviously S is connected.

**claim:** S will form locating dominating set N – S = $\{a_1b_1, a_2b_1, \ldots a_rb_1, a_1b_4, a_2b_4, \ldots . a_rb_4\}$

$A(a_1b_1) \cap S = \{a_2b_2, a_3b_2, \ldots a_r b_2\}$

$A(a_2b_1) \cap S = \{a_1b_2, a_3b_2, \ldots a_r b_2\}$

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$A(a_rb_1) \cap S = \{a_1b_2, a_2b_2, \ldots a_{r-1}b_2\}$

$A(a_1b_4) \cap S = \{a_2b_3, a_3b_2, \ldots a_r b_3\}$

$A(a_2b_1) \cap S = \{a_1b_3, a_3b_3, \ldots a_r b_3\}$

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$A(a_rb_4) \cap S = \{a_1b_3, a_2b_3, \ldots a_{r-1}b_3\}$

Which ensure that all nodes in N – S have distinct neighbours.

Thus S is a Locating dominating set. Again $\langle S \rangle \cong P_r$, which implies is connected.

Suppose we take the nodes in second column of LCD – set, S does not distinct neighbourhood. Also if any one node is removed from S, then S will no longer be a LCD – set.

Thus $\gamma_{LCD}(P_4 \otimes K_r) = |S| = 2r$.

**Illustration:2.12**

For the graph given in Figure 2.13, the $\gamma_{LCD}$ – set is encircled and $\gamma_{LCD}(P_4 \otimes K_r) \cong 8$.

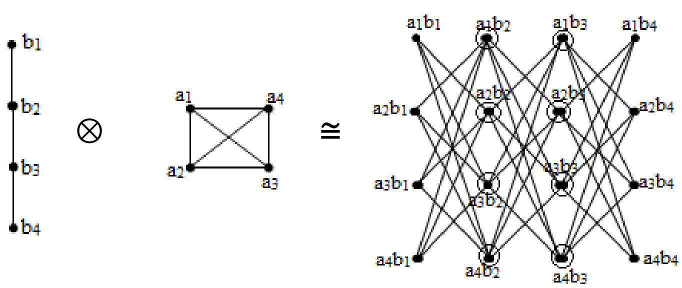


**Figure 2.13**
**$P_4 \otimes K_4$**

**Theorem:2.14**

The Locating connected domination number of the strong product of two graphs $P_2$ and $P_r$ denoted by $P_2 \boxtimes P_r$ is given by $\gamma_{LCD}(P_2 \boxtimes P_r) = r, r \geq 3$.

**Proof:**

Let $P_r$ be the complete graph on n nodes with $N(P_r) = \{a_1, a_2, a_3 \ldots . a_r\}$.

The set $\{a_1b_1, a_1b_2, a_2b_1, a_2b_2, \ldots . . a_rb_1, a_rb_2\}$ to form a strong product $P_2$ and $P_r$ with

$$G \cong P_2 \boxtimes P_r$$

Then the set $S = \{a_1b_2, a_2b_2, \ldots . . a_rb_2\}$ will form a $\gamma_{LCD}$ – set of G.

Since S contain all nodes in second copy of $P_r$, obviously S is connected.

**Claim:**

S will form a locating dominating set

$N - S = \{a_1b_1, a_2b_1, a_3b_1 \ldots . a_rb_1\}$

$N(a_1b_1) = \{a_1b_2, a_2b_2\}$

$N(a_2b_1) = \{a_1b_2, a_2b_2, a_3b_2\}$

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$N(a_rb_1) = \{a_{r-1}b_2, a_rb_2\}$

Which ensure that all the nodes in N – S have distinct neighbours.

Thus S is a Locating dominating set. Again $\langle S \rangle \cong P_r$, which implies is connected.

Also if any one node is removed from S, then S will not a LCD – set.

$$\text{Thus } \gamma_{LCD}(P_2 \boxtimes P_r) = |S| = r.$$

**Illustration:2.15**

For the graph given in Figure 2.16, the $\gamma_{LCD}$ – set is encircled and $\gamma_{LCD}(P_2 \boxtimes P_r) \cong 5$.

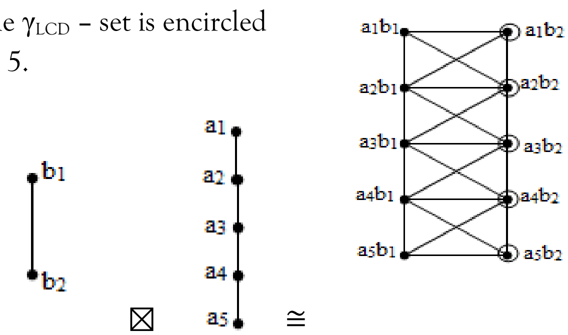


**Figure 2.16**
**$P_2 \boxtimes P_5$**

**Theorem:2.17**

The Locating connected domination number of the strong product of two graphs $P_2$ and $C_r$ denoted by $P_2 \boxtimes C_r$ is given by $\gamma_{LCD}(P_2 \boxtimes C_r) = r$ , $r \geq 4$.

**Proof:**

Let $C_r$ be the complete graph on r nodes with $N(C_r) = \{a_1, a_2, a_3 \ldots a_r\}$.

The set $\{a_1b_1, a_1b_2, a_2b_1, a_2b_2, \ldots a_rb_1, a_rb_2\}$ to form a strong product $P_2$ and $C_r$ with

$$G \cong P_2 \boxtimes C_r$$

Then the set $S = \{a_1b_2, a_2b_2, \ldots a_rb_2\}$ will form a $\gamma_{LCD}$ – set of G.

Since S contains all nodes in second copy of $C_r$, obviously S is connected.

**Claim:**

S will form a locating dominating set

$N - S = \{a_1b_1, a_2b_1, a_3b_1 \ldots a_rb_1\}$

$N(a_1b_1) = \{a_1b_2, a_2b_2\}$

$N(a_2b_1) = \{a_1b_2, a_2b_2, a_3b_2\}$

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$N(a_rb_1) = \{a_{r-1}b_2, a_rb_2\}$

Which ensure that all the nodes in N – S have distinct neighbours.

Thus S is a Locating dominating set. Again $\langle S \rangle \cong P_r$, which implies is connected.

Also if any one node is removed from S, then S will not a LCD – set.

$$\text{Thus } \gamma_{LCD}(P_2 \boxtimes C_r) = |S| = r.$$

**Illustrtion:2.18**

For the graph given in Figure 2.19, the $\gamma_{LCD}$ – set is encircled and $\gamma_{LCD}(P_2 \boxtimes C_r) \cong 4$.

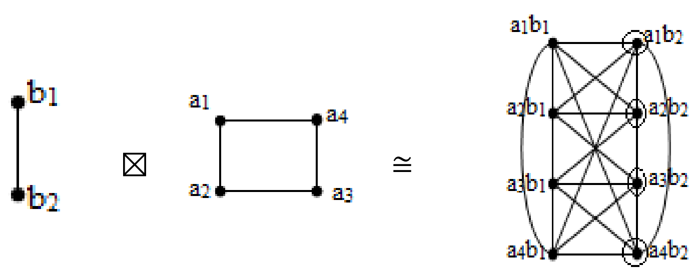


**Figure 2.19**
**$P_2 \boxtimes C_4$**

**Thorem:2.20**

The Locating connected domination number of the strong product of two graphs $P_2$ and $C_r$ denoted by $P_3 \boxtimes C_r$ is given by $\gamma_{LCD}(P_3 \boxtimes C_r) = 2r - 2, r \geq 4$.

**Proof:**

Let $C_r$ be the cycle graph on r nodes with $N(C_r) = \{a_1, a_2, a_3 \ldots . a_r\}$.

The set $\{a_1b_1, a_1b_2, a_1b_3, a_2b_1, a_2b_2, a_2b_3 \ldots\ldots a_nb_1, a_rb_2, a_rb_3\}$ to form a strong product $P_3$ and $C_r$ with

$$G \cong P_3 \boxtimes C_r$$

Then the set $S = \{a_2b_2, a_3b_2, \ldots a_rb_2, a_1b_3, a_2b_3 \ldots a_{r-1}b_3\}$ will form a $\gamma_{LCD}$ – set of G.

Since S contains all nodes in second copy except one node and all the nodes in third copy except one node of $C_r$, obviously S is connected.

**Claim:**

S will form a locating dominating set

$N - S = \{a_1b_1, a_2b_1, \ldots . a_rb_1, a_1b_2, a_rb_3\}$

$N(a_1b_1) = \{a_2b_2, a_rb_2\}$

$N(a_2b_1) = \{a_1b_2, a_2b_2, a_3b_2\}$

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$N(a_nb_1) = \{a_{n-1}b_2, a_rb_2\}$

$N(a_1b_2) = \{a_1b_3, a_2b_3, a_2b_2, a_rb_2\}$

$N(a_nb_3) = \{a_{r-1}b_2, a_rb_2, a_1b_3, a_{r-1}b_3\}$

Which ensure that all the nodes in N– S have distinct neighbours. Thus S is a Locating dominating set. Again $< S > \cong P_r$, which implies is connected.

Also if any one node is removed from S, then S will not a LCD – set.

$$\text{Thus } \gamma_{LCD}(P_3 \boxtimes C_r) = |S| = 2r - 2.$$

**Illustration:2.21**

For the graph given in Figure 2.22, the $\gamma_{LCD}$ – set is encircled and $\gamma_{LCD}(P_3 \boxtimes C_5) \cong 8$.

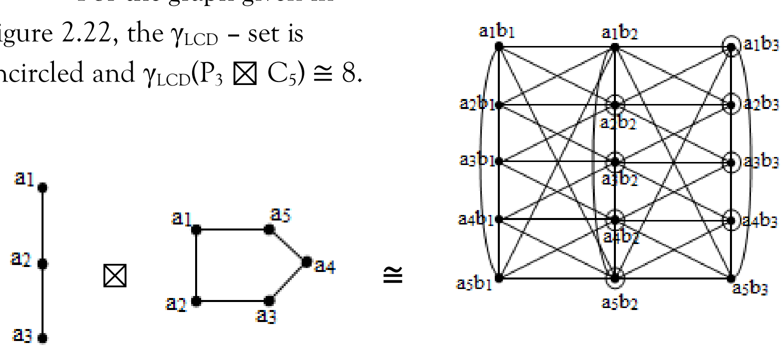


**Figure 2.22**
**$P_3 \boxtimes C_5$**

Theorem:2.23

The Locating connected domination number of the corona product of two graphs $C_n$ and $K_r$ denoted by $C_n \odot K_r$ is given by $\gamma_{LCD}(C_n \odot K_r) = nr$, for $n \geq 3$.

**Proof:**

Let $C_n$ be the cycle graph on n node with $N(C_n) = \{a_1, a_2, a_3, \ldots\ldots a_r\}$
Take n copies of $K_r$ the complete graph on r node with

$N(C_n \odot K_r) = \{a_1,1', a_1,2' \ldots\ldots a_1,r', a_2,1', a_2,2', \ldots\ldots a_2,r', a_r,1', a_r,2', \ldots\ldots .a_r,r'\}$ to form the corona product of $C_n$ and $K_r$ with

$G \cong C_n \odot K_r$

Then the set $S = \bigcup_{i=1}^{r} i' \cup \bigcup_{i=1}^{r-1} \{a_1,i'\} \cup \bigcup_{i=1}^{r-1} \{a_2,i'\} \ldots\ldots \cup \bigcup_{i=1}^{r-1} \{a_r,i'\}$ will form a $\gamma_{LCD}$ – set of G.

Since S contain all the nodes in the cycle and take all the nodes in complete Graph except last node of $K_r$, obviously S is connected.

**Claim:**

S will form a locating connected dominating set

$N - S = \{a_1,r', a_2, r', a_3, r', \ldots .a_r,r'\}$

$A(a_1, r') \cap S = \{ a_1,1', a_1,2' \ldots\ldots a_1, r - 1'\}$

$A(a_2,r') \cap S = \{ a_2,1', a_2,2', \ldots\ldots a_2,r - 1'\}$

. . . . . . . . . . .

. . . . . . . . . . .

$A(a_r,r') \cap S = \{ a_r,1', a_r,2', \ldots\ldots .a_r,r - 1'\}$

Which ensure that all nodes in N – S have distinct neighbours.

Here leave one node for every copy of $K_r$, which ensure that all nodes in N – S have distinct neighbours.

Thus S is a Locating dominating set. Again $< S > \cong P_r$, which implies is connected. Suppose if any one node is removed from S them S will not distinct neighbours. Also if any one node is add from S, then S will not minimum cardinality set, then S will not a LCD – set.

Thus $\gamma_{LCD}(C_n \odot K_r) = |S| = nr$.

**Illustration:2.24**

For the graph given in Figure 2.25, the $\gamma_{LCD}$ – set is encircled and $\gamma_{LCD}(C_4 \odot K_5) \cong 8$.

**$C_4 \odot K_5 \cong$**

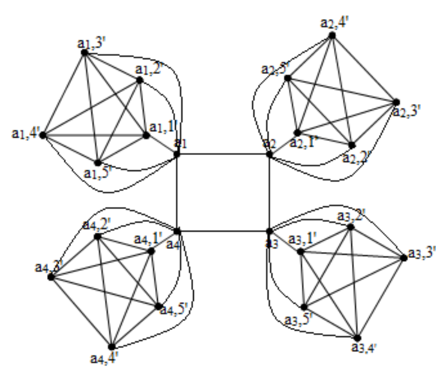


**Figure 2.25**
**$C_5 \odot K_5$**

## 2. Conclusion

The locating connected domination number for several operation namely Cartesian product, tensor product, strong product, corona product is established. To extend the work for generalization the result for the operations namely Cartesian product, tensor product of any two graphs and characterizing their bounds are the future work. To write an algorithm for determining the tensor product of any two graphs is posted as an open problem.

## 3. References

1. Brown, R., Marris, I., Shrimpton, J., Wensely, C.D(2008), "*Graphs of Morphisms of Graphs*", The Electronic Journal of Combinatorics,15.A1.
2. Hahn, Gena; Sabidussi, Gert(1997), *Graph symmetry; algebraic methods and applications*, NATO advanced Science Institutes Series, Vol. 497, Springer, p. 116, ISBN 978 – 0 – 7923 – 4668 – 5.
3. Imrich, wilfried, Klavzar, Sandii Rall, Douglas F.(2008), *Graphs and their Cartesian product*, A. K. Peters ISBN 978 – 1 – 56881 – 429 – 2.
4. Muthammai S., Meenal N.,*Co – isolated Location Domination Number for Cartesian Product of Two Graphs,* International Journal of Engineering Science, Advanced Computing and Bio – Technology, Vol. 6,No. 1, January – March Pp. 17 – 27.
5. Meenal N., Saranya K., *Locating Connected Dominating sets in Graphs*, Journal of Mathematical Control Science and Applications, vol 2 Pp. 2 – 18.
6. Nada S., Elrokh A., Elsakhawi E.A., Sabra D.E., *The corona between cycles and paths*, Journal of Egyptian Mathematical Society, Vol 25 Pp. 111 – 118. Sabidussi, Gert(1960), "*Graph Multiplication*" Mathematische zeitschrift.
7. Sampathkumar E., Walikar H.B., *The Connected Domination Number of a Graph*, Journal of Mathematical Physical Sciences, Vol. 13, Pp. 607- 613, 1979.
8. Whitehead, A. N.; Russell, B.(1912), *Principia Mathematica*, Cambridge University Press, vol. 2, Pp. 384.
9. Weichsel, Paul m.(1962), *The Kronecker product of Graphs*, Proceeding of the American Mathematical Society, 13(1): 47 – 52.

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