ON $\delta(\delta g)^*$-CLOSED SETS IN TOPOLOGICAL SPACES

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ABSTRACT

In this paper, a new class of generalized closed sets called $\delta(\delta g)^*$-closed sets is introduced and its properties are studied in topological spaces. Moreover the relation between $\delta(\delta g)^*$-closed sets and various other classes of closed sets already defined are investigated.

Keywords: g-closed sets, $\hat{g}$ -closed sets, $\delta g$ -closed sets, $\delta g^*$ -closed sets, $\delta(\delta g)^*$ -closed sets, $\hat{\delta g}^*$ -closed sets and $\delta(\delta g)^*$-closed sets.

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1. INTRODUCTION

The concept of generalized closed (briefly g-closed) sets was introduced and investigated by Norman Levine [6] in 1970. Velicko [10] introduced $\delta$-open sets in 1968 which are stronger than open sets. By combining the concepts of $\delta$-closedness and g-closedness, Julian Dontchev [2] proposed a class of generalised closed sets called $\delta g$ -closed sets in 1996. Lellis Thivagar [5] defined a new class of closed set called $\hat{\delta g}$ - closed set in 2010. Veerakumar [8] and [9] introduced $\hat{g}$ -closed sets in 2003 and $\hat{\delta g}^*$-closed sets in 2006. Meena and Sivakamasundari [7] defined a new class of generalised closed sets called $\delta(\delta g)^*$-closed sets and various properties were analysed.

Motivated by the development of various classes of $\delta$-closed sets, we extend the concept of $\delta$-generalized closed sets to a new class of closed sets called $\delta(\delta g)^*$-closed sets and investigate their relationship with other existing closed sets in topological spaces. This new class contains the class of $\delta(\delta g)^*$-closed sets. The following inclusion relation holds.

$\delta(\delta g)^*$-closed sets $\subseteq \delta(\delta g)^*$-closed $\subseteq \hat{\delta g}^*$-closed sets

2. PRELIMINARIES

Definition 2.1 [4]: A Topology on a set X is a collection $\tau$ of subsets of X having the following properties:
   a. $\varnothing$ and X are in $\tau$.
   b. The union of elements of any sub collection of $\tau$ is in $\tau$.
   c. The intersection of the elements of any finite sub collection of $\tau$ is in $\tau$.

A set X for which a topology $\tau$ has been specified is called a Topological space.

Definition 2.2[7]: A subset A of a Topological space (X, $\tau$ ) is called
   1. Regular open if $A = \text{int}(\text{cl}(A))$
   2. Semi-open if $A \subseteq \text{cl}($int$(A))$
   3. Pre-open if $A \subseteq \text{int}(\text{cl}(A))$
   4. $\alpha$-open if $A \subseteq \text{int}($cl$(\text{int}(A))$)
   5. semi preopen if $A \subseteq \text{cl}($int$(\text{cl}(A)))$
   6. $\pi$- open if it is the finite union of regular open sets.
   7. $\delta$- open if it is the union of regular open sets.
The complement of a regular open (resp. semi open, pre-open, α-open, semi preopen, π-open, δ-open) set is called regular closed (resp. semi closed, pre-closed, α-closed, semi preclosed, π-closed and δ-closed).

Definition 2.3[7]: The intersection of all regular closed (resp. semi-closed, pre-closed, α-closed, semi preclosed, π-closed, δ-closed) subsets of (X, τ) containing A is called the regular closure (resp. semi-closure, pre-closure, α-closure, semi pre-closure, π-closure, δ-closure) of A and is denoted by cl(A) (resp. scl(A), pcl(A), acl(A), spcl(A), pcl(A) and δcl(A)).

Definition 2.4: A subset A of a topological space (X, τ) is called
1. generalized closed (briefly g-closed) [6] if cl(A) ⊆ U whenever A ⊆ U, U is open in (X, τ).
2. regular generalized closed (briefly rg-closed) [7] if cl(A) ⊆ U whenever A ⊆ U, U regular is open in (X, τ).
3. δ-generalized closed (briefly δg - closed) [2] if δcl(A) ⊆ U whenever A ⊆ U, U is open in (X, τ).
4. δ-generalized semi closed (briefly δgs- closed) [3] if δscl(A) ⊆ U whenever A ⊆ U, U is δ-open in (X, τ).
5. δg* - closed [7] if δcl(A) ⊆ U whenever A ⊆ U, U is g-open in (X, τ).
6. ˆg - closed [10] if cl(A) ⊆ U whenever A ⊆ U, U is semi open in (X, τ).
7. ˆδg* - closed [5] if δcl(A) ⊆ U whenever A ⊆ U, U is ˆg -open in (X, τ).
8. ˆg* - closed [7] if δcl(A) ⊆ U whenever A ⊆ U, U is ˆδg*-open in (X, τ).
9. α-generalized closed (briefly ag-closed) [7] if acl(A) ⊆ U whenever A ⊆ U, U is open in (X, τ).
11. generalised pre-closed (briefly gp- closed) [7] if pcl(A) ⊆ U whenever A ⊆ U, U is open in (X, τ).
12. generalised pre regular closed (briefly gpr- closed) [7] if pcl(A) ⊆ U whenever A ⊆ U, U is regular open in (X, τ).
13. g* - closed [7] if pcl(A) ⊆ U whenever A ⊆ U, U is g open in (X, τ).
15. g* - closed [7] if scl(A) ⊆ U whenever A ⊆ U, U is g-s open in (X, τ).
16. generalised semi pre regular closed (briefly gspr- closed) [7] if spcl(A) ⊆ U whenever A ⊆ U, U is regular open in (X, τ).
17. (gs)* - closed [7] if cl(A) ⊆ U whenever A ⊆ U, U is g- open in (X, τ).
18. regular weakly generalised closed (briefly rwg- closed) [7] if cl(int(A)) ⊆ U whenever A ⊆ U, U is regular open in (X, τ).
19. generalised δ-closed (briefly δg0 - closed) [7] if cl(A) ⊆ U whenever A ⊆ U, U is δ-open in (X, τ).
20. δg* - closed [5] if scl(A) ⊆ U whenever A ⊆ U, U is g*-open in (X, τ).
22. π-generalised closed (briefly πg- closed) [3] if cl(A) ⊆ U whenever A ⊆ U, U is π- open in (X, τ).
23. π-generalised pre closed (briefly πgp- closed) [3] if pcl(A) ⊆ U whenever A ⊆ U, U is π-open in (X, τ).
24. π-generalised semi pre closed (briefly πgs- closed) [3] if spcl(A) ⊆ U whenever A ⊆ U, U is π-open in (X, τ).
27. π-generalised α-closed (briefly πga- closed) [3] if acl(A) ⊆ U whenever A ⊆ U, U is π-open in (X, τ).
28. ψg-closed set [1] if scl(A) ⊆ U whenever A ⊆ U and U is sg-open in X.
29. ψg-closed set [1] if scl(A) ⊆ U whenever A ⊆ U and U is open in X.
30. g* - closed set [1] if cl(A) ⊆ U whenever A ⊆ U and U is g*-open in X.
31. g* - closed set [1] if cl(A) ⊆ U whenever A ⊆ U and U is g-open in X.

Remark 2.5: r-closed(open) → π-closed(open) → δ-closed(open) → δg* - closed(open) →  δ(δg)* - closed(open) →  δg* - closed(open) →  g0 - closed(open) [7].

Remark 2.6: For every subset A of X,
   i. spcl(A) ⊆ pcl(A) ⊆ δcl(A) [7].
   ii. spcl(A) ⊆ scl(A) ⊆ δscl(A) ⊆ δcl(A) (Lemma 3.4 of [3]).
   iii. bcl(A) ⊆ δscl(A) (Corollary 3.28 of [3]).

Remark 2.7:
   i. Every ˆδg - closed set is g-closed and δg – closed (Proposition 3.5 and 3.14 of [5]).
   ii. Every δ-closed set is ˆδg - closed (Proposition 3.2 of [5]).
3. $\delta(\delta g)^\sim$-CLOSED SETS

In this section we introduce a new class of closed sets called $\delta(\delta g)^\sim$-closed sets which lie between the class of $\delta(\delta g)^*$-closed sets and the class of $\delta(\delta g)^\#$-closed sets.

**Definition 3.1:** A subset $A$ of a topological space $(X, \tau)$ is said to be $\delta(\delta g)^\sim$-closed sets if $\delta\text{cl}(A) \subseteq U$ whenever $A \subseteq U$, $U$ is $\delta\text{g}^\delta$-open in $(X, \tau)$. The class of all $\delta(\delta g)^\sim$-closed sets of $(X, \tau)$ is denoted by $\delta(\delta g)^\sim C(X, \tau)$.

**Theorem 3.2:** Let $A$ and $B$ are $\delta(\delta g)^\sim$-closed sets in a topological space $(X, \tau)$, then
i. $A \cup B$ is $\delta(\delta g)^\sim$-closed in $(X, \tau)$.
ii. $A \cap B$ need not be $\delta(\delta g)^\sim$-closed in $(X, \tau)$.

**Proof:**
i. Suppose that $A \cup B \subseteq U$ where $U$ is any $\delta\text{g}^\delta$-open in $(X, \tau)$. Then $A \subseteq U$ and $B \subseteq U$. Since $A$ and $B$ are $\delta(\delta g)^\sim$-closed sets of $(X, \tau)$, $\delta\text{cl}(A) \subseteq U$ and $\delta\text{cl}(B) \subseteq U$. Also, $\delta\text{cl}(A \cup B) = \delta\text{cl}(A) \cup \delta\text{cl}(B)$. It follows that, $\delta\text{cl}(A \cup B) \subseteq U$. Therefore $A \cup B$ is a $\delta(\delta g)^\sim$-closed set in $(X, \tau)$.

ii. Let $X = \{a, b, c\}$, $\tau = \{X, \varnothing, \{a\}, \{b\}, \{a, b\}\}$. In this topology, the set $\{c\}$ and $\{a, c\}$ are $\delta(\delta g)^\sim$-closed but their intersection $\{c\}$ is not $\delta(\delta g)^\sim$-closed.

**Theorem 3.3:** In a topological space $(X, \tau)$, every $\delta$-closed set is $\delta(\delta g)^\sim$-closed but the converse need not be true.

**Proof:** Let $A$ be a $\delta$-closed set and let $U$ be any $\delta\text{g}^\delta$-open set containing $A$ in $(X, \tau)$. Since $A$ is $\delta$-closed, $\delta\text{cl}(A) = A \subseteq U$ and hence $A$ is $\delta(\delta g)^\sim$-closed.

**Example:** Let $X = \{a, b, c\}$, $\tau = \{x, \varnothing, \{a, c\}\}$. In this topology the set $\{b\}$ is $\delta(\delta g)^\sim$-closed but not $\delta$-closed.

**Theorem 3.4:** Let $(X, \tau)$ be a topological space and $A \subseteq X$. Then the class of $\delta g^*$-closed sets and the class of $\delta(\delta g)^*$-closed sets are proper subsets of the class of $\delta(\delta g)^\sim$-closed sets.

**Proof:**
i. Let $A$ be $\delta g^*$-closed set and $U$ be any $\delta\text{g}^\delta$-open set containing $A$ in $(X, \tau)$. By Remark 2.7(i), every $\delta\text{g}^\delta$-open set is $g$-open. Since $A$ is $\delta g^*$-closed, $\delta\text{cl}(A) = A \subseteq U$ and hence $A$ is $\delta(\delta g)^\sim$-closed.

ii. Let $A$ be $\delta(\delta g)^*$-closed set and $U$ be any $\delta\text{g}^\delta$-open set containing $A$ in $(X, \tau)$. By Remark 2.7(i), every $\delta\text{g}^\delta$-open set is $\delta g^*$-open. Since $A$ is $\delta(\delta g)^*$-closed, $\delta\text{cl}(A) \subseteq U$. Hence $A$ is $\delta(\delta g)^\sim$-closed.

**Remark 3.5:** A $\delta(\delta g)^\sim$-closed set need not be a $\delta g^*$-closed and need not be $\delta(\delta g)^*$-closed.

**Example:** Let $X = \{a, b, c\}$, $\tau = \{X, \varnothing, \{a, c\}, \{b\}\}$. In this topology, the set $\{b\}$ is $\delta(\delta g)^\sim$-closed but not $\delta g^*$ closed.

**Example:** Let $X = \{a, b, c\}$, $\tau = \{X, \varnothing, \{c\}, \{a, b\}\}$. In this topology the set $\{a\}$ is $\delta(\delta g)^\sim$-closed but not $\delta(\delta g)^*$ closed.

**Remark 3.6:** The following diagram gives a diagrammatic representation of the above Theorems.

In the above diagram, $A \longrightarrow B$ means, $A$ implies $B$ but, $B$ does not imply $A$.

**Remark 3.7:** $\pi$-closed(open) $\rightarrow \delta$-closed(open) $\rightarrow g\delta^*$-closed(open) $\rightarrow g\delta^*$-closed(open)
**Theorem 3.8:** Let $(X, \tau)$ be a topological space and $A \subseteq X$ be a $\delta(\delta g)^{o}$-closed set. Then $A$ is

i. $g\delta$-closed ii. gpr-closed iii. gspr-closed.

The converse part of this Theorem need not be true.

**Proof:**

i. Let $A$ be $\delta(\delta g)^{o}$-closed set and $U$ be any $\delta$-open set containing $A$ in $(X, \tau)$. By Remark 2.7(ii), every $\delta$-open set is $\delta g^{o}$-open. Since $A$ is $\delta(\delta g)^{o}$-closed, $\delta cl(A) \subseteq U$. For every subset $A$ of $X$, $cl(A) \subseteq \delta cl(A)$. Therefore $cl(A) \subseteq U$. Hence $A$ is $g\delta$-closed.

ii. Let $A$ be $\delta(\delta g)^{o}$-closed set and $U$ be any regular open set containing $A$ in $(X, \tau)$. By Remark 2.5&7(ii), every regular open is $\delta g^{o}$-open and $A$ is $\delta(\delta g)^{o}$-closed, $\delta cl(A) \subseteq U$. By Remark 2.6(i), For every subset $A$ of $X$, $pcl(A) \subseteq \delta cl(A)$ and so we have $pcl(A) \subseteq U$. Hence $A$ is gpr-closed.

iii. Let $A$ be $\delta(\delta g)^{o}$-closed set and $U$ be any regular open set containing $A$ in $(X, \tau)$. By Remark 2.5 and 2.7(ii), every regular open is $\delta g^{o}$-open and $A$ is $\delta(\delta g)^{o}$-closed, $\delta cl(A) \subseteq U$. By Remark 2.6(i), $spcl(A) \subseteq \delta cl(A)$. And so we have, $spcl(A) \subseteq U$. Hence $A$ is gspr-closed.

**Example:** Let $X = \{a, b, c\}$, $\tau = \{X, \phi, \{a, c\}\}$. In this topology, the set $\{a\}$ is $g\delta$-closed but not $\delta(\delta g)^{o}$-closed.

**Example:** Let $X = \{a, b, c\}$, $\tau = \{X, \phi, \{a, b\}, \{b, c\}, \{b\}\}$. In this topology, the set $\{b\}$ is gpr-closed but not $\delta(\delta g)^{o}$-closed.

**Example:** Let $X = \{a, b, c\}$, $\tau = \{X, \phi, \{a, b\}, \{b, c\}, \{b\}\}$. In this topology, the set $\{b\}$ is gspr-closed but not $\delta(\delta g)^{o}$-closed.

**Theorem 3.9:** Let $(X, \tau)$ be a topological space and $A \subseteq X$. Then,

i. $A$ is $\delta(\delta g)^{o}$-closed set implies, $A$ is $\delta g^{o}$-closed.

ii. $A$ is $\delta(\delta g)^{o}$-closed set implies, $A$ is $\delta g s$-closed.

The converse part of (i) and (ii) need not be true.

**Proof:**

i. Let $A$ be $\delta(\delta g)^{o}$-closed set and $U$ be any $\delta$-open set containing $A$ in $(X, \tau)$. By Remark 2.7(ii), every $\delta$-open set is $\delta g^{o}$-open and $A$ is $\delta(\delta g)^{o}$-closed, $\delta cl(A) \subseteq U$. Hence $A$ is $\delta g^{o}$-closed.

ii. Let $A$ be $\delta(\delta g)^{o}$-closed set and $U$ be any $\delta$-open set containing $A$ in $(X, \tau)$. By Remark 2.7(ii), every $\delta$-open is $\delta g^{o}$-open and $A$ is $\delta(\delta g)^{o}$-closed, $\delta cl(A) \subseteq U$. By Remark 2.6(iii), $\delta scl(A) \subseteq \delta cl(A)$. And hence, $\delta s cl(A) \subseteq U$ and $A$ is $\delta g s$-closed.

**Example:** Let $X = \{a, b, c\}$, $\tau = \{X, \phi, \{a, c\}\}$. In this topology, the set $\{c\}$ is $\delta g^{o}$-closed but not $\delta(\delta g)^{o}$-closed.

**Example:** Let $X = \{a, b, c\}$, $\tau = \{X, \phi, \{a, c\}\}$. In this topology, the set $\{c\}$ is $\delta g s$-closed but not $\delta(\delta g)^{o}$-closed.

**Theorem 3.10:** Let $(X, \tau)$ be a topological space and $A \subseteq X$. Then the class of $\delta(\delta g)^{o}$-closed sets is a proper subset of each of the classes of rg-closed, rWg-closed, πg-closed, πgp-closed and πgb-closed sets.

**Proof:**

i. Let $A$ be $\delta(\delta g)^{o}$-closed set and $U$ be any regular open set containing $A$ in $(X, \tau)$. By Remark 2.5 and 2.7(ii), every regular open is $\delta g^{o}$-open and $A$ is $\delta(\delta g)^{o}$-closed, $\delta cl(A) \subseteq U$. For every subset $A$ of $X$, $cl(A) \subseteq \delta cl(A)$ and so we have $cl(A) \subseteq U$. Hence $A$ is rg-closed.

ii. Let $A$ be $\delta(\delta g)^{o}$-closed set and $U$ be any regular open set containing $A$ in $(X, \tau)$. By Remark 2.5 and 2.7(ii), every regular open is $\delta g^{o}$-open and $A$ is $\delta(\delta g)^{o}$-closed, $\delta cl(A) \subseteq U$. As $int(A) \subseteq U$, we have $cl(int(A)) \subseteq cl(A) \subseteq \delta cl(A)$. Then $cl(int(A)) \subseteq cl(A) \subseteq \delta cl(A)$. Hence $A$ is rWg-closed.

iii. Let $A$ be $\delta(\delta g)^{o}$-closed set and $U$ be any regular open set containing $A$ in $(X, \tau)$. By Remark 2.5 and 2.7(ii), every regular open is $\delta g^{o}$-open and $A$ is $\delta(\delta g)^{o}$-closed, $\delta cl(A) \subseteq U$. By Remark 2.6, $cl(A) \subseteq \delta cl(A)$. And so we have, $cl(A) \subseteq U$. Hence $A$ is πg-closed.

iv. Let $A$ be $\delta(\delta g)^{o}$-closed set and $U$ be any regular open set containing $A$ in $(X, \tau)$. By Remark 2.5 and 2.7(ii), every regular open is $\delta g^{o}$-open and $A$ is $\delta(\delta g)^{o}$-closed, $\delta cl(A) \subseteq U$. By Remark 2.6, $pcl(A) \subseteq \delta cl(A)$. And so we have, $pcl(A) \subseteq U$. Hence $A$ is πgp-closed.
Let $A$ be $\delta(\delta g)^\ast$-closed set and $U$ be any $\pi$-open set containing $A$ in $(X, \tau)$. By Remark 2.5 and 2.7(ii), every $\pi$-open is $\delta^{\ast}\delta$-open and $A$ is $\delta(\delta g)^\ast$-closed, $\delta\text{cl}(A) \subseteq U$. By Remark 2.6(iii), $\text{bcl}(A) \subseteq \delta\text{cl}(A)$. And so we have, $\text{bcl}(A) \subseteq U$. Hence $A$ is $\pi\text{gb}$-closed.

**Remark 3.11:** The converse of the above Theorem need not be true.

**Example:** Let $X = \{a, b, c\}$, $\tau = \{X, \emptyset, \{a, c\}\}$. In this topology, the set $\{a\}$ is $\text{rg}$-closed but not $\delta(\delta g)^\ast$-closed.

**Example:** Let $X = \{a, b, c\}$, $\tau = \{X, \emptyset, \{a, b, c\}\}$. In this topology, the set $\{a\}$ is $\text{rg}$-$\delta$ closed but not $\delta(\delta g)^\ast$-closed.

**Example:** Let $X = \{a, b, c\}$, $\tau = \{X, \emptyset, \{a, b\}, \{b, c\}, \{b\}\}$. In this topology, the set $\{b\}$ is $\pi\text{gsp}$-closed but not $\delta(\delta g)^\ast$-closed.

**Example:** Let $X = \{a, b, c\}$, $\tau = \{X, \emptyset, \{a, c\}\}$. In this topology, the set $\{a\}$ is $\pi\text{gb}$-closed but not $\delta(\delta g)^\ast$-closed.

**Theorem 3.12:** Let $(X, \tau)$ be a topological space and $A \subseteq X$ be a $\delta(\delta g)^\ast$-closed set. Then $A$ is

(i) $\pi\text{g}\alpha$-closed.

(ii) $\pi\text{gs}$-closed

(iii) $\pi\text{gsp}$-closed.

The converse need not be true.

**Proof:**

i. Let $A$ be $\delta(\delta g)^\ast$-closed set and $U$ be any $\pi$-open set containing $A$ in $(X, \tau)$. By Remark 2.5 and 2.7(ii), every $\pi$-open is $\delta^{\ast}\delta$-open and $A$ is $\delta(\delta g)^\ast$-closed, $\delta\text{cl}(A) \subseteq U$. For every subset $A$ of $X$, $\alpha\text{cl}(A) \subseteq \delta\text{cl}(A)$. And so we have, $\alpha\text{cl}(A) \subseteq U$. Hence $A$ is $\pi\text{g}\alpha$-closed.

ii. Let $A$ be $\delta(\delta g)^\ast$-closed set and $U$ be any $\pi$-open set containing $A$ in $(X, \tau)$. By Remark 2.5 and 2.7(ii), every $\pi$-open is $\delta^{\ast}\delta$-open and $A$ is $\delta(\delta g)^\ast$-closed, $\delta\text{cl}(A) \subseteq U$. By Remark 2.6(ii), $\text{scl}(A) \subseteq \delta\text{cl}(A)$. And so we have, $\text{scl}(A) \subseteq U$. Hence $A$ is $\pi\text{gs}$-closed.

iii. Let $A$ be $\delta(\delta g)^\ast$-closed set and $U$ be any $\pi$-open set containing $A$ in $(X, \tau)$. By Remark 2.5 and 2.7(ii), every $\pi$-open is $\delta^{\ast}\delta$-open and $A$ is $\delta(\delta g)^\ast$-closed, $\delta\text{cl}(A) \subseteq U$. By Remark 2.6(i), $\text{spcl}(A) \subseteq \delta\text{cl}(A)$. And so we have, $\text{spcl}(A) \subseteq U$. Hence $A$ is $\pi\text{gsp}$-closed.

**Example:** $X = \{a, b, c\}$, $\tau = \{X, \emptyset, \{a, b\}, \{b, c\}, \{b\}\}$. In this topology, the set $\{b\}$ is $\pi\text{g}\alpha$-closed but not $\delta(\delta g)^\ast$-closed.

**Example:** Let $X = \{a, b, c\}$, $\tau = \{X, \emptyset, \{a, b\}, \{b, c\}, \{b\}\}$. In this topology, the set $\{b\}$ is $\pi\text{gs}$-closed but not $\delta(\delta g)^\ast$-closed.

**Example:** Let $X = \{a, b, c\}$, $\tau = \{X, \emptyset, \{a, b\}, \{a\}, \{b\}\}$. In $(X, \tau)$ the set $\{a\}$ is $\pi\text{gsp}$-closed but not $\delta(\delta g)^\ast$-closed.

**Remark 3.13:** The results of Theorem 3.7 to Theorem 3.12 are illustrated in the following diagram.
Remark 3.14: The following examples show that, the class $\delta(\delta g)^*\text{-closed sets}$ are independent from the classes of g-closed sets, $\delta g$-closed sets, sg-closed sets, gs-closed sets, $^*g$-closed sets, $\alpha g^\#$-closed sets, #gs-closed sets, gp-closed sets, gsp-closed sets, $\psi g$-closed sets, gb-closed sets, $\psi g^*$-closedness and g*s-closed sets.

Example: Let $X = \{a, b, c\}, \tau = \{X, \varnothing, \{a\}\}$. In this topology the set $\{c\}$ is g-closed, $\delta g$-closed, sg-closed, gs-closed, $^*g$-closed, $\alpha g^\#$-closed, $\delta g^\#$-closed, gp-closed, gsp-closed, $\psi g$-closed, gb-closed and $\psi g^*$-closed but not $\delta(\delta g)^*\text{-closed}$.

Example: Let $X = \{a, b, c\}, \tau = \{X, \varnothing, \{a, b\}, \{b, c\}, \{b\}\}$. In this topology the set $\{a, b\}$ is $\delta(\delta g)^*\text{-closed}$ but not g-closed, $\delta g$-closed, sg-closed, gs-closed, $^*g$-closed, $\alpha g^\#$-closed, $g^*p$-closed, $\delta g^\#$-closed, gp-closed, gsp-closed, $\psi g$-closed, gb-closed and $\psi g^*$-closed but not $\delta(\delta g)^*\text{-closed}$.

Example: Let $X = \{X, \varnothing, \{a\}\}, \tau = \{X, \varnothing, \{a\}\}$. In this topology the set $\{b\}$ is g*s-closed but not $\delta(\delta g)^*\text{-closed}$.

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