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CONTRA ψα-CONTINUOUS FUNCTIONS IN TOPOLOGICAL SPACES

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ABSTRACT
In this paper we introduce and investigate the notations of contra ψα-continuous functions and almost contra ψα-continuous functions in topological spaces. We discuss the relationsbetween these contra continuities and other related contra continuities.

KEYWORDS: Contra continuous functions,almost contra continuous functions, ψα-continuous functions, ψα-closed sets and ψα-open sets..

1. INTRODUCTION
Singal M.Kand Singal A.R [12] introduced almost continuous functions in topological spaces.Levine [9] introduced the idea of continuous functions in topological spaces.Dontchev[3] introduced the notation of contra continuous functions in topological spaces. Jafari and Noiri [5] introduced and studied the new form of functions called contra α-continuous functions in topological spaces.Ekici [4]introduced the concept of almost contra continuous functions in topological spaces. Shakila and Balamani [11]introduced ψα-continuous functions in topological spaces. Recently Karthika and Balamani [7] introduced totally ψα-continuous functions and ψα totally continuous functions in topological spaces.

The purpose of this paper is to introduce and study a new type of contra continuous functions namely contra ψα-continuous functions and almost contra ψα-continuous functions in topological spaces. Also we obtain the interrelations between these continuous functions.

2. PRELIMINARIES
Definition 2.1 Let (X,τ) be a topological space.A Subset A of a topological space (X,τ) is called
1) **Regular open[13]** if A = int(cl(A)).
2) **Semi-open [8]** if A ⊆ cl(int(A)).
3) **α-open [10]** if A ⊆ int(cl(int(A))).
4) **generalized closed [9]** if cl(A) ⊆ U whenever A⊆ U and U is open in (X,τ).
5) **Semi generalized closed [2]** if scl(A) ⊆ U whenever A⊆ U and U is semi open in (X,τ).
6) **ψ-closed [14]** if scl(A) ⊆ U whenever A⊆ U and U is sg-open in (X,τ).
7) **ψα-closed [11]**if ψcl(A) ⊆ U whenever A ⊆ U and U is α-open in (X,τ).
8) **ψα-clopen [11]**if it is both ψα-open and ψα-closed in (X,τ).

Results 2.2
- Every **closed** (open) subset in (X,τ) is **ψα-closed** (ψα-open).
- Every **clopen** subset in (X,τ) is **ψα-clopen**.
- Every **regular open**(regular closed) subset in (X,τ) is **open**(closed).
- Every **α-open** subset in (X,τ) is **ψα-open**.

Definition 2.3 Let (X,τ) and (Y,σ) be two topological spaces. A function f: $(X,\tau) \rightarrow (Y,\sigma)$ is called
1) **Almost continuous [12]** if $f^{-1}(V)$ is closed in (X,τ) for every regular closed set V of (Y,σ).

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2) **Continuous [9]** if $f^{-1}(V)$ is closed in (X,τ) for every closed set V of (Y,σ).
3) **Completely continuous [1]**if $f^{-1}(V)$ is regular open in (X,τ) for every open set V of (Y,σ).
4) **Totally Continuous [6]** if $f^{-1}(V)$ is clopen in (X,τ) for every open set V of (Y,σ).
5) **Almost contra continuous [4]**if $f^{-1}(V)$ is closed in (X,τ) for every regular open set V of (Y,σ).
6) **Contra continuous [3]**if $f^{-1}(V)$ is closed in (X,τ) for every open set V of (Y,σ).
7) **Contra α-continuous [5]**if $f^{-1}(V)$ is α-closed in (X,τ) for every open set V of (Y,σ).
8) **ψα-Continuous[11]** if $f^{-1}(V)$ is ψα-closed in (X,τ) for every closed set V of (Y,σ).
9) **Totally ψα-continuous [7]** if $f^{-1}(V)$ is ψα-clopen in (X,τ) for every open set V of (Y,σ).
10) **ψα-totally continuous [7]** if $f^{-1}(V)$ is clopen in (X,τ) for every ψα-open set V of (Y,σ).

3. CONTRA ψα-CONTINUOUS FUNCTIONS

Definition 3.1A function f: (X,τ) →(Y,σ) is called **contra ψα-continuous** if $f^{-1}(V)$ is ψα-open in (X,τ) for every closed set V of (Y,σ).

Example 3.2 Let X = Y = {a,b,c},τ = {ϕ,{a},X}and σ = {ϕ,{a,b},Y}. Let f:(X,τ)→(Y,σ) be a function defined by f(a) = c, f(b) = b, f(c) =a. Then f is contra ψα-continuous.

Theorem 3.3A function f: (X,τ) →(Y,σ) is contra ψα-continuous if and only if $f^{-1}(V)$ is ψα -closed in (X,τ) for every open set V of (Y,σ).

Proof: (Necessity) Let f: (X,τ) →(Y,σ) be contra ψα-continuous and V be any open set in (Y,σ). Then Y -V is closed in (Y,σ). Since f is contra ψα-continuous, $f^{-1}(Y - V) = X - f^{-1}(V)$ is ψα-open in (X,τ) which implies that $f^{-1}(V)$ is ψα-closed in (X,τ).

(Sufficiency): Let U be any closed set in (Y,σ). Then Y-U is open in (Y,σ). By assumption, $f^{-1}(Y - U) = X - f^{-1}(U)$ is ψα-closed in (X,τ) which implies that $f^{-1}(U)$ is ψα-open in (X,τ). Hence f is contra ψα-continuous.

Proposition 3.4 Every contra continuous function is a contra ψα-continuous function but not conversely.

Proof: Let V be any open set in (Y,σ). Since f is contra continuous, $f^{-1}(V)$ is closed in (X,τ).By result 2.2, $f^{-1}(V)$ is ψα-closed in (X,τ). Hence f is contra ψα-continuous.

Example 3.5 Let X = Y = {a,b,c}, τ = {ϕ,{a},{a,b},X}and σ = {ϕ,{a},Y}. Let f:(X,τ)→(Y,σ) be a function defined by f(a)=b, f(b)=a, f(c)=c. Then f is contra ψα-continuous but not contra continuous, since for the open set {a} in (Y,σ), $f^{-1}(\{a\}) = \{b\}$ is ψα-closed but not closed in (X,τ).

Proposition 3.6 Every contra α-continuous functionis a contra ψα-continuous function but not conversely.

Proof: Let V be any closed set in (Y,σ). Since f is contra α-continuous, $f^{-1}(V)$ is α-open in (X,τ). By result 2.2, $f^{-1}(V)$ is ψα-open in (X,τ).Hence f is contra ψα-continuous.

Example 3.7 Let X = Y = {a,b,c}, τ = {ϕ,{a}, {b}, {a,b},X}and σ = {ϕ,{a},Y}. Let f: (X,τ)→(Y,σ) be a function defined by f(a) = b, f(b) = a,f(c) =c. Then f is contra ψα-continuous but not contra α-continuous, since for the closed set{b,c} in (Y,σ), $f^{-1}(\{b,c\}) = \{a,c\}$ is ψα-open but not α-open in (X,τ).

Proposition 3.8 Every totally continuous function is a contra ψα-continuous function but not conversely.
Proof: Let V be any open set in (Y,σ). Since f is totally continuous, $f^{-1}(V)$ is clopen in (X,τ). By result 2.2, $f^{-1}(V)$ is ψα-clopenin (X,τ) which implies that $f^{-1}(V)$ is ψα-closed in (X,τ). Hence f is contra ψα-continuous.

Example 3.9 Let X = Y = {a,b,c}, τ = {ϕ,{a},{a,b},X}and σ = {ϕ,{a},Y}. Let f: (X,τ)→(Y,σ) be a function defined f(a) = b, f(b) = a, f(c) = c. Then f is contra ψα-continuous but not totally continuous, since for the open set {a} in (Y,σ), $f^{-1}(\{a\}) = \{b\}$ is ψα- closed but not clopen in (X,τ).

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Proposition 3.10 Every totally ψα-continuous function is a contra ψα-continuous function but not conversely.

Proof: Let V be any closed set in (Y,σ). Since f is totally ψα-continuous, $f^{-1}(V)$ is ψα-clopen in (X,τ) which implies that $f^{-1}(V)$ is ψα-open in (X,τ). Hence f is contra ψα-continuous.

Example 3.11 Let X = Y = {a,b,c}, τ = {ϕ,{a},X}and σ = {ϕ,{a,b},Y}. Let f: (X,τ)→(Y,σ) be a function defined by f(a) = c, f(b) = b ,f(c) =a. Then f iscontra ψα-continuousbut not totallyψα-continuous, since for the closed set{c} in (Y,σ), f^{-1}({c}) = {a} is ψα-open but not ψα-closed in (X,τ).

Proposition 3.12 Every ψα- totally continuous function is a contra ψα-continuous function but not conversely.

Proof: Let V be any open set in (Y,σ).By result 2.2, V is ψα-open in(Y,σ). Since f is ψα-totally continuous, $f^{-1}(V)$ is clopen in (X,τ). By result 2.2 , $f^{-1}(V)$ is ψα-clopen in (X,τ) which implies that $f^{-1}(V)$ is ψα-closed in (X,τ). Hence f is contra ψα-continuous.

Example 3.13 Let X = Y = {a,b,c}, τ = {ϕ,{a},{b},{a,b},X} and σ = {ϕ,{a,b},Y}. Let f:(X,τ)→(Y,σ) be a function defined f(a) = a, f(b) = c, f(c) = b.Then f is contra ψα-continuous but not ψα-totally continuous, since for the ψα-open set {a,b} in (Y,σ), f^{-1}({a,b}) = {a,c}is not clopen in (X,τ).

Remark 3.14 Contra ψα-continuous function is independent from ψα-continuous function as seen from the following examples.

Example 3.15 Let X =Y ={a,b,c}, τ = {ϕ,{a},X}and σ = {ϕ,{a,b},Y}. Let f:(X,τ)→(Y,σ) be a function defined by f(a) =c ,f(b) =b, f(c)=a .Then f is contra ψα-continuous but not ψα-continuous, since for the closed set {c} in (Y,σ), f^{-1}({c}) = {a} is ψα-open but not ψα-closed in (X,τ).

Example 3.16 Let X = Y = {a,b,c}, τ = {ϕ,{a},{a,b},X}and σ = {ϕ,{a,b},Y}. Let f: (X,τ)→(Y,σ) be the identity function. Then f is ψα-continuous but not contra ψα-continuous, since for the closed set{c} in (Y,σ), f^{-1}({c}) = {c} is ψα-closed but not ψα-open in (X,τ).

Proposition 3.17 If f:(X,τ)→(Y,σ) is a contra ψα-continuous function and g:(Y,σ)→(Z, η) is a continuous function, then g o f :(X,τ) →(Z,η) is a contra ψα-continuous function.

Proof: Let V be any closed set in (Z, η). Since g is continuous, $g^{-1}(V)$ is closed in (Y,σ). Since f is contra ψα-continuous, $(g \circ f)^{-1}(V) = f^{-1}(g^{-1}(V))$ is ψα-open in (X,τ). Hence g o f is a contra ψα-continuous function.

Proposition 3.18 If f:(X,τ)→(Y,σ) is a totally ψα-continuous function and g:(Y,σ)→(Z, η) is a continuous function, then g o f :(X,τ) →(Z,η) is a contra ψα-continuous function.

Proof: Let V be any closed set in (Z, η). Since g is continuous, $g^{-1}(V)$ is closed in (Y,σ). Since f is totally ψα-continuous,$(g \circ f)^{-1}(V) = f^{-1}(g^{-1}(V))$ is ψα-clopen in (X,τ) which implies that$(g \circ f)^{-1}(V)$is ψα-open in (X,τ). Hence g o f is a contra ψα-continuous function.

Proposition 3.19 If f:(X,τ)→(Y,σ) is a totally continuous function and g:(Y,σ)→(Z, η) is a continuous function, then g o f :(X,τ) →(Z,η) is a contra ψα-continuous function.

Proof: Let V be any closed set in (Z, η). Since g is continuous, $g^{-1}(V)$ is closed in (Y,σ). Since f is totally continuous, $(g \circ f)^{-1}(V) = f^{-1}(g^{-1}(V))$ is clopen in (X,τ). By result 2.2, $(g \circ f)^{-1}(V)$ is ψα-clopen in (X,τ) which implies that $(g \circ f)^{-1}(V)$is ψα-open in (X,τ) . Hence g o f is contra ψα-continuous.

Proposition 3.20 If f:(X,τ)→(Y,σ) is a ψα-totally continuous function and g:(Y,σ)→(Z, η) is a continuous function, then g o f :(X,τ) →(Z,η) is a contra ψα-continuous function.

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Proof: Let V be any closed set in (Z, η). Since g is continuous, $g^{-1}(V)$ is closed in (Y,σ). By result 2.2, $g^{-1}(V)$ is ψα-closed in (Y,σ). Since f is ψα-totally continuous, $(g \circ f)^{-1}(V) = f^{-1}(g^{-1}(V))$ is clopen in (X,τ) By result 2.2, $(g \circ f)^{-1}(V)$ is ψα-clopen in (X,τ) which implies that $(g \circ f)^{-1}(V)$is ψα-open in (X,τ). Hence g o f is a contra ψα-continuous function.

Proposition 3.21 If f:(X,τ)→(Y,σ) is a contra ψα-continuous function and g:(Y,σ)→(Z, η) is atotally continuous function, then g o f :(X,τ) →(Z,η) is a contra ψα-continuous function.

Proof: Let V be any closed set in (Z, η). Since g is totally continuous, $g^{-1}(V)$ is clopen in (Y,σ) which implies that $g^{-1}(V)$ is closed in (Y,σ). Since f is contra ψα-continuous,$(g \circ f)^{-1}(V) = f^{-1}(g^{-1}(V))$ is ψα-open in (X,τ). Hence g o f is a contra ψα-continuous function.

Proposition 3.22 If f:(X,τ)→(Y,σ) is a contra ψα-continuous function and g:(Y,σ)→(Z, η) is a ψα- totally continuous function, then g o f :(X,τ) →(Z,η) is a contra ψα-continuous function.

Proof: Let V be any closed set in (Z, η). By result 2.2 V is ψα-closed in (Z, η). Since g is ψα-totally continuous, $g^{-1}(V)$ is clopen in (Y,σ) which implies that $g^{-1}(V)$ is closed in (Y,σ). Since f is contra ψα-continuous, $(g \circ f)^{-1}(V) = f^{-1}(g^{-1}(V))$ is ψα-open in (X,τ). Hence g o f is a contra ψα-continuous function.

Proposition 3.23 If f:(X,τ)→(Y,σ) is a totally ψα-continuous function and g:(Y,σ)→(Z, η) is a completely continuous function, then g o f :(X,τ) →(Z,η) is a contra ψα-continuous function.

Proof: Let V be any open set in (Z, η). Since g is completely continuous, $g^{-1}(V)$ is regular open in (Y,σ). By result 2.2, $g^{-1}(V)$ is open in (Y,σ). Since f is totally ψα-continuous, $(g \circ f)^{-1}(V) = f^{-1}(g^{-1}(V))$ is ψα-clopen in (X,τ) which implies that $(g \circ f)^{-1}(V)$ is ψα-closed in (X,τ). Hence g o f is a contra ψα-continuous function.

Proposition 3.24 If f:(X,τ)→(Y,σ) is a contra continuous function and g:(Y,σ)→(Z, η) is a continuous function, then g o f :(X,τ) →(Z,η) is a contra ψα-continuous function.

Proof: Let V be any open set in (Z, η). Since g is continuous, $g^{-1}(V)$ is open in (Y,σ). Since f is contra continuous, $(g \circ f)^{-1}(V) = f^{-1}(g^{-1}(V))$ is closed in (X,τ). By result 2.2, $(g \circ f)^{-1}(V)$is ψα-closed in (X,τ). Hence g o f is a contra ψα-continuous function.

Remark3.25 The composition of two contra ψα-continuous functions need not be a contra ψα-continuous function as seen from the following example.

Example 3.26 Let X=Y = Z ={a,b,c}, τ = {ϕ, {a}, {a,b},X} and σ = {ϕ,{a,b},Y},η ={ϕ, {a}, Z}. Let f: (X,τ)→(Y,σ) be a function defined by f(a) = c, f(b) = b ,f(c) =a and g: (Y,σ)→(Z, η)be a function defined by g(a) = c, g(b) = b , g(c) =a. Then the functions f and g are contra ψα-continuous,but their composition g o f : (X,τ) →(Z,η) is not contra ψα-continuous, since for the closed set {b,c}in (Z,η), $(g \circ f)^{-1}$ ({b,c})={b,c} is not ψα-open in (X,τ).

4. ALMOST CONTRA ψα-CONTINUOUS FUNCTIONS

Definition 4.1A function f: (X,τ) →(Y,σ) is called **almost contra ψα-continuous** if $f^{-1}(V)$ is ψα-closed in (X,τ) for every regular open set V of (Y,σ).

Example 4.2 Let X=Y={a,b,c}, τ ={ϕ,{a},{a,b},X} and σ={ϕ,{a},{b},{a,b},Y}. Let f: (X,τ)→(Y,σ) be afunction defined by f(a)=c, f(b)=b, f(c)=a. Then f isa almost contra ψα-continuous function.

Theorem 4.3 A function f: (X,τ) →(Y,σ) is almost contra ψα-continuous if and only if the inverse image of every regular open subset of (Y,σ) is ψα-closed in (X,τ) .

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Proof:(Necessity) Let f:(X,τ) →(Y,σ) be almost contra ψα-continuous. Let V be any regular open set in (Y,σ). Then Y-V is regular closed in (Y,σ).Since f is almost contra ψα-continuous, f^{-1}(Y -V) = X - f^{-1}(V) is ψα-open in (X,τ) which implies that f^{-1}(V) is ψα-closed in (X,τ).

(Sufficiency): Let U be any regular closed set in (Y,σ). Then Y-U is regular open in (Y,σ). By assumption, f^{-1}(Y -U) = X - f^{-1}(U) is ψα-closed in (X,τ) which implies that f^{-1}(U) is ψα-open in (X,τ). Hence f is almost contra ψα-continuous.

Proposition 4.4 Every contra ψα-continuous function is aalmost contra ψα- continuous function but not conversely.
Proof: Let V be any regular open set in (Y,σ). By result 2.2, V is open in (Y,σ). Since f is contra ψα-continuous, f^{-1}(V) is ψα-closed in (X,τ). Hence f is almost contra ψα-continuous.

Example 4.5 Let X = Y = {a,b,c},τ = {ϕ,{a},{b},{a,b},X}and σ = {ϕ,{a},{b},{a,b},{a,c},Y}. Let f: (X,τ)→(Y,σ) be the identity function . Then f is almost contra ψα-continuous but not contra ψα-continuous, since for the open set {a,b} in(Y,σ), f^{-1}({a,b}) = {a,b} is not ψα-closed in (X,τ).

Proposition 4.6 Every contra continuous function is a almost contra ψα-continuous function but not conversely.

Proof: Let V be any regular open set in (Y,σ). By result 2.2, V is open in (Y,σ). Since f is contra continuous, f^{-1}(V) is closed in (X,τ). By result 2.2, f^{-1}(V) is ψα-closed in(X,τ).Hence f is almost contra ψα-continuous.

Example 4.7 Let X=Y={a,b,c},τ ={ϕ,{a},{a,b},X}and σ={ϕ,{a},{b},{a,b},Y}. Letf:(X,τ)→(Y,σ) be a function defined by f(a)=c,f(b)=b,f(c)=a. Then f is almost contra ψα-continuous but not contra continuous, since for the open set {b} in(Y,σ), f^{-1}({b}) = {b} is not closed in (X,τ).

Proposition 4.8 Every totally ψα-continuous function is aalmost contra ψα-continuous function but not conversely. **Proof:** Let V be any regular open set in (Y,σ).By result 2.2, V is open in (Y,σ). Since f is totally ψα- continuous, f^{-1}(V) is ψα- clopen in (X,τ) which implies that f^{-1}(V) is ψα- closed in (X,τ). Hence f is almost contra ψα-continuous.

Example 4.9 Let X = Y = {a,b,c},τ = {ϕ,{a},{b},{a,b},{a,c},X} and σ = {ϕ,{a},{b},{a,b},Y}. Let f: (X,τ)→(Y,σ) be a function defined by f(a)=c, f(b)=b, f(c)=a. Then f is almost contra ψα-continuous but not totally ψα-continuous, since for the open set {a} in(Y,σ), f^{-1}({a}) = {c} is not ψα-clopen in (X,τ).

Proposition 4.10 Every ψα-totally continuous function is a almost contra ψα-continuous functionbut not conversely

.**Proof:** Let V be any regular open set in (Y,σ).By result 2.2, V is open in (Y,σ) which implies that V is ψα-open in (Y,σ). Since f is ψα-totally continuous, f^{-1}(V) is clopen in (X,τ).By result 2.2, f^{-1}(V) is ψα- clopen in (X,τ) which implies that f^{-1}(V) is ψα-closed in (X,τ). Hence f is almost contra ψα-continuous.

Example 4.11 Let X =Y ={a,b,c},τ ={ϕ,{a},{a,b},X} and σ ={ϕ,{a},{b},{a,b},Y}. Let f:(X,τ)→(Y,σ) be a function defined by f(a)=c, f(b)=b, f(c)=a. Then f is almost contra ψα- continuous but not ψα- totally continuous, since for the ψα-open set {a,c} in(Y,σ), f^{-1}({a,c}) = {a,c} is not clopen in (X,τ).

Proposition 4.12 Every totally continuous function is a almost contra ψα-continuous function but not conversely.

Proof: Let V be any regular open set in (Y,σ).By result 2.2, V is open in (Y,σ). Since f is totally continuous, f^{-1}(V) is clopen in (X,τ).By result 2.2,f^{-1}(V) is ψα- clopen in (X,τ) which implies that f^{-1}(V) is ψα-closed in (X,τ). Hence f is almost contra ψα-continuous.

Example 4.13 Let X = Y = {a,b,c},τ = {ϕ,{a},{b},{a,b},X} and σ = {ϕ,{a},{b,c},Y}. Let f:(X,τ)→(Y,σ) be the identity function. Then f is almost contra ψα- continuous but not totally continuous, since for the open set {a} in(Y,σ), f^{-1}({a}) = {a} is not clopen in (X,τ).

Proposition 4.14 If f:(X,τ)→(Y,σ) is aalmost contra ψα-continuous function and g:(Y,σ)→(Z, η) is a completely continuous function, then g o f :(X,τ) →(Z,η) is aalmost contra ψα-continuousfunction.

Proof: Let V be any regular open set in (Z, η). By result 2.2, V is open in (Z, η).Since g is completely continuous function, g^{-1}(V) is regular open in (Y,σ). Since f is almost contra ψα- continuous, $(g \circ f)^{-1}(V) = f^{-1}(g^{-1}(V))$ is ψα-closed in (X,τ). Hence g o f is a almost contra ψα- continuous function.

Proposition 4.15 If f:(X,τ)→(Y,σ) is a contra ψα-continuous function and g:(Y,σ)→(Z, η) is aalmost continuous function, then g o f :(X,τ) →(Z,η) is a almost contra ψα-continuous function.

Proof: Let V be any regular open set in (Z, η).Since g is almost continuous, g^{-1}(V) is open in (Y,σ).Since f is contra ψα continuous,$(g \circ f)^{-1}(V) = f^{-1}(g^{-1}(V))$ is ψα-closed in (X,τ). Hence g o f is a almost contra ψα-continuous function.

Proposition 4.16 If f:(X,τ)→(Y,σ) is a almost contra ψα-continuous function and g:(Y,σ)→(Z, η) is a completely continuous function, then g o f :(X,τ) →(Z,η) is a contra ψα-continuous function.

Proof: Let V be any open set in (Z, η). Since g is completely continuous, g^{-1}(V) is regular open in (Y,σ). Since f is almost contra ψα-continuous, $(g \circ f)^{-1}(V) = f^{-1}(g^{-1}(V))$ is ψα-closed in (X,τ). Hence g o f is a contra ψα-continuous function.

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