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**KARAKTERISTIKE SLOŽENIH  
KOMBINERA U DVA TRENUTKA  
VREMENA U PRISUSTVU FEDINGA**

**doktorska disertacija**

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Faculty of Electronic Engineering



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**CHARACTERISTICS OF COMPLEX  
COMBINERS AT TWO TIME INSTANTS IN  
THE PRESENCE OF FADING**

**doctoral dissertation**

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# Podaci o mentoru i članovima komisije

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# Podaci o doktorskoj disertaciji

## Naslov doktorske disertacije:

Karakteristike složenih kombinera u dva trenutka vremena u prisustvu fedinga

## Rezime:

U ovoj disertaciji se razmatraju performanse bežičnih telekomunikacionih sistema u prisustvu šuma, smetnji i fedinga kada se semplovanje vrši u dva trenutka vremena. Cilj upotrebe ovakve metode je poboljšanje pouzdanosti i povećanje kapaciteta bez povećanja snage prenosa i prenosnog opsega, u odnosu na klasične kombinere kada se semplovanje vrši u jednom trenutku vremena.

Tokom prenosa digitalno moduliranih signala kroz komunikacione kanale dolazi do fluktuacija amplitude prijemnog signala u tokom kratkotrajnih vremenskih intervala. Ova pojava se naziva feding. Ukupan feding u sistemu je kompleksna kombinacija fedinga usled interferencije između dve ili više komponenti signala koje se prostiru po različitim putanjama i efekta senke. Efikasna i pritom isplativa tehnika za prevazilaženje fedinga i poboljšanje performansi jeste diverziti prenos. Ova tehnika se zasniva na slučajnoj prirodi prostiranja signala, tako što se za dobijanje korisnog signala koriste signali dobijeni iz različitih grana prijemnika. Ukoliko signal na jednoj putanji oslabi, u određenom trenutku na drugoj putanji on može biti jači, pa se zbog postojanja većeg broja putanja mogu značajno poboljšati performanse sistema. U ovom radu će biti predstavljena kombinacija prostornog diverzita i semplovanja signala u dva vremenska trenutka.

Kombinovanje sa selekcijom (SC) i kombinovanje sa prebacivanjem (SSC) predstavljaju jednostavne i široko korišćene tehnike, gde se za razliku od kombinovanja sa maksimalnim odnosom (MRC) i kombinovanja sa istom težinom (EGC), procesira samo jedna grana prijemnika. Kada se koristi SC tehnika kombinovanja, signal na izlazu jednak je najboljoj vrednosti signala na ulazu u kombiner. U slučaju SSC kombinera sa dve grane, najpre se ispituje jedna grana i ona ostaje selektovana sve dok je vrednost signala ili odnosa signal-šum veća od unapred definisanog praga. Kada je vrednost signala prve grane manja od praga odlučivanja, kombiner prelazi na drugu granu.

U disertaciji se razmatra SSC kombiner sa dva ulaza u dva vremenska trenutka. Verovatnoća događaja da kombiner prvo ispituje signal na nekom od ulaza je ista kao kod SSC kombinera u kome se razmatra jedan vremenski trenutak, i ona zavisi od funkcija raspodele verovatnoće za vrednost praga odlučivanja u ulaznim kanalima SSC kombinera. Pretpostavlja se da signali nisu korelisani između grana prijemnika, što je veoma čest slučaj u mobilnim komunikacijama, a da postoji korelacija između signala u jednoj grani u dva vremenska trenutka. Na osnovu odlučivanja SSC kombinera u dva trenutka vremena dobijeni su izrazi za združenu gustinu raspodele verovatnoće signala na izlazu SSC kombinera u dva trenutka vremena za Rayleigh-jev, Nakagami-m, Rice-ov, Weibull-ov, log-normalni i gamma feding, na osnovu kojih će se mogu dobiti parametri koji karakterišu performanse složenog SSC/SC kombinera.

Gustine raspodele verovatnoće izvoda signala na izlazima iz SSC kombinera u dva trenutka vremena biće definisane za različite tipove fedinga. Za Rayleigh-jev, Nakagami-m, Rice-ov i log-normalni feding, izvodi signala imaju normalnu raspodelu sa nultom srednjom vrednošću i nekorelisani su kako međusobno u dva vremenska trenutka, tako i sa samim signalom. Za Weibull-ovu i gamma raspodelu izvodi signala takođe imaju normalnu raspodelu, ali varijansa izvoda zavisi od vrednosti signala, što je pokazano u literaturi. I u ovom slučaju se može uzeti da su izvodi signala međusobno nekorelisani.

Performanse složenog SSC/SC prijemnika u dva trenutka vremena se mogu dobiti kada signali na izlazu iz SSC kombinera predstavljaju ulaze u SC kombiner. Za Rayleigh-jev, Nakagami-m, Rice-ov, Weibull-ov, log-normalni i gamma feding se dobijaju izrazi za gustinu raspodele verovatnoće i verovatnoću otkaza na izlazu iz složenog SSC/SC kombinera. Verovatnoća otkaza i srednja verovatnoća greške po bitu ili simbolu su najčešće korišćeni parametri za merenje performansi SSC i SC diverziti sistema. Ipak u određenim telekomunikacionim bežičnim sistemima ovi parametri ne obezbeđuju dovoljno informacija za projektovanje i konfigurisanje sistema, pa se koriste i parametri drugog reda kao što su

srednja učestanost preseka nivoa i srednje trajanje otkaza. Ovo naročito važi za proračun brzine prenosa po simbolu, dužinu paketa i trajanje vremenskog slota. U ovoj disertaciji će biti predstavljene karakteristike drugog reda SSC/SC prijemnika. Na osnovu izraza za gustine raspodele verovatnoće izvoda signala na izlazima iz SSC kombinera u dva trenutka vremena i izraza za združenu gustinu raspodele verovatnoće signala na izlazu, biće dobijene vrednosti za srednju učestanost preseka nivoa. Takođe će upotrebom srednje učestanosti preseka nivoa i verovatnoće otkaza biti izveden izraz za srednje trajanje otkaza.

Predložena tema je aktuelna sa naučnog stanovišta, jer sa razvojem mobilne telefonije i bežičnih telekomunikacija, primena ovih sistema u prenosu telekomunikacionih signala postaje sve zastupljenija. Rezultati izloženi u ovoj disertaciji mogu imati i praktičnu primenu.

**Ključne reči:**

Feding, kombinovanje, gustina raspodele verovatnoće, karakteristike drugog reda, verovatnoća otkaza, SSC kombiner, SC kombiner.

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# Doctoral dissertation information

## Doctoral dissertation title:

Characteristics of complex combiners at two time instants in the presence of fading

## Abstract:

Performances of wireless telecommunications systems in the presence of noise, interference and fading when the sampling is done at two time instants are discussed in this dissertation. The goal of using this method is to improve reliability and increase capacity without increasing the transmission power and transmission bandwidth, compared to conventional combiner when sampling is done at one time instant.

During the transmission of digitally modulated signals through communication channels some fluctuations in the amplitude of the received signal during short time intervals may occur. This phenomenon is called fading. Total fading in the system is defined as a complex combination of fading due to interference between two or more components of the signal arriving from different paths and shadowing. Efficient and at the same time cost-effective technique for reduce of fading and performance improvement are the diversity combining technique. This technique is based on the random nature of the signal propagation, since the useful signal is obtained using signals obtained from different branches of the receiver. If the signal on one path is attenuated, at some specific moment the same signal that goes through a different path can be stronger. In this way the existence of a more than one path can

significantly improve system performances. In this study, the combination of the spatial diversity and sampling signals at two time points will be presented.

Selection combining (SC) and switch and stay combining (SSC) represent simple and widely used techniques process only one branch of the receiver, opposed to maximum ratio combining (MRC) and equal gain combining (EGC) that use all the received signals. When using the SC combining technique, the signal at the output is equal to the highest value of the combiner's input signal. In the case of the SSC combiner with two branches, one branch is selected, and it remains selected until the value of the signal or the signal to noise ratio stays greater than a predefined threshold. When the signal value of the first branch is less than the threshold, the combiner switches to another branch.

In this dissertation the SSC combiner with two inputs at two time instants is discussed. The probability of events that combiner first analyse the signal from one of the inputs is the same as for SSC combiner which considers one time instant, and it depends on the probability distribution functions for the given threshold value at the input channels of the SSC combiner. It is assumed that the signals are not correlated between the branches of the receiver, which is the common case in mobile communications, and that there is a correlation between the signals in one branch at the two different time instants. According to the SSC combiner decision-making at two time instants, the expressions for the joint probability density functions of the signals at the output of the SSC combiner at two time instants for Rayleigh's, Nakagami-m, Rice's, Weibull, log-normal and gamma fading are obtained. In this way, one can obtain parameters that characterize the performance of a complex SSC/SC combiner.

Probability density functions for the signal derivatives at the SSC combiner output at two time instances will be defined for several different fading types. For Rayleigh's, Nakagami-m, Rice's and log-normal fading, signal derivatives have normal distribution with zero mean, and they are mutually uncorrelated at two time instants, as well as with the signal itself. For Weibull and gamma distribution signal derivatives also have a normal distribution, while the variance of the derivative depends on the value of the signal, as shown in the literature. In this case it could be assumed that the signal derivatives are mutually uncorrelated.

Performances of complex SSC/SC receiver at two time instants can be obtained when the signals at the output of the SSC combiner are used as the inputs of the SC combiner. For Rayleigh's, Nakagami-m, Rice's, Weibull, log-normal and gamma fading, one can obtain expressions for probability density function and outage probability at the output of the complex SSC/SC combiner. Outage probability and the average bit or symbol error rate are



the most commonly used parameters for performance measures of the SSC and SC diversity system. However, in certain telecommunication wireless systems, these parameters do not provide sufficient information for the design and configuration of the system, and the second order statistics parameters are used instead, such as level crossing rate and average fade duration. This is particularly important for the calculation of the transfer speed per symbol, the length of the packet and the duration of the time slots. In this dissertation, it will be presented the second order statistics of SSC/SC receiver. Using the expressions for joint probability density function for the signal and the signal derivative at the output of the SSC combiner at two time instants, the expression for level crossing rate will be obtained. The average fade duration can be obtained using the level crossing rate and the outage probability.

The subject of this dissertation is a very topical from a scientific point of view, because with the development of mobile and wireless telecommunications, the use of these systems in the transmission of telecommunications signals significantly increases. Results presented in this thesis can have many practical applications.

**Keywords:**

Fading, combining, probability density function, second order characteristics, outage probability, SSC combiner, SC combiner.

**Scientific area:**

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# 1 Uvod

U ovoj disertaciji se razmatraju performanse bežičnih telekomunikacionih sistema u prisustvu šuma, smetnji i fedinga kada se odmeravanje vrši u dva trenutka vremena. Cilj upotrebe ovakve metode je poboljšanje pouzdanosti i povećanje kapaciteta bez povećanja snage prenosa i prenosnog opsega, u odnosu na klasične kombinere kada se odmeravanje vrši u jednom trenutku vremena.

Tokom prenosa digitalno modulisanih signala kroz komunikacione kanale dolazi do fluktuacija amplitude prijemnog signala u toku kratkog vremenskog intervala. Ova pojava se naziva feding [1]-[3]. Ukupan feding u sistemu je kompleksna kombinacija fedinga usled interferencije između dve ili više komponenti signala koje se prostiru po različitim putanjama i efekta senke. Feding koji nastaje zbog prostiranja duž više putanja je relativno brz i odgovoran je za kratke varijacije signala, dok usled efekta senke dolazi do sporijih varijacija nivoa srednje vrednosti signala. Efikasna i pritom isplativa tehnika za prevazilaženje fedinga, i samim tim poboljšanje performansi, predstavlja diverziti prenos [1], [4]. Ova tehnika se zasniva na slučajnoj prirodi prostiranja signala, tako što se za dobijanje korisnog signala koriste signali dobijeni iz različitih grana prijemnika. Ukoliko signal na jednoj putanji oslabi, u određenom trenutku na drugoj putanji on može biti jači, pa se zbog postojanja većeg broja putanja mogu značajno poboljšati performanse sistema. Postoje vremenski, prostorni i frekventni diverziti. U mobilnim telekomunikacionim sistema se najčešće koriste prostorni diverziti. Vršer se razne vrste kombinovanja signala koji se pojavljuju na ulazu u diverziti sistem. Kombinovanje može biti predeteksiono i posledeteksiono. U ovom radu će biti

predstavljena kombinacija prostornog diverzita i odmeravanja signala u dva vremenska trenutka.

U radu će detaljno biti razmatran uticaj brzog fedinga nastao zbog prostiranja signala po više puteva i sporog efekta senke na performanse sistema. Amplituda signala na ulazu u prijemnik ima Rayleigh-jevu gustinu raspodele verovatnoće ako postoji više komponenti signala sa približno konstantnim amplitudama i sa uniformno raspodeljenim fazama [5]. Do Rice-ovog fedinga dolazi kada se na prijemu pojavljuje dominantna komponenta koja je najčešće direktni talas [6]. U urbanim sredinama, zbog složenih refleksija sistema, amplituda signala ima Nakagami-m gustinu verovatnoće [1]. Weibull-ovom raspodelom se može predstaviti amplituda fedinga usled prostiranja signala po više putanja, naročito za mobilne telekomunikacione sisteme koji rade u frekventnom opsegu 800/900 MHz [7],[8]. Osim brzog fedinga, pri prostiranju signala može doći i do pojave efekta senke, kada su promene amplitude signala spore. U ovom slučaju amplituda signala ima log-normalnu raspodelu [9], [10]. Gamma raspodela se može koristiti za modelovanje efekta senke umesto log-normalne, zbog lakšeg matematičkog određivanja karakteristika sistema, naročito kod složenih raspodela fedinga, gde istovremeno deluju i brzi feding i efekat senke [11].

Kombinovanje sa selekcijom (selection combining - SC) i kombinovanje sa prebacivanjem (switch and stay - SSC) predstavljaju jednostavne i široko korišćene tehnike, gde se za razliku od kombinovanja sa maksimalnim odnosom (maximal ratio combining - MRC) i kombinovanja sa istom težinom (equal gain combining - EGC), procesira samo jedna grana prijemnika [1].

Kada se koristi SC tehnika kombinovanja, signal na izlazu jednak je najboljoj vrednosti signala na ulazu u kombiner. Sagias i ostali su analizirali karakteristike SC prijemnika sa dve grane u prisustvu nekorelisanih Weibull feding kanala sa različitim parametrima raspodele u [12], a u prisustvu korelisanih kanala u [13]. Dobili su u zatvorenom obliku izraze za gustinu raspodele verovatnoće, verovatnoću otkaza i momente odnosa signal-šum.

U slučaju SSC kombiner sa dve grane, kombiner prvo ispituje jednu granu i ona ostaje selektovana sve dok je vrednost signala ili odnosa signal-šum na njoj veća od unapred definisanog praga, čak i kada je vrednost signala, tj. odnosa signal-šum, na drugoj grani veća od vrednosti na prvoj [1], [14]. Kada je vrednost signala na prvoj grani manja od praga odlučivanja, kombiner prelazi na drugu granu, i ostaje na njoj sve dok vrednost ulaznog signala ne padne ispod praga.

Verovatnoća otkaza i srednja verovatnoća greške po bitu ili simbolu su najčešće korišćeni parametri za merenje performansi SSC i SC diverziti sistema. Ipak, u određenim

bežičnim telekomunikacionim sistemima, kao što su adaptivni i kodirani prenosni sistemi, ovi parametri ne obezbeđuju dovoljno informacija za projektovanje i konfigurisanje sistema. U tom slučaju se koriste i parametri drugog reda kao što su srednja učestanost preseka nivoa i srednje trajanje otkaza, naročito za proračun brzine prenosa po simbolu, dužine paketa i trajanje vremenskog slota.

Gustine raspodele verovatnoće izvoda signala na izlazima iz SSC kombinera u dva trenutka vremena će takođe biti definisane. Na sličan način kao i za signale biće razmatrane različite raspodele fedinga.

Za Rayleigh-jev, Nakagami-m, Rice-ov i log-normalni feding, izvodi signala imaju normalnu raspodelu sa nultom srednjom vrednošću i nekorelisani su kako međusobno u dva vremenska trenutka, tako i sa samim signalom [15],[16]. Varijansa izvoda za ove raspodele zavisi od varijanse signala i od maksimalne Doppler-ove frekvencije. Za Weibull-ovu [17], i gamma raspodelu [18],[19] izvodi signala takođe imaju normalnu raspodelu, ali varijansa izvoda zavisi od vrednosti signala. I u ovom slučaju se može smatrati da su izvodi signala međusobno nekorelisani.

Karakteristike drugog reda za SC kombiner su analizirali Yang i Alouni u [18] i dali analitički metod za procenu srednjeg broja osnih preseka (level crossing rate - LCR) i srednje trajanje otkaza (average outage duration - AOD) za generalizovani SC kombiner sa nezavisnim kanalima, koji ne moraju da imaju identične raspodele, a zatim je data detaljnija analiza za nezavisne feding kanale sa identičnom Rayleigh-jevom raspodelom. U [20] Chakraborty i Yong dobijaju LCR i AOD za SC kombiner u prisustvu nekorelisano i identičnog Rayleigh-jevog fedinga na ulaznim granama.

Mitić i Stefanović su u [21] dobili LCR i AOD za prenosni SC prijemnik u prisustvu složenog fedinga koji se sastoji od Rice-ovog fedinga i efekta senke, za nezavisne grane sa istim parametrima feding kanala.

Yang i Alouni su u [15] dobili izraze u zatvorenom obliku za LCR i AOD za SSC kombinere. Rezultati su prilično opšti i primenljivi na sisteme sa dve grane sa istim ili različitim pragovima, sa nezavisnim feding kanalima koji ne moraju da imaju identične raspodele. Upoređeni su LCR i AOD za SSC i SC kombinere i pokazano je da za odgovarajući izbor praga odluke, SSC obezbeđuje manji AOD od SC, ali sa većim LCR, odnosno frekvencijom otkaza. U radovima autora disertacije sa kolegama analizirane su karakteristike drugog reda SSC kombinera za različite tipove fedinga [22]-[28].

Složeni kombineri u dva trenutka vremena nisu mnogo razmatrani u dostupnoj literaturi, osim u radovima grupe autora među kojima je i autor disertacije. U radovima [29]-[31] su

analizirane karakteristike SSC kombinera u dva trenutka vremena i dobijeni izrazi za združene gustine raspodele verovatnoće na izlazu iz kombinera u dva trenutka vremena. Parametri prvog reda SSC/SC kombinera su dati u radovima [32], [33], dok su u [34]-[39] određene karakteristike prvog reda (verovatnoća otkaza i verovatnoća greške po bitu) za SSC/MRC kombiner u dva trenutka vremena. Karakteristike drugog reda za SSC kombiner u dva trenutka vremena su predstavljene u radovima [40]-[42], a za složeni SSC/SC kombiner u prisustvu Rice-ovog fedinga u [43].

U drugoj glavi ove doktorske disertacije biće dat kratak prikaz osnovnih karakteristika i parametara bežičnih digitalnih prenosnih sistema u prisustvu fedinga. U poglavlju 2.1. biće predstavljeni osnovni parametri feding kanala, kao i njihova klasifikacija. U narednom poglavlju će biti prikazane statističke veličine kojima se opisuju karakteristike bežičnih prenosnih sistema u prisustvu fedinga. U poglavlju 2.3. će biti izložen sažeti prikaz diverziti tehnika za poboljšanje karakteristika bežičnih telekomunikacionih sistema u kanalima sa fedingom, dok će različiti osnovni i hibridni tipovi diverziti sistema biti opisani u poglavlju 2.4. Odmeravanje signala u digitalnim bežinim telekomunikacionim sistemima će ukratko biti prikazano u poglavlju 2.5.

U trećoj glavi disertacije razmatra se SSC kombiner sa dva ulaza i sa odmeravanjem u dva vremenska trenutka. Verovatnoće događaja da kombiner prvo ispituje signal na prvom i na drugom ulazu su iste kao za SSC kombiner sa odmeravanjem u jednom vremenskom trenutku i zavise od funkcija raspodele verovatnoće za vrednost praga odlučivanja u ulaznim kanalima SSC kombinera. Pretpostavlja se da signali nisu korelisani između grana prijemnika, što je veoma čest slučaj u mobilnim komunikacijama, a da postoji korelacija između signala u jednoj grani u dva vremenska trenutka. Zavisno od vrednosti signala na ulazima u SSC kombiner u dva trenutka vremena moguća su četiri slučaja. Ako kombiner prvo ispituje signal na prvom ulazu u prvom trenutku vremena i vrednost signala je iznad praga, SSC kombiner propušta signal sa prvog ulaza za prvi vremenski trenutak u kolo za odlučivanje i razmatra vrednost signala na prvoj grani u drugom vremenskom trenutku. Ako je vrednost signala na prvom ulazu iznad praga, onda se i u drugom trenutku bira signal sa prve grane, a ako je ispod praga, SSC kombiner u drugom trenutku vremena propušta signal sa drugog ulaza u kolo za odlučivanje, bez obzira da li njegova vrednost iznad ili ispod praga. Ako je vrednost signala na prvom ulazu u prvom trenutku vremena ispod praga, onda na kolo za odlučivanje ide signal sa drugog ulaza, koji se prvo ispituje i u drugom trenutku vremena. Ako je i tada iznad praga, SSC kombiner u drugom trenutku vremena propušta signal sa drugog ulaza a ako je ispod praga u kolo za odlučivanje ide signal sa prvog ulaza. Ako SSC

kombiner prvo ispituje signal sa druge grane, logika odlučivanja je ekvivalentna slučaju kada se prvo ispituje prvi signal. Na osnovu odlučivanja SSC kombinera u dva trenutka vremena će biti dobijeni izrazi za združenu gustinu raspodele verovatnoće signala na izlazu SSC kombinera u dva trenutka vremena za Rayleigh-jev, Nakagami-m, Rice-ov, Weibull-ov, log-normalni i gamma feding, na osnovu kojih će se dobiti parametri koji karakterišu performanse složenog SSC/SC kombinera.

Četvrta glava je posvećena dobijanju karakteristika drugog reda SSC kombinera u dva trenutka vremena. Biće dobijeni izrazi za združene gustine raspodele verovatnoće signala i njihovih izvoda na izlazu iz kombinera u dva vremenska trenutka i za gustine raspodele verovatnoće izvoda signala za raspodele kod kojih signal i izvod nisu korelisani. Rezultati će biti dobijeni pod pretpostavkom da su signali u prvom i drugom vremenskom trenutku u jednoj grani kombinera međusobno nekorelisani. Na osnovu opštih izraza će biti analiziran sistem u prisustvu Rayleigh-jevog, Nakagami-m, Rice-ovog, log-normalnog i Weibull-ovog fedinga.

U petoj glavi će biti dobijeni parametri složenog SSC/SC prijemnika u dva trenutka vremena, kada signali na izlazu iz SSC kombinera razmatranog u trećoj glavi predstavljaju ulaze u SC kombiner. Za Rayleigh-jev i log-normalni feding koji predstavljaju brze i spore fedinge, biće dobijeni izrazi za gustinu raspodele verovatnoće i verovatnoću otkaza na izlazu iz složenog SSC/SC kombinera. Na osnovu gustine raspodele verovatnoće signala se mogu dobiti i momenti signala, veličina fedinga i verovatnoća greške po bitu, odnosno simbolu. Verovatnoće otkaza će biti grafički predstavljene, da bi se pokazala opravdanost upotrebe složenog SSC/SC kombinera u dva trenutka vremena u odnosu na klasične SSC i SC kombinere i jednokanalni prijemnik. Biće prikazana i zavisnost karakteristika sistema na izlazu od korelacije između signala u jednoj grani prijemnika između dva vremenska trenutka i kako korist od korišćenja složenog kombinera zavisi od njihove međusobne korelacije.

U šestoj glavi biće predstavljene karakteristike drugog reda SSC/SC prijemnika. Na osnovu rezultata za združene gustine raspodele verovatnoće signala i izvoda signala na izlazima iz SSC kombinera u dva trenutka vremena i izraza za združenu gustinu raspodele verovatnoće signala na izlazu, biće dobijene vrednosti za srednju učestanost preseka nivoa. Takođe će upotrebom srednje učestanosti preseka nivoa i verovatnoće otkaza biti dobijeno srednje vreme trajanja otkaza.

Na kraju je dat zaključak u kome su sumirani glavni rezultati i doprinosi ove doktorske disertacije, kao i pregled korišćene literature.



## 2 Karakteristike prostiranja signala u prisustvu fedinga

Prilikom prostiranja signala kroz bežične komunikacione sisteme dolazi do degradacije performansi sistema usled više različitih efekata, kao što su prostiranje signala po više putanja i efekat senke [1], koji predstavljaju veoma komplikovane pojave. Precizan matematički opis ovih pojava je ili nepoznat ili previše komplikovan za odgovarajuću sistemsku analizu, tako da se za njihovo proučavanje uvode statistički modeli feding kanala koji opisuju prostiranje signala kroz ovakve bežične komunikacione sisteme [44].

### 2.1 Bežični prenos signala u prisustvu fedinga

Feding je jedan od glavnih uzroka degradacije performansi u bežičnim telekomunikacijama. U tipičnom bežičnom komunikacionom sistemu postoji više putanja signala između predajnika i prijemnika zbog rasejavanja (scattering) o različite objekte. Ti signali imaju različita slabljenja, distorzije, kašnjenja i fazne pomeraje. U prijemniku se može javiti interferencija ovih signala, koja će biti konstruktivna ili destruktivna u zavisnosti od njihove faze u trenutku superponiranja. Destruktivna interferencija izaziva značajno smanjenje snage signala. Ovaj fenomen poznat je kao feding i izaziva degradaciju performansi sistema. Vrlo često, ne samo da postoje različite putanje prenosa, već se one menjaju u vremenu. Što dovodi do vremenski promenljivog fedinga, što dodatno otežava komunikaciju, s obzirom da je ovakav feding teško modelovati [45].

Feding se može klasifikovati na više načina [44]. Ukoliko je širina frekventnog spektra signala mala u poredjenju sa širinom frekventnog opsega u okviru kojeg je feding korelisan,

radi se o ravnom ili frekventno neselektivnom fedingu, gde sve frekventne komponente signala podležu istom nivou fedinga. U tom slučaju je trajanje simbola veliko u poređenju sa vremenom u okviru koga je feding korelisan. Može se smatrati da je signal u prijemniku kopija jednog signala čije su amplituda i faza određeni superpozicijom svih kopija signala koje stižu tokom vremena. U slučaju frekventno selektivnog fedinga, komponente signala različite frekvencije podležu različitom stepenu fedinga. Kašnjenje signala je mnogo veće od trajanja simbola, pa se primaju višestruke kopije signala.

U slučaju sporog fedinga, trajanje simbola je malo u odnosu na vreme u toku kojeg je feding korelisan. Ovakav feding se razmatra posmatranjem kanala tokom više vremenskih trenutaka, pri čemu su parametri kanala sporo promenljivi i mogu biti dobro procenjeni. U suprotnom se radi o brzom ili vremenski selektivnom fedingu, kod koga je teško proceniti parametre kanala. Može se zaključiti da ove klasifikacije zavise od karakteristika samog signala.

U bežičnom prenosu signala, i anvelopa i faza signala podležu fedingu tokom vremena. Dok fazne fluktuacije degradiraju performanse samo u koherentnim prijemnicima, s obzirom da informacije o fazi nisu potrebne kod nekoherentnih prijemnika, anvelopa fedinga utiče na karakteristike obe vrste prijemnika [1].

U zavisnosti od izgleda gustine raspodele anvelope fedinga, u literaturi postoji više modela fedinga. Dugotrajne varijacije signala opisuju se log-normalnom raspodelom, koja se može aproksimirati gamma raspodelom, radi lakših proračuna karakteristika prenosnih sistema. Kratkotrajne se opisuju nizom drugih raspodela, kao što je Rayleigh-ova, Rice-ova, Nakagami-m, ili Weibull-ova, koja je prvobitno bila namenjena teoriji pouzdanosti, pa joj se poklanjala u početki mala pažnja u teoriji telekomunikacija. Generalno je prihvaćeno da se ove raspodele koriste kada je dimenzija prostora na kome se javlja feding reda veličine nekoliko hiljada talasnih dužina, a log-normalna i gamma raspodele se koriste na većim površinama. Nijedna od navedenih raspodela se ne slaže u potpunosti sa eksperimentalnim rezultatima, mada se u blizini srednje vrednosti javlja dosta dobro slaganje. Dobro poznate raspodele fedinga izvedene su za slučajeve homogeno rasporedjenih polja rasejavanja, što je posledica slučajne raspodele objekata od kojih se vrši rasejanje. Ova pretpostavka je samo aproksimacija, jer se u praksi javljaju nehomogena okruženja.

## 2.2 Statističke veličine za opisivanje karakteristika sistema

Momenti signala su veličine koje su korisne za izračunavanje ostalih osnovnih parametara sistema.  $N$ -ti moment signala je [35]:

$$E[r^n] = \int_0^{\infty} r^n p_r(r) dr \quad (2.2.1)$$

Veličina fedinga predstavlja meru osetljivosti sistema na uticaj fedinga za definisani model kanala i zavisi od trenutne vrednosti signala, a ne od snage fedinga. Veličina fedinga se definiše kao u [36]:

$$AF = \frac{E[r^2] - (E[r])^2}{(E[r])^2} = \frac{E[r^2]}{(E[r])^2} - 1 \quad (2.2.2)$$

Verovatnoća otkaza predstavlja verovatnoću da trenutna vrednost verovatnoće greške pređe određenu vrednost, odnosno da signal na izlazu iz kombinera padne ispod predefinisanih praga  $r_{th}$  [7] i upotrebljava se kao kriterijum za procenu performansi diverziti sistema koji vrše ekstrakciju signala iz feding kanala. Može se prikazati u integralnom obliku, u zavisnosti od gustine raspodele verovatnoće signala

$$P_{out} = P[r \leq r_{th}] \quad (2.2.3)$$

$$P_{out} = \int_0^{r_{th}} p_r(r) dr \quad (2.2.4)$$

Srednja učestanost preseka nivoa (Level crossing rate – LCR) je učestanost kojom signal preseca određeni nivo,  $r_{th}$  i definiše se kao broj prolazaka trenutne vrednosti signala u jedinici vremena, kroz zadati nivo  $r_{th}$  i može se prikazati sledećom jednakošću [37]:

$$N(r_{th}) = \int_0^{\infty} \dot{r} p_{r,\dot{r}}(r_{th}, \dot{r}) d\dot{r} \quad (2.2.5)$$

gde je  $p_{r,\dot{r}}(r_{th}, \dot{r})$  združena gustina raspodele verovatnoće signala i njegovog izvoda.

Srednje trajanje otkaza (Average outage duration – AOD) je srednje vreme za koje je vrednost signala ispod zadanog nivoa  $r_{th}$ , odnosno u stanju otkaza ili nezadovoljavajućeg prijema i određuje se kao odnos verovatnoće otkaza i srednje učestanosti preseka nivoa [38]:

$$T(r_{th}) = \frac{P_{out}}{N(r_{th})} \quad (2.2.6)$$

## 2.3 Diverziti sistemi

Za poboljšanje karakteristika bežičnih telekomunikacionih sistema u kanalima sa fedingom se upotrebljavaju različite diverziti tehnike [44], [46]. Povećanje ukupnog odnosa signal-šum na izlazu prijemnika, kao i povećanje verovatnoće donošenja korektne odluke o prenetom signalu se postiže prenosom L kopija željenog signala po M različitih kanala umesto prenosa signala po jednom kanalu. Dok su neke kopije podložne dubokom fedingu u jednom trenutku, druge nisu sa velikom verovatnoćom, tako da se više kopija signala se mogu dobiti ekstrakcijom signala iz različitih bežičnih putanja, na osnovu čega se razlikuju diverziti tehnike [1], [44]:

### 1) Frekvencijski diverziti

Signal se prenosi upotrebom M različitih frekvencijskih opsega. Nosioци su međusobno pomereni najmanje za frekventni opseg  $(\Delta f)c$  u kome je feding korelisan, tako da su različite kopije međusobno nezavisne u pogledu fedinga. U prijemniku se kombinuje L nezavisnih kopija signala sa fedingom da bi se dobio statistički optimalni signal za odlučivanje. Ova tehnika se uglavnom koristi za frekventno selektivni feding [44].

### 2) Vremenski diverziti

Više kopija istog signala se prenosi u M različitih perioda vremena tj. svaki simbol se prenosi M puta. Intervali između prenošenja istog simbola treba da budu veći ili jednaki vremenu koherencije  $(\Delta t)c$ , tako da su različite kopije međusobno nezavisne u pogledu fedinga. Optimalno kombinovanje postiže se MRC kombinerom. Može se zapaziti i da slanje istog simbola M puta odgovara trivijalnom kodovanju. Takođe, može se koristiti i netrivialno kodovanje sa kontrolom greške i interleaving. Ova tehnika je pogodna za vremenski selektivni (brzi) feding [44].

### 3) Prostorni diverziti

M kopija signala koji se prenosi po različitim prostornim putanjama, dok se pri prijemu koristi M antena. One se moraju nalaziti na dovoljnom rastojanju da bi primljene kopije

signala bile nezavisne u pogledu fedinga. Za razliku od frekventnog i vremenskog diverzita ne zahteva se dodatni napor u predajniku, niti dodatni propusni opseg i dodatno vreme prenosa. Ipak, fizičke smetnje ograničavaju njegovu upotrebu. Ponekad se koristi i veći broj antena na predaji. Prostorni diverzitet je pogodan i za frekventno selektivni feding i za vremenski selektivni feding [44].

#### 4) Polarizacioni diverziteti

Kopije signala se emituju i primaju antenama sa različitom polarizacijom. Na ovaj način, postiže se efekat diverzita s obzirom da vertikalno i horizontalno polarisane komponente podležu različitom stepenu fedinga. Prednosti u odnosu na prostorni diverzitet su što se antene mogu instalirati jedna pored druge na istom mestu i nije potreban dodatni spektar. Osnovne mane su što se mogu realizovati samo sistemi sa dve grane i što se emitovanje vrši snagom za 3 dB većom nego kod ostalih tehnika, jer se signalom napajaju obe polarizacione antene u predajniku [44].

#### 5) Ugaoni (direkcionni) diverziteti

Primljeni signal sastoji se od komponenti nastalih refleksijom, difrakcijom ili rasejanjem, koje dolaze iz različitih pravaca (uglova). Korišćenjem jako usmerenih antena, moguće je razložiti primljeni signal na veći broj signala, koji se mogu smatrati međusobno nezavisnim signalima sa fedingom, čime se ostvaruje diverziteti prijem [44].

#### 6) Diverziteti po putanjama

U slučaju ove tehnike se vrši razlaganje direktne komponente i zakašnjenih komponenti i njihovo koherentno kombinovanje. Tipičan primer je RAKE prijemnik (ovaj prijemnik podseća na grabulje jer poseduje krak za svaku komponentu primljenog signala) [44].

## 2.4 Tehnike za kombinovanje

Primena diverziteti sistema je jedna od najefikasnijih metoda za prevazilaženje degradacija signala nastalih usled fedinga. U prijemnicima diverziteti sistema se vrši kombinovanje više kopija signala koji se prenosi, a koje podležu fedingu na međusobno nezavistan način, čime se uvećava ukupna primljena snaga signala. Kombinovanje u diverziteti sistemima je efikasan način da se poboljša odnos signal-šum (SNR) primljenog signala, zato što signal na izlazu iz

kombinera ima veći SNR nego SNR u svim pojedinačnim granama prijemnika. Postoji više osnovnih i hibridnih metoda za izdvajanje korisnog signala [47]. Različiti tipovi diverziteti sistema zahtevaju različite tehnike kombinovanja. Najčešće se primenju sledeći tipovi kombinovanja [1], [44]:

1) MRC - Kombinovanje sa maksimalnim odnosom

(maximal ratio combining - MRC) je optimalna komunikaciona tehnika u odsustvu interferencije, nezavisno od karakteristika fading kanala. Ova tehnika zahteva kompleksan kombiner, jer je potrebno poznavati sve fading parametre kanala. Grane kombinera su ponderisane tako da se dobije maksimalni SNR. Kad postoje dva ulaza, gustina verovatnoće odnosa snage signala i šuma na izlazu iz kombinera jednaka je konvoluciji gustina verovatnoća odnosa snage signala i šuma na njegovim ulazima. Zbog neophodnosti poznavanja parametara fading kanala ova tehnika je pogodna za primenu sistemima u kojima se koriste amplitudna i fazna modulacija, dok je manje praktična za sisteme sa diferencijalnom koherentnom i nekoherentnom detekcijom.

2) EGC - Kombinovanje sa istom težinom

(equal gain combining - EGC) tehnika kombinovanja je slična MRC tehnici, ali je manje efikasna od nje. Često se koristi, jer ne zahteva određivanje vrednosti fading amplitude, tako da je kombinovanje manje kompleksno od MRC tehnike, uz nešto slabije rezultate.

3) SC - Kombinovanje sa selekcijom

(selection combining - SC) procesira samo jednu granu prijamnika u jednom vremenskom trenutku, za razliku od MRC i EGC, koji vrše obradu na osnovu kopija signala u svim granama. U slučaju SC kombinera bira se grana sa najvećim odnosom signal-šum. SC se uglavnom koristi sa diferencijalnom koherentnom i nekoherentnom detekcijom, jer ne zahteva poznavanje faza signala u granama kombinera.

4) SSC, SEC - Kombinovanje sa prebacivanjem

(switch and stay combining - SSC, switch and examine combinig - SEC) su pogodne za primenu kod sistema sa neprekidnim prenosom. Da bi se izbeglo simultano i kontinualno praćenje stanja na svim granama, SC se često zamenjuje ovom tehnikom. U ovom slučaju prijemnik nije uvek vezan za najbolju granu, već je vezan na istu granu, sve dok SNR te grane ne padne ispod praga. Kad se to desi, prijemnik jednostavno bira sledeću granu. S ovim pristupom, prijemnik u bilo kom trenutku prati stanje na trenutno selektovanoj grani. Ovim se

smanjuje kompleksnost u odnosu na SC, ali dolazi do izvesnog gubitka kvaliteta. Osnovni problem je izbor optimalnog praga dovoljno visokog da spreči da se uvek skida signal sa iste grane i dovoljno niskog da se izbegne kontinualno prebacivanje izmedju grana. Pokazuje se da postoji optimalni prag u pogledu minimalnog BER-a i zavisi od srednje snage fedinga.

#### 5) GSC - Generalizovane diverziti tehnike

(Generalized Diversity Techniques - GSC) predstavljaju hibridne tehnike kombinovanja i uvedene su zbog velikog povećanja složenosti MRC i EGC prijemnika sa povećanjem broja grana. U ovom slučaju GSC između grana prijemnika adaptivno kombinuje (MRC ili EGC tehnikom) grana sa najvećim odnosom signal-šum na prijemu. Ove tehnike se označavaju kao SC/MRC ili SC/EGC .

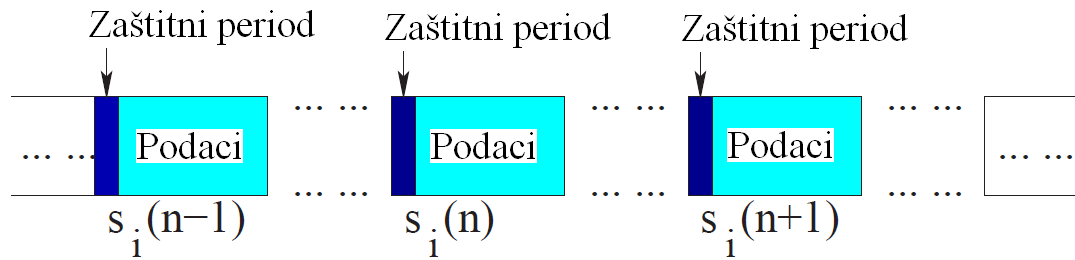
#### 6) Multidimenzionalne diverziti tehnike

Ove tehnike uključuju kombinaciju dva ili više načina za postizanje diverziti efekta, kao na primer prostorni i diverzitet po putanjama u cilju dobijanja boljih karakteristika prijemnika. Jedan od primera je prenos u širokopojasnoj CDMA tehnici gde u prijemniku postoje dvodimenzionalni RAKE prijemnici. RAKE prijemnici se sastoje od polja antena od kojih je svaka praćena konvencionalnim RAKE prijemnikom. Ovakav način prenosa se može generalizovati na istovremenu primenu prostornog, frekvencijskog i diverzita po putanjama.

## 2.5 Odmeravanje signala u prijemnicima bežičnih telekomunikacionih sistema

Vremenski okvir kod bežičnog prenosa digitalnih podataka se može podeliti na zaštitne periode u kojima nema prenosa korisnih podataka i sistem vrši neophodna podešavanja i periode za prenos podataka [48]. Na slici 2.5.1. je prikazana struktura vremenskog okvira kod bežičnog prenosa podataka.

Za ovakve sisteme važi da se kombinovanje u prijemnicima vrši jedino za vreme zaštitnih perioda. U svakom zaštitnom periodu prijemnik vrši procenu stanja kanala i obavlja proračune, na osnovu kojih donosi odluku, koja za SSC kombiner predstavlja granu sa koje se signal prenosi na izlaz iz kombinera, odnosno da li će doći do prebacivanja sa grane na granu. Ovaj princip važi i za uplink i za downlink.



Slika 2.5.1. Struktura vremenskog okvira kod bežičnog prenosa podataka

Sistem radi pod pretpostavkama da je fading sporo promenljiv, tako da se može smatrati da je raspodela fadinga ista kao u prethodnom zaštitnom periodu, kao i da su signali za vreme dva sukcesivna zaštitna perioda skoro nezavisni.

U klasičnim prijemnicima se odmeravanje signala na ulaznim granama prijemnika vrši jednom u svakom zaštitnom periodu. U ovoj disertaciji će biti predstavljen sistem u kome se odmeravanje vrši dva puta u toku jednog zaštitnog intervala, gde signali na ulazu jedne grane u dva trenutka vremena mogu biti korelisani.



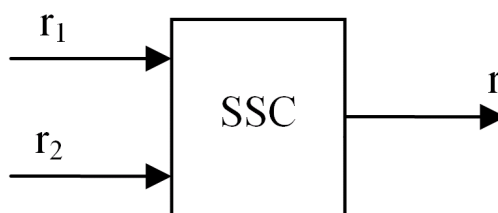
### 3 Karakteristike SSC kombinera

Kombinovanje sa prebacivanjem (SSC) je pokušaj uprošćavanja složenosti sistema, ali sa gubitkom performansi u odnosu na složenije tipove diverziti prijemnika. U ovom slučaju prijemnik selektuje jednu antenu sve dok kvalitet signala na njenom ulazu ne padne ispod nekog predefinisano je praga. Kada se to desi, prijemnik se prebacuje na drugu antenu i koristi podatke sa nje u sledećem semplu, bez obzira na to da li je kvalitet signala na anteni iznad ili ispod predefinisano je praga. Razmatranje SSC sistema u literaturi je ograničeno na manje kompleksne mobilne jedinice gde broj diverziti antena obično ograničen na 2 [14], [49], [50]. Ovo uzrokuje smanjenje kompleksnosti u odnosu na SC kombinere, jer nije potrebno istovremeno pratiti obe grane prijemnika.

#### 3.1 Model sistema u jednom trenutku vremena

Razmatra se SSC kombiner sa dva ulaza. Model ovog sistema je prikazan na slici 3.1.1. Verovatnoća događaja da kombiner prvo ispituje signal na prvom ulazu je  $P_1$ , a na drugom ulazu je  $P_2$ . Ako kombiner prvo ispituje signal na prvom ulazu i vrednost signala  $r_1$  je iznad praga  $r_T$ , SSC kombiner propušta signal u kolo za odlučivanje. Ako je vrednost signala na prvom ulazu ispod praga  $r_T$ , SSC kombiner propušta signal sa drugog ulaza u kolo za odlučivanje, bez obzira da li je  $r_2$  iznad ili ispod predefinisano je praga. Ako SSC kombiner prvo ispituje signal sa druge grane, logika odlučivanja je ekvivalentna prvom slučaju. Prvo se ispituje signal na drugom ulazu i ako je vrednost signala  $r_2$  iznad praga  $r_T$ , SSC kombiner propušta signal u kolo za odlučivanje, a ako je vrednost signala na drugom ulazu ispod praga

$r_T$ , SSC kombiner propušta signal sa prvog ulaza u kolo za odlučivanje, bez obzira da li je  $r_I$  iznad ili ispod predefinisano praga.



Slika 3.1.1. Model SSC kombinera sa dva ulaza u jednom trenutku vremena

Izraz za gustinu raspodele verovatnoće signala na izlazu iz kombinera će prvo biti određen za slučaj  $r < r_T$ . Na osnovu algoritma rada SSC kombinera u ovom slučaju, gustina raspodele verovatnoće je:

$$p_r(r) = P_1 F_{r_1}(r_T) p_{r_2}(r) + P_2 F_{r_2}(r_T) p_{r_1}(r) \quad (3.1.1)$$

Za slučaj  $r \geq r_T$ , gustina raspodele verovatnoće na izlazu iz kombinera je:

$$p_r(r) = P_1 p_{r_1}(r) + P_1 F_{r_1}(r_T) p_{r_2}(r) + P_2 p_{r_2}(r) + P_2 F_{r_2}(r_T) p_{r_1}(r) \quad (3.1.2)$$

gde je  $r_T$  prag odluke, a kumulativne raspodele verovatnoće su date kao [1]:

$$F_{r_1}(r_T) = \int_0^{r_T} p_{r_1}(x) dx \quad (3.1.3)$$

$$F_{r_2}(r_T) = \int_0^{r_T} p_{r_2}(x) dx \quad (3.1.4)$$

Verovatnoće  $P_1$  i  $P_2$  su [1]:

$$P_1 = P_1 (1 - F_{r_1}(r_T)) + P_2 F_{r_2}(r_T) \quad (3.1.5)$$

$$P_2 = P_2 (1 - F_{r_2}(r_T)) + P_1 F_{r_1}(r_T) \quad (3.1.6)$$

Na osnovu (3.1.5-6) dobijaju se  $P_1$  i  $P_2$  u zavisnosti od kumulativne raspodele verovatnoće:

$$P_1 = \frac{F_{r_2}(r_T)}{F_{r_1}(r_T) + F_{r_2}(r_T)} \quad (3.1.7)$$

$$P_2 = \frac{F_{r_1}(r_T)}{F_{r_1}(r_T) + F_{r_2}(r_T)} \quad (3.1.8)$$

### 3.2 Model sistema u dva trenutka vremena

U ovom poglavlju se razmatra SSC kombiner sa dve grane u dva trenutka vremena. Model sistema je prikazan na slici 3.2.1. Signali na ulazima su  $r_{11}$  i  $r_{21}$  u prvom trenutku vremena, a  $r_{12}$  i  $r_{22}$  u drugom trenutku vremena. Signali na izlazu su  $r_1$  i  $r_2$ . Indeksi za ulazne signale su: prvi indeks je broj grane, a drugi razmatran vremenski trenutak. Za izlazni signal, indeks predstavlja razmatrani vremenski trenutak. Verovatnoća da kombiner prvo razmatra signal na prvoj grani je  $P_1$ , a na drugoj je  $P_2$ .

Za  $r_1 < r_T, r_2 < r_T$

U ovom slučaju svi signali su manji od praga  $r_T$ , odnosno:  $r_{11} < r_T, r_{12} < r_T, r_{21} < r_T, r_{22} < r_T$ . Neka kombiner prvo razmatra signal  $r_{11}$ . Pošto je  $r_{11} < r_T$ , onda je  $r_1 = r_{21}$ , a kako je  $r_{22} < r_T$ , onda je  $r_2 = r_{12}$ . Verovatnoća ovog događaja je  $P_1$ . Kada kombiner prvo razmatra signal  $r_{21}$ , onda važi da je  $r_{21} < r_T, r_1 = r_{11}$ , kao i  $r_{21} < r_T, r_2 = r_{22}$ . Verovatnoća ovog događaja je  $P_2$ .

$$- r_{11} < r_T, r_{21} < r_T, r_{22} < r_T, r_{12} < r_T, r_1 = r_{21} \quad r_2 = r_{12} \quad P_1$$

$$- r_{21} < r_T, r_{11} < r_T, r_{12} < r_T, r_{22} < r_T, r_1 = r_{11} \quad r_2 = r_{22} \quad P_2$$

Za  $r_1 \geq r_T, r_2 < r_T$

Moguće kombinacije su:

$$- r_{11} \geq r_T, r_{12} < r_T, r_{22} < r_T, r_1 = r_{11} \quad r_2 = r_{22} \quad P_1$$

$$- r_{11} < r_T, r_{21} \geq r_T, r_{22} < r_T, r_{12} < r_T, r_1 = r_{21} \quad r_2 = r_{12} \quad P_1$$

$$- r_{21} \geq r_T, r_{22} < r_T, r_{12} < r_T, r_1 = r_{21} \quad r_2 = r_{12} \quad P_2$$

$$- r_{21} < r_T, r_{11} \geq r_T, r_{12} < r_T, r_{22} < r_T, r_1 = r_{11} \quad r_2 = r_{22} \quad P_2$$

Za  $r_1 < r_T, r_2 \geq r_T$

Moguće kombinacije su:

$$- r_{11} < r_T, r_{21} < r_T, r_{22} \geq r_T, r_1 = r_{21} \quad r_2 = r_{22} \quad P_1$$

$$- r_{11} < r_T, r_{21} < r_T, r_{22} < r_T, r_{12} \geq r_T, r_1 = r_{21} \quad r_2 = r_{12} \quad P_1$$

$$- r_{21} < r_T, r_{11} < r_T, r_{12} \geq r_T, r_1 = r_{11} \quad r_2 = r_{12} \quad P_2$$

$$- r_{21} < r_T, r_{11} < r_T, r_{12} < r_T, r_{22} \geq r_T, r_1 = r_{11} \quad r_2 = r_{22} \quad P_2$$

Za  $r_1 \geq r_T, r_2 \geq r_T$

Moguće kombinacije su:

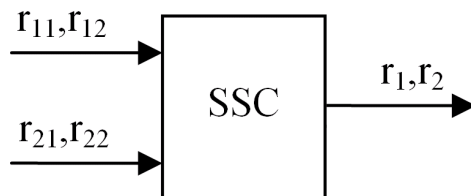
$$- r_{11} \geq r_T, r_{12} \geq r_T, r_1 = r_{11} \quad r_2 = r_{12} \quad P_1$$

$$- r_{11} \geq r_T, r_{12} < r_T, r_{22} \geq r_T, r_1 = r_{11} \quad r_2 = r_{22} \quad P_1$$

$$- r_{11} < r_T, r_{21} \geq r_T, r_{22} \geq r_T, r_1 = r_{21} \quad r_2 = r_{22} \quad P_1$$

$$- r_{11} < r_T, r_{21} \geq r_T, r_{22} < r_T, r_{12} \geq r_T, r_1 = r_{21} \quad r_2 = r_{12} \quad P_1$$

- $r_{21} \geq r_T$ ,	$r_{22} \geq r_T$ ,	$r_1 = r_{21}$	$r_2 = r_{22}$	$P_2$
- $r_{21} \geq r_T$ ,	$r_{22} < r_T$ , $r_{12} \geq r_T$ ,	$r_1 = r_{21}$	$r_2 = r_{12}$	$P_2$
- $r_{21} < r_T$ , $r_{11} \geq r_T$ ,	$r_{12} \geq r_T$ ,	$r_1 = r_{11}$	$r_2 = r_{12}$	$P_2$
- $r_{21} < r_T$ , $r_{11} \geq r_T$ ,	$r_{12} < r_T$ , $r_{22} \geq r_T$ ,	$r_1 = r_{11}$	$r_2 = r_{22}$	$P_2$



Slika 3.2.1. Model SSC kombinera sa dva ulaza u dva trenutka vremena

Za  $r_1 < r_T$ ,  $r_2 < r_T$

$$p_{r_1 r_2}(r_1, r_2) = P_1 \int_0^{r_T} dr_{11} \int_0^{r_T} dr_{22} p_{r_{11} r_{22} r_{21} r_{12}}(r_{11}, r_{22}, r_1, r_2) + P_2 \int_0^{r_T} dr_{21} \int_0^{r_T} dr_{12} p_{r_{21} r_{12} r_{11} r_{22}}(r_{21}, r_{12}, r_1, r_2) \quad (3.2.1)$$

Za  $r_1 \geq r_T$ ,  $r_2 < r_T$

$$p_{r_1 r_2}(r_1, r_2) = P_1 \int_0^{r_T} dr_{12} p_{r_{12} r_{11} r_{22}}(r_{12}, r_1, r_2) + P_1 \int_0^{r_T} dr_{11} \int_0^{r_T} dr_{22} p_{r_{11} r_{22} r_{21} r_{12}}(r_{11}, r_{22}, r_1, r_2) + P_2 \int_0^{r_T} dr_{22} p_{r_{22} r_{21} r_{12}}(r_{22}, r_1, r_2) + P_2 \int_0^{r_T} dr_{21} \int_0^{r_T} dr_{12} p_{r_{21} r_{12} r_{11} r_{22}}(r_{21}, r_{12}, r_1, r_2) \quad (3.2.2)$$

Za  $r_1 < r_T$ ,  $r_2 \geq r_T$

$$p_{r_1 r_2}(r_1, r_2) = P_1 \int_0^{r_T} dr_{11} p_{r_{11} r_{21} r_{22}}(r_{11}, r_1, r_2) + P_1 \int_0^{r_T} dr_{11} \int_0^{r_T} dr_{22} p_{r_{11} r_{22} r_{21} r_{12}}(r_{11}, r_{22}, r_1, r_2) + P_2 \int_0^{r_T} dr_{21} p_{r_{21} r_{11} r_{12}}(r_{21}, r_1, r_2) + P_2 \int_0^{r_T} dr_{21} \int_0^{r_T} dr_{12} p_{r_{21} r_{12} r_{11} r_{22}}(r_{21}, r_{12}, r_1, r_2) \quad (3.2.3)$$

Za  $r_1 \geq r_T$ ,  $r_2 \geq r_T$

$$p_{r_1 r_2}(r_1, r_2) = P_1 p_{r_{11} r_{12}}(r_1, r_2) + P_1 \int_0^{r_T} dr_{12} p_{r_{12} r_{11} r_{22}}(r_{12}, r_1, r_2) + P_1 \int_0^{r_T} dr_{11} p_{r_{11} r_{21} r_{22}}(r_{11}, r_1, r_2) + P_1 \int_0^{r_T} dr_{11} \int_0^{r_T} dr_{22} p_{r_{11} r_{22} r_{21} r_{12}}(r_{11}, r_{22}, r_1, r_2) +$$

$$\begin{aligned}
& + P_2 p_{r_{21}r_{22}}(r_1, r_2) + P_2 \int_0^{r_T} dr_{22} p_{r_{22}r_{21}r_{12}}(r_{22}, r_1, r_2) + \\
& + P_2 \int_0^{r_T} dr_{21} p_{r_{21}r_{12}r_{12}}(r_{21}, r_1, r_2) + P_2 \int_0^{r_T} dr_{21} \int_0^{r_T} dr_{12} p_{r_{21}r_{12}r_{12}r_{22}}(r_{21}, r_{12}, r_1, r_2)
\end{aligned} \quad (3.2.4)$$

Kada su signali na ulazu u grane kombinera nekorelisani, PDF se može predstaviti u obliku:

Za  $r_1 < r_T, r_2 < r_T$

$$p_{r_1 r_2}(r_1, r_2) = P_1 \int_0^{r_T} p_{r_{11}r_{12}}(r_{11}, r_2) dr_{11} \int_0^{r_T} p_{r_{22}r_{21}}(r_{22}, r_1) dr_{22} + P_2 \int_0^{r_T} p_{r_{21}r_{22}}(r_{21}, r_2) dr_{21} \int_0^{r_T} p_{r_{12}r_{11}}(r_{12}, r_1) dr_{12} \quad (3.2.5)$$

Za  $r_1 \geq r_T, r_2 < r_T$

$$\begin{aligned}
p_{r_1 r_2}(r_1, r_2) = & P_1 p_{r_{22}}(r_2) \int_0^{r_T} p_{r_{12}r_{11}}(r_{12}, r_1) dr_{12} + P_1 \int_0^{r_T} p_{r_{11}r_{12}}(r_{11}, r_2) dr_{11} \int_0^{r_T} p_{r_{22}r_{21}}(r_{22}, r_1) dr_{22} + \\
& + P_2 p_{r_{12}}(r_2) \int_0^{r_T} p_{r_{22}r_{21}}(r_{22}, r_1) dr_{22} + P_2 \int_0^{r_T} p_{r_{21}r_{22}}(r_{21}, r_2) dr_{21} \int_0^{r_T} p_{r_{12}r_{11}}(r_{12}, r_1) dr_{12}
\end{aligned} \quad (3.2.6)$$

Za  $r_1 < r_T, r_2 \geq r_T$

$$\begin{aligned}
p_{r_1 r_2}(r_1, r_2) = & P_1 \int_0^{r_T} p_{r_{11}}(r_{11}) dr_{11} p_{r_{21}r_{22}}(r_1, r_2) + P_1 \int_0^{r_T} p_{r_{11}r_{12}}(r_{11}, r_2) dr_{11} \int_0^{r_T} p_{r_{22}r_{21}}(r_{22}, r_1) dr_{22} + \\
& + P_2 \int_0^{r_T} p_{r_{21}}(r_{21}) dr_{21} p_{r_{11}r_{12}}(r_1, r_2) + P_2 \int_0^{r_T} p_{r_{21}r_{22}}(r_{21}, r_2) dr_{21} \int_0^{r_T} p_{r_{12}r_{11}}(r_{12}, r_1) dr_{12}
\end{aligned} \quad (3.2.7)$$

Za  $r_1 \geq r_T, r_2 \geq r_T$

$$\begin{aligned}
p_{r_1 r_2}(r_1, r_2) = & P_1 p_{r_{11}r_{12}}(r_1, r_2) + P_1 p_{r_{22}}(r_2) \int_0^{r_T} p_{r_{12}r_{11}}(r_{12}, r_1) dr_{12} + \\
& + P_1 \int_0^{r_T} p_{r_{11}}(r_{11}) dr_{11} p_{r_{21}r_{22}}(r_1, r_2) + P_1 \int_0^{r_T} p_{r_{11}r_{12}}(r_{11}, r_2) dr_{11} \int_0^{r_T} p_{r_{22}r_{21}}(r_{22}, r_1) dr_{22} + \\
& + P_2 p_{r_{21}r_{22}}(r_1, r_2) + P_2 p_{r_{12}}(r_2) \int_0^{r_T} p_{r_{22}r_{21}}(r_{22}, r_1) dr_{22} + \\
& + P_2 \int_0^{r_T} p_{r_{21}}(r_{21}) dr_{21} p_{r_{11}r_{12}}(r_1, r_2) + P_2 \int_0^{r_T} p_{r_{21}r_{22}}(r_{21}, r_2) dr_{21} \int_0^{r_T} p_{r_{12}r_{11}}(r_{12}, r_1) dr_{12}
\end{aligned} \quad (3.2.8)$$

### 3.3 Zdužena gustina raspodele verovatnoće na izlazu SSC kombinera u dva trenutka vremena u prisustvu Rayleigh-jevog fedinga

Gustina raspodele verovatnoće i kumulativna raspodela verovatnoće (CDF) signala na ulazima u grane kombinera  $r_{i,j}$  u prisustvu Rayleigh-jevog fedinga su [5]:

$$p_{r_i}(r_{i,j}) = \frac{r_{i,j}}{\sigma_i^2} e^{-\frac{r_{i,j}^2}{2\sigma_i^2}} \quad , \quad r_{i,j} \geq 0 \quad (3.3.1)$$

$$F_{r_i}(r_{i,j}) = 1 - e^{-\frac{r_{i,j}^2}{2\sigma_i^2}} \quad , \quad r_{i,j} \geq 0 \quad (3.3.2)$$

gde su  $i=1,2$   $j=1,2$  i  $\sigma$  je standardna devijacija raspodele.

Verovatnoće  $P_1$  i  $P_2$  se dobijaju ako se u (3.1.17-18) stavi (3.3.2):

$$P_1 = \frac{F_{r_2}(r_T)}{F_{r_1}(r_T) + F_{r_2}(r_T)} = \frac{1 - e^{-\frac{r_T^2}{2\sigma_2^2}}}{2 - \left( e^{-\frac{r_T^2}{2\sigma_1^2}} + e^{-\frac{r_T^2}{2\sigma_2^2}} \right)} \quad (3.3.3)$$

$$P_2 = \frac{F_{r_1}(r_T)}{F_{r_1}(r_T) + F_{r_2}(r_T)} = \frac{1 - e^{-\frac{r_T^2}{2\sigma_1^2}}}{2 - \left( e^{-\frac{r_T^2}{2\sigma_1^2}} + e^{-\frac{r_T^2}{2\sigma_2^2}} \right)} \quad (3.3.4)$$

Zdužena gustina raspodele verovatnoće korelisanih signala  $x_1$  i  $x_2$  sa Rayleigh-jevom raspodelom i istim parametrom  $\sigma$  je [19]:

$$p_{x_1 x_2}(x_1, x_2) = \frac{x_1 x_2}{\sigma^4 (1 - \rho^2)} e^{-\frac{x_1^2 + x_2^2}{2\sigma^2 (1 - \rho^2)}} I_0 \left( \frac{\rho x_1 x_2}{\sigma^2 (1 - \rho^2)} \right) \quad (3.3.5)$$

gde je  $\rho$  koeficijent korelacije, a  $I_0(\ )$  je modifikovana Bessel-ova funkcija prve vrste nultog reda [51].

Zdužena gustina raspodele verovatnoće signala  $r_1$  i  $r_2$  na izlazu SSC kombinera u dva trenutka vremena u prisustvu Rayleigh-jevog fedinga kada su signali na ulazu u grane kombinera nezavisni, može se dobiti ako se u (3.2.5-8) stave izrazi (3.3.1) i (3.3.5), gde su  $P_1$  i  $P_2$  definisane sa (3.2.3-4):

Za  $r_1 < r_T, r_2 < r_T$

$$\begin{aligned}
& p_{\eta r_2}(r_1, r_2) = \\
& = P_1 \int_0^{r_T} \frac{r_{11} r_2}{\sigma_1^4 (1 - \rho_1^2)} e^{-\frac{r_1^2 + r_2^2}{2\sigma_1^2 (1 - \rho_1^2)}} I_0 \left( \frac{\rho_1 r_{11} r_2}{\sigma_1^2 (1 - \rho_1^2)} \right) dr_{11} \int_0^{r_T} \frac{r_{22} r_1}{\sigma_2^4 (1 - \rho_2^2)} e^{-\frac{r_{22}^2 + r_1^2}{2\sigma_2^2 (1 - \rho_2^2)}} I_0 \left( \frac{\rho_2 r_{22} r_1}{\sigma_2^2 (1 - \rho_2^2)} \right) dr_{22} + \\
& + P_2 \int_0^{r_T} \frac{r_{21} r_2}{\sigma_2^4 (1 - \rho_2^2)} e^{-\frac{r_{21}^2 + r_2^2}{2\sigma_2^2 (1 - \rho_2^2)}} I_0 \left( \frac{\rho_2 r_{21} r_2}{\sigma_2^2 (1 - \rho_2^2)} \right) dr_{21} \int_0^{r_T} \frac{r_{12} r_1}{\sigma_1^4 (1 - \rho_1^2)} e^{-\frac{r_{12}^2 + r_1^2}{2\sigma_1^2 (1 - \rho_1^2)}} I_0 \left( \frac{\rho_1 r_{12} r_1}{\sigma_1^2 (1 - \rho_1^2)} \right) dr_{12}
\end{aligned} \tag{3.3.6}$$

Za  $r_1 \geq r_T, r_2 < r_T$

$$\begin{aligned}
& p_{\eta r_2}(r_1, r_2) = P_1 \frac{r_2}{\sigma_2^2} e^{-\frac{r_2^2}{2\sigma_2^2}} \int_0^{r_T} \frac{r_{12} r_1}{\sigma_1^4 (1 - \rho_1^2)} e^{-\frac{r_{12}^2 + r_1^2}{2\sigma_1^2 (1 - \rho_1^2)}} I_0 \left( \frac{\rho_1 r_{12} r_1}{\sigma_1^2 (1 - \rho_1^2)} \right) dr_{12} + \\
& + P_1 \int_0^{r_T} \frac{r_{11} r_2}{\sigma_1^4 (1 - \rho_1^2)} e^{-\frac{r_{11}^2 + r_2^2}{2\sigma_1^2 (1 - \rho_1^2)}} I_0 \left( \frac{\rho_1 r_{11} r_2}{\sigma_1^2 (1 - \rho_1^2)} \right) dr_{11} \int_0^{r_T} \frac{r_{22} r_1}{\sigma_2^4 (1 - \rho_2^2)} e^{-\frac{r_{22}^2 + r_1^2}{2\sigma_2^2 (1 - \rho_2^2)}} I_0 \left( \frac{\rho_2 r_{22} r_1}{\sigma_2^2 (1 - \rho_2^2)} \right) dr_{22} + \\
& + P_2 \frac{r_2}{\sigma_1^2} e^{-\frac{r_2^2}{2\sigma_1^2}} \int_0^{r_T} \frac{r_{22} r_1}{\sigma_2^4 (1 - \rho_2^2)} e^{-\frac{r_{22}^2 + r_1^2}{2\sigma_2^2 (1 - \rho_2^2)}} I_0 \left( \frac{\rho_2 r_{22} r_1}{\sigma_2^2 (1 - \rho_2^2)} \right) dr_{22} + \\
& + P_2 \int_0^{r_T} \frac{r_{21} r_2}{\sigma_2^4 (1 - \rho_2^2)} e^{-\frac{r_{21}^2 + r_2^2}{2\sigma_2^2 (1 - \rho_2^2)}} I_0 \left( \frac{\rho_2 r_{21} r_2}{\sigma_2^2 (1 - \rho_2^2)} \right) dr_{21} \int_0^{r_T} \frac{r_{12} r_1}{\sigma_1^4 (1 - \rho_1^2)} e^{-\frac{r_{12}^2 + r_1^2}{2\sigma_1^2 (1 - \rho_1^2)}} I_0 \left( \frac{\rho_1 r_{12} r_1}{\sigma_1^2 (1 - \rho_1^2)} \right) dr_{12}
\end{aligned} \tag{3.3.7}$$

Za  $r_1 < r_T, r_2 \geq r_T$

$$\begin{aligned}
& p_{\eta r_2}(r_1, r_2) = P_1 \left( 1 - e^{-\frac{r_T^2}{2\sigma_1^2}} \right) \frac{r_1 r_2}{\sigma_2^4 (1 - \rho_2^2)} e^{-\frac{r_1^2 + r_2^2}{2\sigma_2^2 (1 - \rho_2^2)}} I_0 \left( \frac{\rho_2 r_1 r_2}{\sigma_2^2 (1 - \rho_2^2)} \right) + \\
& + P_1 \int_0^{r_T} \frac{r_{11} r_2}{\sigma_1^4 (1 - \rho_1^2)} e^{-\frac{r_{11}^2 + r_2^2}{2\sigma_1^2 (1 - \rho_1^2)}} I_0 \left( \frac{\rho_1 r_{11} r_2}{\sigma_1^2 (1 - \rho_1^2)} \right) dr_{11} \int_0^{r_T} \frac{r_{22} r_1}{\sigma_2^4 (1 - \rho_2^2)} e^{-\frac{r_{22}^2 + r_1^2}{2\sigma_2^2 (1 - \rho_2^2)}} I_0 \left( \frac{\rho_2 r_{22} r_1}{\sigma_2^2 (1 - \rho_2^2)} \right) dr_{22} + \\
& + P_2 \left( 1 - e^{-\frac{r_T^2}{2\sigma_2^2}} \right) \frac{r_1 r_2}{\sigma_1^4 (1 - \rho_1^2)} e^{-\frac{r_1^2 + r_2^2}{2\sigma_1^2 (1 - \rho_1^2)}} I_0 \left( \frac{\rho_1 r_1 r_2}{\sigma_1^2 (1 - \rho_1^2)} \right) + \\
& + P_2 \int_0^{r_T} \frac{r_{21} r_2}{\sigma_2^4 (1 - \rho_2^2)} e^{-\frac{r_{21}^2 + r_2^2}{2\sigma_2^2 (1 - \rho_2^2)}} I_0 \left( \frac{\rho_2 r_{21} r_2}{\sigma_2^2 (1 - \rho_2^2)} \right) dr_{21} \int_0^{r_T} \frac{r_{12} r_1}{\sigma_1^4 (1 - \rho_1^2)} e^{-\frac{r_{12}^2 + r_1^2}{2\sigma_1^2 (1 - \rho_1^2)}} I_0 \left( \frac{\rho_1 r_{12} r_1}{\sigma_1^2 (1 - \rho_1^2)} \right) dr_{12}
\end{aligned} \tag{3.3.8}$$

Za  $r_1 \geq r_T, r_2 \geq r_T$

$$\begin{aligned}
p_{r_1 r_2}(r_1, r_2) = & P_1 \frac{r_1 r_2}{\sigma_1^4 (1 - \rho_1^2)} e^{-\frac{r_1^2 + r_2^2}{2\sigma_1^2 (1 - \rho_1^2)}} I_0 \left( \frac{\rho_1 r_1 r_2}{\sigma_1^2 (1 - \rho_1^2)} \right) + \\
& + P_1 \frac{r_2}{\sigma_2^2} e^{-\frac{r_2^2}{2\sigma_2^2}} \int_0^{r_1} \frac{r_{12} r_1}{\sigma_1^4 (1 - \rho_1^2)} e^{-\frac{r_{12}^2 + r_1^2}{2\sigma_1^2 (1 - \rho_1^2)}} I_0 \left( \frac{\rho_1 r_{12} r_1}{\sigma_1^2 (1 - \rho_1^2)} \right) dr_{12} + \\
& + P_1 \left( 1 - e^{-\frac{r_1^2}{2\sigma_1^2}} \right) \frac{r_1 r_2}{\sigma_2^4 (1 - \rho_2^2)} e^{-\frac{r_1^2 + r_2^2}{2\sigma_2^2 (1 - \rho_2^2)}} I_0 \left( \frac{\rho_2 r_1 r_2}{\sigma_2^2 (1 - \rho_2^2)} \right) + \\
& + P_1 \int_0^{r_1} \frac{r_{11} r_2}{\sigma_1^4 (1 - \rho_1^2)} e^{-\frac{r_{11}^2 + r_2^2}{2\sigma_1^2 (1 - \rho_1^2)}} I_0 \left( \frac{\rho_1 r_{11} r_2}{\sigma_1^2 (1 - \rho_1^2)} \right) dr_{11} \int_0^{r_2} \frac{r_{22} r_1}{\sigma_2^4 (1 - \rho_2^2)} e^{-\frac{r_{22}^2 + r_1^2}{2\sigma_2^2 (1 - \rho_2^2)}} I_0 \left( \frac{\rho_2 r_{22} r_1}{\sigma_2^2 (1 - \rho_2^2)} \right) dr_{22} + \\
& + P_2 \frac{r_1 r_2}{\sigma_2^4 (1 - \rho_2^2)} e^{-\frac{r_1^2 + r_2^2}{2\sigma_2^2 (1 - \rho_2^2)}} I_0 \left( \frac{\rho_2 r_1 r_2}{\sigma_2^2 (1 - \rho_2^2)} \right) + \\
& + P_2 \frac{r_2}{\sigma_1^2} e^{-\frac{r_2^2}{2\sigma_1^2}} \int_0^{r_1} \frac{r_{22} r_1}{\sigma_2^4 (1 - \rho_2^2)} e^{-\frac{r_{22}^2 + r_1^2}{2\sigma_2^2 (1 - \rho_2^2)}} I_0 \left( \frac{\rho_2 r_{22} r_1}{\sigma_2^2 (1 - \rho_2^2)} \right) dr_{22} + \\
& + P_2 \left( 1 - e^{-\frac{r_1^2}{2\sigma_1^2}} \right) \frac{r_1 r_2}{\sigma_1^4 (1 - \rho_1^2)} e^{-\frac{r_1^2 + r_2^2}{2\sigma_1^2 (1 - \rho_1^2)}} I_0 \left( \frac{\rho_1 r_1 r_2}{\sigma_1^2 (1 - \rho_1^2)} \right) + \\
& + P_2 \int_0^{r_1} \frac{r_{21} r_2}{\sigma_2^4 (1 - \rho_2^2)} e^{-\frac{r_{21}^2 + r_2^2}{2\sigma_2^2 (1 - \rho_2^2)}} I_0 \left( \frac{\rho_2 r_{21} r_2}{\sigma_2^2 (1 - \rho_2^2)} \right) dr_{21} \int_0^{r_2} \frac{r_{12} r_1}{\sigma_1^4 (1 - \rho_1^2)} e^{-\frac{r_{12}^2 + r_1^2}{2\sigma_1^2 (1 - \rho_1^2)}} I_0 \left( \frac{\rho_1 r_{12} r_1}{\sigma_1^2 (1 - \rho_1^2)} \right) dr_{12}
\end{aligned} \tag{3.3.9}$$

Izrazi (3.3.6-9) su u obliku jednostrukog integrala sa konačnim granicama. Združena gustina raspodele verovatnoće signala na izlazu iz SSC kombinera u dva vremenska trenutka se može dobiti u zatvorenom obliku korišćenjem Marcum-ove  $Q$ -funkcije prvog reda koja se definiše kao [1]:

$$Q_1(\alpha, \beta) = \int_{\beta}^{\infty} x \exp \left[ - \left( \frac{x^2 + \alpha^2}{2} \right) \right] I_0(\alpha x) dx \tag{3.3.10}$$

Za predstavljanje združene PDF u zatvorenom obliku potrebno je rešiti integral  $\int_{r_T}^{\infty} p_{x_1 x_2}(x_1, x_2) dx_1$ , gde je  $p_{x_1 x_2}(x_1, x_2)$  dato u (3.3.5). Transformacijom  $p_{x_1 x_2}(x_1, x_2)$ , ona se može prikazati u obliku koji u podintegralnom delu predstavlja podintegralni deo Marcum-ove  $Q$ -funkcije prvog reda.



$$x_1 = x\sigma\sqrt{1-\rho^2} \quad x = \frac{x_1}{\sigma\sqrt{1-\rho^2}} \quad (3.3.11)$$

$$x_2 = \frac{\alpha\sigma}{\rho}\sqrt{1-\rho^2} \quad \alpha = \frac{\rho x_2}{\sigma\sqrt{1-\rho^2}} \quad (3.3.12)$$

$$p_{x_1x_2}(x_1, x_2) = \frac{\alpha}{\rho\sigma^2} e^{-\frac{1-\rho^2}{2\rho^2}\alpha^2} x e^{-\frac{x^2+\alpha^2}{2}} I_0(\alpha x) \quad (3.3.13)$$

$$\begin{aligned} \int_{r_T}^{\infty} p_{x_1x_2}(x_1, x_2) dx_1 &= \frac{\alpha}{\rho\sigma^2} e^{-\frac{1-\rho^2}{2\rho^2}\alpha^2} \int_{r_T}^{\infty} x e^{-\frac{x^2+\alpha^2}{2}} I_0(\alpha x) dx_1 = \\ &= \frac{\alpha}{\rho\sigma^2} e^{-\frac{1-\rho^2}{2\rho^2}\alpha^2} \int_{\frac{r_T}{\sigma\sqrt{1-\rho^2}}}^{\infty} x e^{-\frac{x^2+\alpha^2}{2}} I_0(\alpha x) dx \sigma\sqrt{1-\rho^2} = \frac{x_2}{\sigma^2} e^{-\frac{x_2^2}{2\sigma^2}} Q_1\left(\frac{\rho x_2}{\sigma\sqrt{1-\rho^2}}, \frac{r_T}{\sigma\sqrt{1-\rho^2}}\right) \end{aligned} \quad (3.3.14)$$

Na osnovu (3.3.14) se dobija:

$$\int_0^{r_T} p_{x_1x_2}(x_1, x_2) dx_1 = \frac{x_2}{\sigma^2} e^{-\frac{x_2^2}{2\sigma^2}} \left[ 1 - Q_1\left(\frac{\rho x_2}{\sigma\sqrt{1-\rho^2}}, \frac{r_T}{\sigma\sqrt{1-\rho^2}}\right) \right] \quad (3.3.15)$$

Zamenom (3.3.15) u izrazima (3.3.6-9) dobija se konačni oblik za združenu gustinu raspodele verovatnoće na izlazu iz SSC kombinera

Za  $r_1 < r_T, r_2 < r_T$

$$\begin{aligned} p_{r_1r_2}(r_1, r_2) &= P_1 \frac{r_1}{\sigma_2} e^{-\frac{r_1^2}{2\sigma_2^2}} \frac{r_2}{\sigma_1} e^{-\frac{r_2^2}{2\sigma_1^2}} \cdot \\ &\cdot \left[ 1 - Q_1\left(\frac{\rho_2 r_1}{\sigma_2\sqrt{1-\rho_2^2}}, \frac{r_T}{\sigma_2\sqrt{1-\rho_2^2}}\right) \right] \left[ 1 - Q_1\left(\frac{\rho_1 r_2}{\sigma_1\sqrt{1-\rho_1^2}}, \frac{r_T}{\sigma_1\sqrt{1-\rho_1^2}}\right) \right] + \\ &+ P_2 \frac{r_1}{\sigma_1} e^{-\frac{r_1^2}{2\sigma_1^2}} \frac{r_2}{\sigma_2} e^{-\frac{r_2^2}{2\sigma_2^2}} \left[ 1 - Q_1\left(\frac{\rho_1 r_1}{\sigma_1\sqrt{1-\rho_1^2}}, \frac{r_T}{\sigma_1\sqrt{1-\rho_1^2}}\right) \right] \left[ 1 - Q_1\left(\frac{\rho_2 r_2}{\sigma_2\sqrt{1-\rho_2^2}}, \frac{r_T}{\sigma_2\sqrt{1-\rho_2^2}}\right) \right] \end{aligned} \quad (3.3.16)$$

Za  $r_1 \geq r_T, r_2 < r_T$

$$p_{r_1r_2}(r_1, r_2) = P_1 \frac{r_1}{\sigma_1} e^{-\frac{r_1^2}{2\sigma_1^2}} \frac{r_2}{\sigma_2} e^{-\frac{r_2^2}{2\sigma_2^2}} \left[ 1 - Q_1\left(\frac{\rho_1 r_1}{\sigma_1\sqrt{1-\rho_1^2}}, \frac{r_T}{\sigma_1\sqrt{1-\rho_1^2}}\right) \right] +$$

$$\begin{aligned}
& + P_1 \frac{r_1}{\sigma_2^2} e^{-\frac{r_1^2}{2\sigma_2^2}} \frac{r_2}{\sigma_1^2} e^{-\frac{r_2^2}{2\sigma_1^2}} \left[ 1 - Q_1 \left( \frac{\rho_2 r_1}{\sigma_2 \sqrt{1-\rho_2^2}}, \frac{r_T}{\sigma_2 \sqrt{1-\rho_2^2}} \right) \right] \left[ 1 - Q_1 \left( \frac{\rho_1 r_2}{\sigma_1 \sqrt{1-\rho_1^2}}, \frac{r_T}{\sigma_1 \sqrt{1-\rho_1^2}} \right) \right] + \\
& \quad + P_2 \frac{r_1}{\sigma_2^2} e^{-\frac{r_1^2}{2\sigma_2^2}} \frac{r_2}{\sigma_1^2} e^{-\frac{r_2^2}{2\sigma_1^2}} \left[ 1 - Q_1 \left( \frac{\rho_2 r_1}{\sigma_2 \sqrt{1-\rho_2^2}}, \frac{r_T}{\sigma_2 \sqrt{1-\rho_2^2}} \right) \right] + \\
& \quad + P_2 \frac{r_1}{\sigma_1^2} e^{-\frac{r_1^2}{2\sigma_1^2}} \frac{r_2}{\sigma_2^2} e^{-\frac{r_2^2}{2\sigma_2^2}} \left[ 1 - Q_1 \left( \frac{\rho_1 r_1}{\sigma_1 \sqrt{1-\rho_1^2}}, \frac{r_T}{\sigma_1 \sqrt{1-\rho_1^2}} \right) \right] \left[ 1 - Q_1 \left( \frac{\rho_2 r_2}{\sigma_2 \sqrt{1-\rho_2^2}}, \frac{r_T}{\sigma_2 \sqrt{1-\rho_2^2}} \right) \right]
\end{aligned} \tag{3.3.17}$$

Za  $r_1 < r_T, r_2 \geq r_T$

$$\begin{aligned}
p_{r_1 r_2}(r_1, r_2) &= P_1 \left( 1 - e^{-\frac{r_T^2}{2\sigma_1^2}} \right) \frac{r_1 r_2}{\sigma_2^4 (1-\rho_2^2)} e^{-\frac{r_1^2 + r_2^2}{2\sigma_2^2 (1-\rho_2^2)}} I_0 \left( \frac{\rho_2 r_1 r_2}{\sigma_2^2 (1-\rho_2^2)} \right) + \\
& + P_1 \frac{r_1}{\sigma_2^2} e^{-\frac{r_1^2}{2\sigma_2^2}} \frac{r_2}{\sigma_1^2} e^{-\frac{r_2^2}{2\sigma_1^2}} \left[ 1 - Q_1 \left( \frac{\rho_2 r_1}{\sigma_2 \sqrt{1-\rho_2^2}}, \frac{r_T}{\sigma_2 \sqrt{1-\rho_2^2}} \right) \right] \left[ 1 - Q_1 \left( \frac{\rho_1 r_2}{\sigma_1 \sqrt{1-\rho_1^2}}, \frac{r_T}{\sigma_1 \sqrt{1-\rho_1^2}} \right) \right] + \\
& \quad + P_2 \left( 1 - e^{-\frac{r_T^2}{2\sigma_1^2}} \right) \frac{r_1 r_2}{\sigma_1^4 (1-\rho_1^2)} e^{-\frac{r_1^2 + r_2^2}{2\sigma_1^2 (1-\rho_1^2)}} I_0 \left( \frac{\rho_1 r_1 r_2}{\sigma_1^2 (1-\rho_1^2)} \right) + \\
& \quad + P_2 \frac{r_1}{\sigma_1^2} e^{-\frac{r_1^2}{2\sigma_1^2}} \frac{r_2}{\sigma_2^2} e^{-\frac{r_2^2}{2\sigma_2^2}} \left[ 1 - Q_1 \left( \frac{\rho_1 r_1}{\sigma_1 \sqrt{1-\rho_1^2}}, \frac{r_T}{\sigma_1 \sqrt{1-\rho_1^2}} \right) \right] \left[ 1 - Q_1 \left( \frac{\rho_2 r_2}{\sigma_2 \sqrt{1-\rho_2^2}}, \frac{r_T}{\sigma_2 \sqrt{1-\rho_2^2}} \right) \right]
\end{aligned} \tag{3.3.18}$$

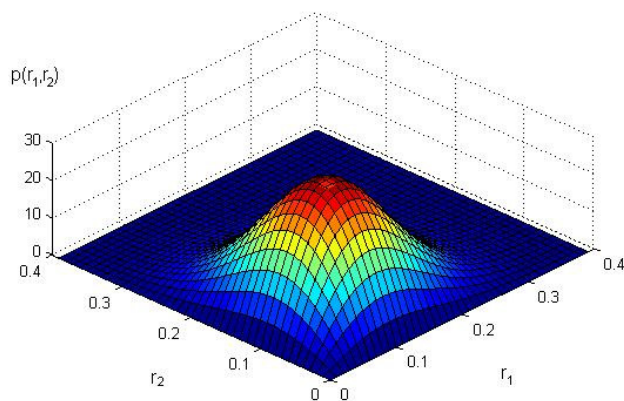
Za  $r_1 \geq r_T, r_2 \geq r_T$

$$\begin{aligned}
p_{r_1 r_2}(r_1, r_2) &= P_1 \frac{r_1 r_2}{\sigma_1^4 (1-\rho_1^2)} e^{-\frac{r_1^2 + r_2^2}{2\sigma_1^2 (1-\rho_1^2)}} I_0 \left( \frac{\rho_1 r_1 r_2}{\sigma_1^2 (1-\rho_1^2)} \right) + \\
& + P_1 \frac{r_1}{\sigma_1^2} e^{-\frac{r_1^2}{2\sigma_1^2}} \frac{r_2}{\sigma_2^2} e^{-\frac{r_2^2}{2\sigma_2^2}} \left[ 1 - Q_1 \left( \frac{\rho_1 r_1}{\sigma_1 \sqrt{1-\rho_1^2}}, \frac{r_T}{\sigma_1 \sqrt{1-\rho_1^2}} \right) \right] + \\
& \quad + P_1 \left( 1 - e^{-\frac{r_T^2}{2\sigma_1^2}} \right) \frac{r_1 r_2}{\sigma_2^4 (1-\rho_2^2)} e^{-\frac{r_1^2 + r_2^2}{2\sigma_2^2 (1-\rho_2^2)}} I_0 \left( \frac{\rho_2 r_1 r_2}{\sigma_2^2 (1-\rho_2^2)} \right) +
\end{aligned}$$

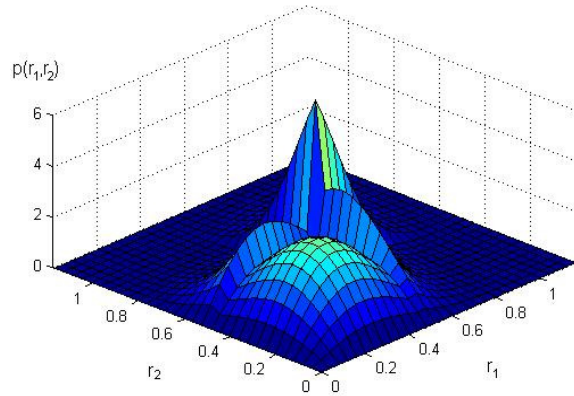
$$\begin{aligned}
& + P_1 \frac{r_1}{\sigma_2^2} e^{-\frac{r_1^2}{2\sigma_2^2}} \frac{r_2}{\sigma_1^2} e^{-\frac{r_2^2}{2\sigma_1^2}} \left[ 1 - Q_1 \left( \frac{\rho_2 r_1}{\sigma_2 \sqrt{1-\rho_2^2}}, \frac{r_T}{\sigma_2 \sqrt{1-\rho_2^2}} \right) \right] \left[ 1 - Q_1 \left( \frac{\rho_1 r_2}{\sigma_1 \sqrt{1-\rho_1^2}}, \frac{r_T}{\sigma_1 \sqrt{1-\rho_1^2}} \right) \right] + \\
& \quad + P_2 \frac{r_1 r_2}{\sigma_2^4 (1-\rho^2)} e^{-\frac{r_1^2+r_2^2}{2\sigma_2^2(1-\rho^2)}} I_0 \left( \frac{\rho r_1 r_2}{\sigma_2^2 (1-\rho^2)} \right) + \\
& \quad + P_2 \frac{r_1}{\sigma_2^2} e^{-\frac{r_1^2}{2\sigma_2^2}} \frac{r_2}{\sigma_1^2} e^{-\frac{r_2^2}{2\sigma_1^2}} \left[ 1 - Q_1 \left( \frac{\rho_2 r_1}{\sigma_2 \sqrt{1-\rho_2^2}}, \frac{r_T}{\sigma_2 \sqrt{1-\rho_2^2}} \right) \right] + \\
& \quad + P_2 \left( 1 - e^{-\frac{r_T^2}{2\sigma_2^2}} \right) \frac{r_1 r_2}{\sigma_1^4 (1-\rho^2)} e^{-\frac{r_1^2+r_2^2}{2\sigma_1^2(1-\rho^2)}} I_0 \left( \frac{\rho r_1 r_2}{\sigma_1^2 (1-\rho^2)} \right) + \\
& \quad + P_2 \frac{r_1}{\sigma_1^2} e^{-\frac{r_1^2}{2\sigma_1^2}} \frac{r_2}{\sigma_2^2} e^{-\frac{r_2^2}{2\sigma_2^2}} \left[ 1 - Q_1 \left( \frac{\rho_1 r_1}{\sigma_1 \sqrt{1-\rho_1^2}}, \frac{r_T}{\sigma_1 \sqrt{1-\rho_1^2}} \right) \right] \left[ 1 - Q_1 \left( \frac{\rho_2 r_2}{\sigma_2 \sqrt{1-\rho_2^2}}, \frac{r_T}{\sigma_2 \sqrt{1-\rho_2^2}} \right) \right]
\end{aligned} \tag{3.3.19}$$

Združena gustina raspodele verovatnoće na izlazu iz SSC kombinera se može jednostavno predstaviti grafički upotrebom matematičkog softvera kao što je “MatLab”. Radi uproštavanja, a ne gubeći uopštenost, pretpostavljeno je da su parametri raspodele isti za obe grane kombinera.

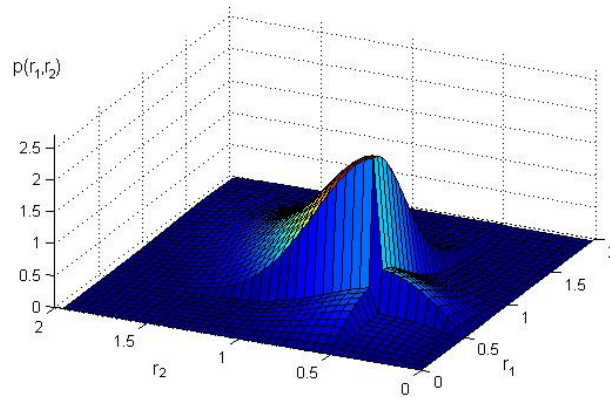
Na slikama 3.3.1.-9. predstavljena je zavisnost PDF na izlazu od vrednosti signala na ulazu za različite vrednosti standardne devijacije, korelacije i praga odlučivanja.



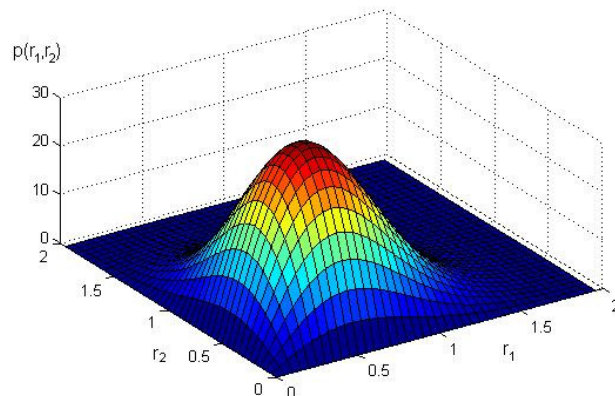
Slika 3.3.1. Združena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena prisustvu Rayleigh-jevog fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 0.5$ ,  $\sigma = 0.1$



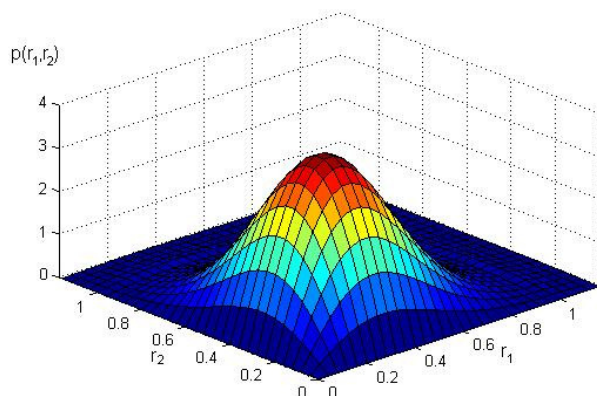
Slika 3.3.2. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Rayleigh-jevog fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 0.5$ ,  $\sigma = 0.3$



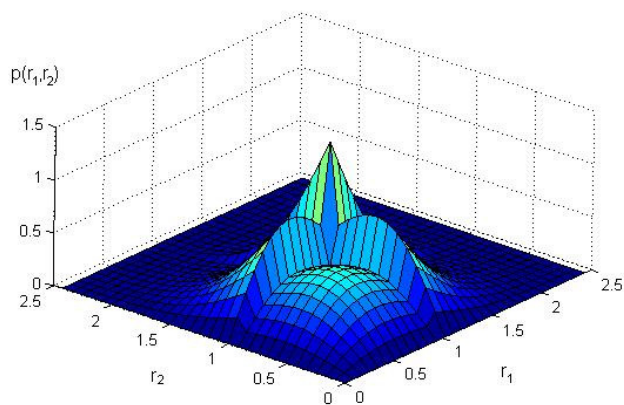
Slika 3.3.3. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Rayleigh-jevog fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 0.5$ ,  $\sigma = 0.6$



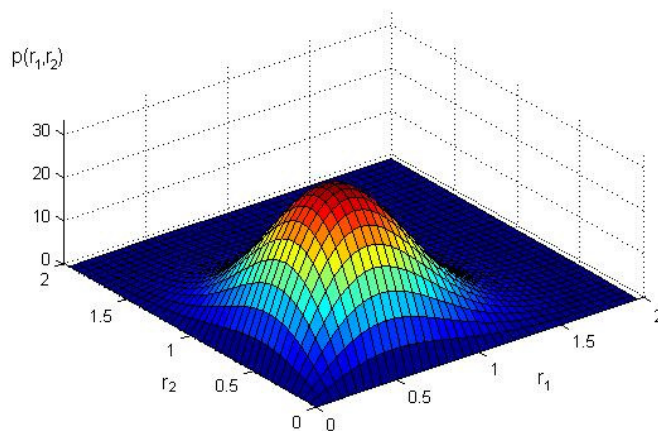
Slika 3.3.4. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Rayleigh-jevog fedinga za parametre:  $\rho = 0.1$ ,  $r_T = 1$ ,  $\sigma = 0.1$



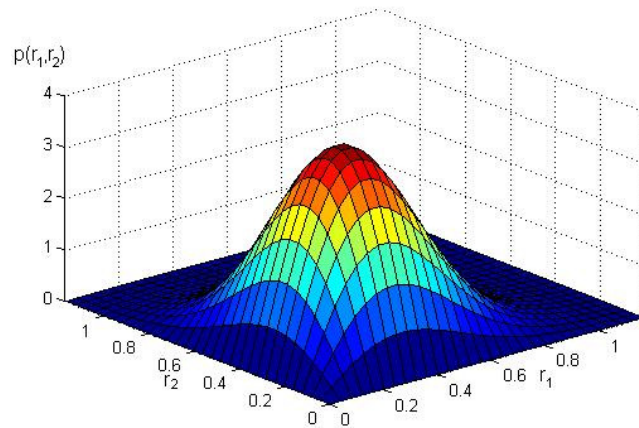
Slika 3.3.5. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Rayleigh-jevog fedinga za parametre:  $\rho = 0.1$ ,  $r_T = 1$ ,  $\sigma = 0.3$



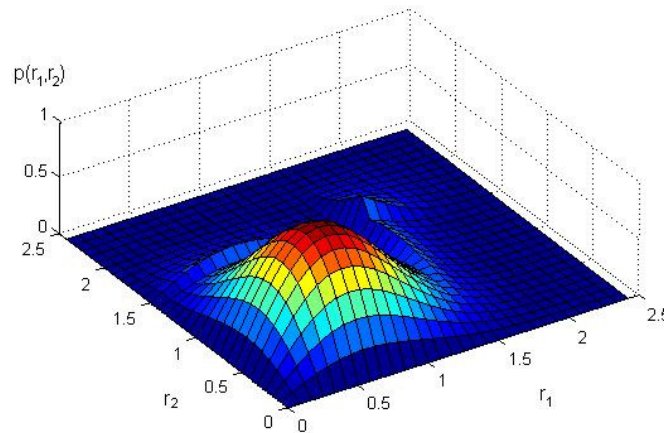
Slika 3.3.6. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Rayleigh-jevog fedinga za parametre:  $\rho = 0.1$ ,  $r_T = 1$ ,  $\sigma = 0.6$



Slika 3.3.7. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Rayleigh-jevog fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 1.5$ ,  $\sigma = 0.1$



Slika 3.3.8. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Rayleigh-jevog fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 1.5$ ,  $\sigma = 0.3$



Slika 3.3.9. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Rayleigh-jevog fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 1.5$ ,  $\sigma = 0.6$

### 3.4 Zdužena gustina raspodele verovatnoće na izlazu SSC kombinera u dva trenutka vremena u prisustvu Nakagami-m fedinga

Gustina raspodele verovatnoće i kumulativna raspodela verovatnoće (CDF) signala na ulazima u grane kombinera  $r_{i,j}$  u prisustvu Nakagami-m fedinga su [1]:

$$p_{r_i}(r_{i,j}) = \frac{2m_i^{m_i} r_{i,j}^{2m_i-1}}{\Omega_i^{m_i} \Gamma(m_i)} e^{-\frac{m_i r_{i,j}^2}{\Omega_i}}, \quad r_{i,j} \geq 0 \quad (3.4.1)$$

$$F_{r_i}(r_{i,j}) = \gamma\left(\frac{m_i}{\Omega_i} r_{i,j}^2, m_i\right) \quad , \quad r_{i,j} \geq 0 \quad (3.4.2)$$

gde su  $i=1,2$   $j=1,2$ ,  $m$  je Nakagami- $m$  faktor, a  $\Omega$  je srednja vrednost snage signala.

$\gamma(x, a)$  je nekompletna gama funkcija definisana sa [45]:

$$\gamma(x, a) = \frac{1}{\Gamma(a)} \int_0^x t^{a-1} e^{-t} dt \quad (3.4.3)$$

Verovatnoće  $P_1$  i  $P_2$  se dobijaju ako se u (3.1.17-18) stavi (3.3.15):

$$P_1 = \frac{\gamma\left(\frac{m_2}{\Omega_2} r_t^2, m_2\right)}{\gamma\left(\frac{m_1}{\Omega_1} r_t^2, m_1\right) + \gamma\left(\frac{m_2}{\Omega_2} r_t^2, m_2\right)} \quad (3.4.4)$$

$$P_2 = \frac{\gamma\left(\frac{m_1}{\Omega_1} r_t^2, m_1\right)}{\gamma\left(\frac{m_1}{\Omega_1} r_t^2, m_1\right) + \gamma\left(\frac{m_2}{\Omega_2} r_t^2, m_2\right)} \quad (3.4.5)$$

Združena gustina raspodele verovatnoće korelisanih signala  $x_1$  i  $x_2$  sa Nakagami- $m$  raspedlom i istim parametrima raspodele je [52], [53]:

$$p_{x_1, x_2}(x_1, x_2) = \frac{4(x_1 x_2)^m}{\Gamma(m)(1-\rho)\rho^{(m-1)/2}} \left(\frac{m}{\Omega}\right)^{m+1} \cdot I_{m-1}\left(\frac{2m\sqrt{\rho} x_1 x_2}{\Omega(1-\rho)}\right) e^{-\frac{m(x_1^2 + x_2^2)}{\Omega(1-\rho)}} \quad (3.4.6)$$

gde je  $\rho$  koeficijent korelacije, a  $I_m(\ )$  je modifikovana Bessel-ova funkcija prve vrste  $m$ -tog reda [51]:

$$I_m(x) = \left(\frac{x}{2}\right)^m \sum_{k=0}^{\infty} \frac{\left(\frac{x^2}{4}\right)^k}{k! \Gamma(m+k+1)} \quad (3.4.7)$$

Združena gustina raspodele verovatnoće signala  $r_1$  i  $r_2$  na izlazu SSC kombinera u dva trenutka vremena u prisustvu Nakagami- $m$  fedinga kada su signali na ulazu u grane kombinera nezavisni, može se dobiti ako se u (3.2.5-8) stave izrazi (3.4.1) i (3.4.5)

Za  $r_1 < r_T$ ,  $r_2 < r_T$

$$p_{r_1, r_2}(r_1, r_2) = P_1 \int_0^{r_T} \frac{4(r_{11} r_2)^{m_1}}{\Gamma(m_1)(1-\rho_1)\rho_1^{(m_1-1)/2}} \left(\frac{m_1}{\Omega_1}\right)^{m_1+1} I_{m_1-1}\left(\frac{2m_1\sqrt{\rho_1} r_{11} r_2}{\Omega_1(1-\rho_1)}\right) e^{-\frac{m_1(r_{11}^2 + r_2^2)}{\Omega_1(1-\rho_1)}} dr_{11} \cdot$$

$$\begin{aligned}
& \cdot \int_0^{r_T} \frac{4(r_{22}r_1)^{m_2}}{\Gamma(m_2)(1-\rho_2)\rho_2^{(m_2-1)/2}} \left(\frac{m_2}{\Omega_2}\right)^{m_2+1} I_{m-1} \left(\frac{2m_2\sqrt{\rho_2} r_{22}r_1}{\Omega_2(1-\rho_2)}\right) e^{-\frac{m_2(r_{22}^2+r_1^2)}{\Omega_2(1-\rho_2)}} dr_{22} + \\
& + P_2 \int_0^{r_T} \frac{4(r_{21}r_2)^{m_2}}{\Gamma(m_2)(1-\rho_2)\rho_2^{(m_2-1)/2}} \left(\frac{m_2}{\Omega_2}\right)^{m_2+1} I_{m-1} \left(\frac{2m_2\sqrt{\rho_2} r_{21}r_2}{\Omega_2(1-\rho_2)}\right) e^{-\frac{m_2(r_{21}^2+r_2^2)}{\Omega_2(1-\rho_2)}} dr_{21} \cdot \\
& \cdot \int_0^{r_T} \frac{4(r_{12}r_1)^{m_1}}{\Gamma(m_1)(1-\rho_1)\rho_1^{(m_1-1)/2}} \left(\frac{m_1}{\Omega_1}\right)^{m_1+1} I_{m-1} \left(\frac{2m_1\sqrt{\rho_1} r_{12}r_1}{\Omega_1(1-\rho_1)}\right) e^{-\frac{m_1(r_{12}^2+r_1^2)}{\Omega_1(1-\rho_1)}} dr_{12} \quad (3.4.8)
\end{aligned}$$

Za  $r_1 \geq r_T, r_2 < r_T$

$$\begin{aligned}
p_{r_1 r_2}(r_1, r_2) &= P_1 \frac{2m_2^{m_2} r_2^{2m_2-1}}{\Omega_2^{m_2} \Gamma(m_2)} e^{-\frac{m_2 r_2^2}{\Omega_2}} \cdot \\
& \cdot \int_0^{r_T} \frac{4(r_{12}r_1)^{m_1}}{\Gamma(m_1)(1-\rho_1)\rho_1^{(m_1-1)/2}} \left(\frac{m_1}{\Omega_1}\right)^{m_1+1} I_{m-1} \left(\frac{2m_1\sqrt{\rho_1} r_{12}r_1}{\Omega_1(1-\rho_1)}\right) e^{-\frac{m_1(r_{12}^2+r_1^2)}{\Omega_1(1-\rho_1)}} dr_{12} + \\
& + P_1 \int_0^{r_T} \frac{4(r_{11}r_2)^{m_1}}{\Gamma(m_1)(1-\rho_1)\rho_1^{(m_1-1)/2}} \left(\frac{m_1}{\Omega_1}\right)^{m_1+1} I_{m-1} \left(\frac{2m_1\sqrt{\rho_1} r_{11}r_2}{\Omega_1(1-\rho_1)}\right) e^{-\frac{m_1(r_{11}^2+r_2^2)}{\Omega_1(1-\rho_1)}} dr_{11} \cdot \\
& \cdot \int_0^{r_T} \frac{4(r_{22}r_1)^{m_2}}{\Gamma(m_2)(1-\rho_2)\rho_2^{(m_2-1)/2}} \left(\frac{m_2}{\Omega_2}\right)^{m_2+1} I_{m-1} \left(\frac{2m_2\sqrt{\rho_2} r_{22}r_1}{\Omega_2(1-\rho_2)}\right) e^{-\frac{m_2(r_{22}^2+r_1^2)}{\Omega_2(1-\rho_2)}} dr_{22} + \\
& + P_2 \frac{2m_1^{m_1} r_2^{2m_1-1}}{\Omega_1^{m_1} \Gamma(m_1)} e^{-\frac{m_1 r_2^2}{\Omega_1}} \int_0^{r_T} \frac{4(r_{22}r_1)^{m_2}}{\Gamma(m_2)(1-\rho_2)\rho_2^{(m_2-1)/2}} \left(\frac{m_2}{\Omega_2}\right)^{m_2+1} I_{m-1} \left(\frac{2m_2\sqrt{\rho_2} r_{22}r_1}{\Omega_2(1-\rho_2)}\right) e^{-\frac{m_2(r_{22}^2+r_1^2)}{\Omega_2(1-\rho_2)}} dr_{22} + \\
& + P_2 \int_0^{r_T} \frac{4(r_{21}r_2)^{m_2}}{\Gamma(m_2)(1-\rho_2)\rho_2^{(m_2-1)/2}} \left(\frac{m_2}{\Omega_2}\right)^{m_2+1} I_{m-1} \left(\frac{2m_2\sqrt{\rho_2} r_{21}r_2}{\Omega_2(1-\rho_2)}\right) e^{-\frac{m_2(r_{21}^2+r_2^2)}{\Omega_2(1-\rho_2)}} dr_{21} \cdot \\
& \cdot \int_0^{r_T} \frac{4(r_{12}r_1)^{m_1}}{\Gamma(m_1)(1-\rho_1)\rho_1^{(m_1-1)/2}} \left(\frac{m_1}{\Omega_1}\right)^{m_1+1} I_{m-1} \left(\frac{2m_1\sqrt{\rho_1} r_{12}r_1}{\Omega_1(1-\rho_1)}\right) e^{-\frac{m_1(r_{12}^2+r_1^2)}{\Omega_1(1-\rho_1)}} dr_{12} \quad (3.4.9)
\end{aligned}$$

Za  $r_1 < r_T, r_2 \geq r_T$

$$\begin{aligned}
p_{r_1 r_2}(r_1, r_2) &= P_1 \gamma \left(\frac{m_1}{\Omega_1} r_T^2, m_1\right) \frac{4(r_1 r_2)^{m_2}}{\Gamma(m_2)(1-\rho_2)\rho_2^{(m_2-1)/2}} \left(\frac{m_2}{\Omega_2}\right)^{m_2+1} I_{m-1} \left(\frac{2m_2\sqrt{\rho_2} r_1 r_2}{\Omega_2(1-\rho_2)}\right) e^{-\frac{m_2(r_1^2+r_2^2)}{\Omega_2(1-\rho_2)}} + \\
& + P_1 \int_0^{r_T} \frac{4(r_{11}r_2)^{m_1}}{\Gamma(m_1)(1-\rho_1)\rho_1^{(m_1-1)/2}} \left(\frac{m_1}{\Omega_1}\right)^{m_1+1} I_{m-1} \left(\frac{2m_1\sqrt{\rho_1} r_{11}r_2}{\Omega_1(1-\rho_1)}\right) e^{-\frac{m_1(r_{11}^2+r_2^2)}{\Omega_1(1-\rho_1)}} dr_{11} \cdot \\
& \cdot \int_0^{r_T} \frac{4(r_{22}r_1)^{m_2}}{\Gamma(m_2)(1-\rho_2)\rho_2^{(m_2-1)/2}} \left(\frac{m_2}{\Omega_2}\right)^{m_2+1} I_{m-1} \left(\frac{2m_2\sqrt{\rho_2} r_{22}r_1}{\Omega_2(1-\rho_2)}\right) e^{-\frac{m_2(r_{22}^2+r_1^2)}{\Omega_2(1-\rho_2)}} dr_{22} +
\end{aligned}$$



$$\begin{aligned}
 & + P_2 \gamma \left( \frac{m_2}{\Omega_2} r_T^2, m_2 \right) \cdot \frac{4(r_1 r_2)^{m_1}}{\Gamma(m_1)(1-\rho_1)\rho_1^{(m_1-1)/2}} \left( \frac{m_1}{\Omega_1} \right)^{m_1+1} I_{m-1} \left( \frac{2m_1 \sqrt{\rho_1} r_1 r_2}{\Omega_1(1-\rho_1)} \right) e^{-\frac{m_1(r_1^2+r_2^2)}{\Omega_1(1-\rho_1)}} + \\
 & + P_2 \int_0^{r_T} \frac{4(r_{21} r_2)^{m_2}}{\Gamma(m_2)(1-\rho_2)\rho_2^{(m_2-1)/2}} \left( \frac{m_2}{\Omega_2} \right)^{m_2+1} I_{m-1} \left( \frac{2m_2 \sqrt{\rho_2} r_{21} r_2}{\Omega_2(1-\rho_2)} \right) e^{-\frac{m_2(r_{21}^2+r_2^2)}{\Omega_2(1-\rho_2)}} dr_{21} \cdot \\
 & \cdot \int_0^{r_T} \frac{4(r_{12} r_1)^{m_1}}{\Gamma(m_1)(1-\rho_1)\rho_1^{(m_1-1)/2}} \left( \frac{m_1}{\Omega_1} \right)^{m_1+1} I_{m-1} \left( \frac{2m_1 \sqrt{\rho_1} r_{12} r_1}{\Omega_1(1-\rho_1)} \right) e^{-\frac{m_1(r_{12}^2+r_1^2)}{\Omega_1(1-\rho_1)}} dr_{12} \quad (3.4.10)
 \end{aligned}$$

Za  $r_1 \geq r_T, r_2 \geq r_T$

$$\begin{aligned}
 p_{r_1 r_2}(r_1, r_2) & = P_1 \frac{4(r_1 r_2)^{m_1}}{\Gamma(m_1)(1-\rho_1)\rho_1^{(m_1-1)/2}} \left( \frac{m_1}{\Omega_1} \right)^{m_1+1} I_{m-1} \left( \frac{2m_1 \sqrt{\rho_1} r_1 r_2}{\Omega_1(1-\rho_1)} \right) e^{-\frac{m_1(r_1^2+r_2^2)}{\Omega_1(1-\rho_1)}} + \\
 & + P_1 \frac{2m_2 m_2^{2m_2-1}}{\Omega_2^{m_2} \Gamma(m_2)} e^{-\frac{m_2 r_2^2}{\Omega_2}} \int_0^{r_T} \frac{4(r_{12} r_1)^{m_1}}{\Gamma(m_1)(1-\rho_1)\rho_1^{(m_1-1)/2}} \left( \frac{m_1}{\Omega_1} \right)^{m_1+1} I_{m-1} \left( \frac{2m_1 \sqrt{\rho_1} r_{12} r_1}{\Omega_1(1-\rho_1)} \right) e^{-\frac{m_1(r_{12}^2+r_1^2)}{\Omega_1(1-\rho_1)}} dr_{12} + \\
 & + P_1 \gamma \left( \frac{m_1}{\Omega_1} r_T^2, m_1 \right) \frac{4(r_1 r_2)^{m_2}}{\Gamma(m_2)(1-\rho_2)\rho_2^{(m_2-1)/2}} \left( \frac{m_2}{\Omega_2} \right)^{m_2+1} I_{m-1} \left( \frac{2m_2 \sqrt{\rho_2} r_1 r_2}{\Omega_2(1-\rho_2)} \right) e^{-\frac{m_2(r_1^2+r_2^2)}{\Omega_2(1-\rho_2)}} + \\
 & + P_1 \int_0^{r_T} \frac{4(r_{11} r_2)^{m_1}}{\Gamma(m_1)(1-\rho_1)\rho_1^{(m_1-1)/2}} \left( \frac{m_1}{\Omega_1} \right)^{m_1+1} I_{m-1} \left( \frac{2m_1 \sqrt{\rho_1} r_{11} r_2}{\Omega_1(1-\rho_1)} \right) e^{-\frac{m_1(r_{11}^2+r_2^2)}{\Omega_1(1-\rho_1)}} dr_{11} \cdot \\
 & \cdot \int_0^{r_T} \frac{4(r_{22} r_1)^{m_2}}{\Gamma(m_2)(1-\rho_2)\rho_2^{(m_2-1)/2}} \left( \frac{m_2}{\Omega_2} \right)^{m_2+1} I_{m-1} \left( \frac{2m_2 \sqrt{\rho_2} r_{22} r_1}{\Omega_2(1-\rho_2)} \right) e^{-\frac{m_2(r_{22}^2+r_1^2)}{\Omega_2(1-\rho_2)}} dr_{22} + \\
 & + P_2 \frac{4(r_1 r_2)^{m_2}}{\Gamma(m_2)(1-\rho_2)\rho_2^{(m_2-1)/2}} \left( \frac{m_2}{\Omega_2} \right)^{m_2+1} I_{m-1} \left( \frac{2m_2 \sqrt{\rho_2} r_1 r_2}{\Omega_2(1-\rho_2)} \right) e^{-\frac{m_2(r_1^2+r_2^2)}{\Omega_2(1-\rho_2)}} + \\
 & + P_2 \frac{2m_1 m_1^{2m_1-1}}{\Omega_1^{m_1} \Gamma(m_1)} e^{-\frac{m_1 r_2^2}{\Omega_1}} \int_0^{r_T} \frac{4(r_{22} r_1)^{m_2}}{\Gamma(m_2)(1-\rho_2)\rho_2^{(m_2-1)/2}} \left( \frac{m_2}{\Omega_2} \right)^{m_2+1} I_{m-1} \left( \frac{2m_2 \sqrt{\rho_2} r_{22} r_1}{\Omega_2(1-\rho_2)} \right) e^{-\frac{m_2(r_{22}^2+r_1^2)}{\Omega_2(1-\rho_2)}} dr_{22} + \\
 & + P_2 \gamma \left( \frac{m_2}{\Omega_2} r_T^2, m_2 \right) \cdot \frac{4(r_1 r_2)^{m_1}}{\Gamma(m_1)(1-\rho_1)\rho_1^{(m_1-1)/2}} \left( \frac{m_1}{\Omega_1} \right)^{m_1+1} I_{m-1} \left( \frac{2m_1 \sqrt{\rho_1} r_1 r_2}{\Omega_1(1-\rho_1)} \right) e^{-\frac{m_1(r_1^2+r_2^2)}{\Omega_1(1-\rho_1)}} + \\
 & + P_2 \int_0^{r_T} \frac{4(r_{21} r_2)^{m_2}}{\Gamma(m_2)(1-\rho_2)\rho_2^{(m_2-1)/2}} \left( \frac{m_2}{\Omega_2} \right)^{m_2+1} I_{m-1} \left( \frac{2m_2 \sqrt{\rho_2} r_{21} r_2}{\Omega_2(1-\rho_2)} \right) e^{-\frac{m_2(r_{21}^2+r_2^2)}{\Omega_2(1-\rho_2)}} dr_{21} \cdot \\
 & \cdot \int_0^{r_T} \frac{4(r_{12} r_1)^{m_1}}{\Gamma(m_1)(1-\rho_1)\rho_1^{(m_1-1)/2}} \left( \frac{m_1}{\Omega_1} \right)^{m_1+1} I_{m-1} \left( \frac{2m_1 \sqrt{\rho_1} r_{12} r_1}{\Omega_1(1-\rho_1)} \right) e^{-\frac{m_1(r_{12}^2+r_1^2)}{\Omega_1(1-\rho_1)}} dr_{12} \quad (3.4.11)
 \end{aligned}$$

Izrazi (3.4.8-11) su u obliku jednostrukog integrala sa konačnim granicama. Zdužena gustina raspodele verovatnoće se može dobiti u zatvorenom obliku korišćenjem generalizovane Marcum-ove  $Q$ -funkcije ( $m$ -tog reda) definisane sa [1], [54]:

$$Q_m(\alpha, \beta) = \frac{1}{\alpha^{m-1}} \int_{\beta}^{\infty} x^m \exp\left[-\left(\frac{x^2 + \alpha^2}{2}\right)\right] I_{m-1}(\alpha x) dx \quad (3.4.12)$$

gde je  $m$  ceo broj.

Zdužena gustina raspodele verovatnoće se može dobiti u zatvorenom obliku korišćenjem generalizovane Marcum-ove  $Q$ -funkcije  $m$ -tog reda, gde je  $m$  pozitivan ceo broj, što nije ozbiljno ograničenje, jer ako  $m$  nije ceo broj, ova formula se može upotrebiti za  $\lfloor m \rfloor$  i  $\lfloor m + 1 \rfloor$  za dobijanje donje i gornje granice.

Za predstavljanje zdužene PDF u zatvorenom obliku potrebno je rešiti integral  $\int_{r_T}^{\infty} p_{x_1 x_2}(x_1, x_2) dx_1$ , gde je  $p_{x_1 x_2}(x_1, x_2)$  dato u (3.3.19). Transformacijom  $p_{x_1 x_2}(x_1, x_2)$ , ona se može predstaviti u obliku koji u podintegralnom delu predstavlja podintegralni deo generalizovane Marcum-ove  $Q$ -funkcije  $m$ -tog reda.

$$x_1 = x \frac{1}{\sqrt{2m}} \sqrt{\Omega(1-\rho)} \quad x = \sqrt{2m} \frac{x_1}{\sqrt{\Omega(1-\rho)}} \quad (3.4.13)$$

$$x_2 = \frac{\alpha}{\sqrt{2m\rho}} \sqrt{\Omega(1-\rho)} \quad \alpha = \frac{\sqrt{2m\rho} x_2}{\sqrt{\Omega(1-\rho)}} \quad (3.4.14)$$

$$\begin{aligned} \int_{r_T}^{\infty} p_{x_1 x_2}(x_1, x_2) dx_1 &= \frac{4m\alpha^{2m-1}(1-\rho)^{m-1}}{2^m \Omega \Gamma(m) \rho^{m-1/2}} e^{-\frac{\alpha^2(1-\rho)}{2\rho}} \int_{r_T}^{\infty} \frac{1}{\alpha^{m-1}} x^m e^{-\frac{x^2+\alpha^2}{2}} I_{m-1}(x\alpha) dx_1 = \\ &= \frac{4m\alpha^{2m-1}(1-\rho)^{m-1}}{2^m \Omega \Gamma(m) \rho^{m-1/2}} e^{-\frac{\alpha^2(1-\rho)}{2\rho}} \int_{\frac{\sqrt{m}\sqrt{2}}{\sqrt{\Omega}\sqrt{1-\rho}} r_T}^{\infty} \frac{1}{\alpha^{m-1}} x^m e^{-\frac{x^2+\alpha^2}{2}} I_{m-1}(x\alpha) dx \frac{1}{\sqrt{2}\sqrt{m}} \sqrt{\Omega}\sqrt{1-\rho} = \\ &= \frac{2m^m x_2^{2m-1}}{\Omega^m \Gamma(m)} e^{-\frac{m x_2^2}{\Omega}} Q_m\left(\frac{\sqrt{2m\rho} x_2}{\sqrt{\Omega(1-\rho)}}, \frac{\sqrt{2m} r_T}{\sqrt{\Omega(1-\rho)}}\right) \end{aligned} \quad (3.4.15)$$

Na osnovu (3.4.15) se dobija:

$$\int_0^{r_T} p_{x_1 x_2}(x_1, x_2) dx_1 = \frac{2m^m x_2^{2m-1}}{\Omega^m \Gamma(m)} e^{-\frac{m x_2^2}{\Omega}} \left[ 1 - Q_m\left(\frac{\sqrt{2m\rho} x_2}{\sqrt{\Omega(1-\rho)}}, \frac{\sqrt{2m} r_T}{\sqrt{\Omega(1-\rho)}}\right) \right] \quad (3.4.16)$$

Zamenom (3.4.16) u izrazima (3.4.8-11) dobija se konačni oblik za združenu gustinu raspodele verovatnoće na izlazu iz SSC kombinera u prisustvu Nakagami-m fedinga koji je dobijen u zatvorenom obliku.

Za  $r_1 < r_T, r_2 < r_T$

$$\begin{aligned}
 p_{r_1 r_2}(r_1, r_2) = & P_1 \frac{2m_2 m_2 r_1^{2m_2-1}}{\Omega_2^{m_2} \Gamma(m_2)} e^{-\frac{m_2 r_1^2}{\Omega_2}} \frac{2m_1 m_1 r_2^{2m_1-1}}{\Omega_1^{m_1} \Gamma(m_1)} e^{-\frac{m_1 r_2^2}{\Omega_1}} \cdot \\
 & \cdot \left[ 1 - Q_{m_2} \left( \frac{\sqrt{2m_2 \rho_1} r_1}{\sqrt{\Omega_2(1-\rho_1)}}, \frac{\sqrt{2m_2} r_T}{\sqrt{\Omega_2(1-\rho_1)}} \right) \right] \left[ 1 - Q_{m_1} \left( \frac{\sqrt{2m_1 \rho_1} r_2}{\sqrt{\Omega_1(1-\rho_1)}}, \frac{\sqrt{2m_1} r_T}{\sqrt{\Omega_1(1-\rho_1)}} \right) \right] + \\
 & + P_2 \frac{2m_1 m_1 r_1^{2m_1-1}}{\Omega_1^{m_1} \Gamma(m_1)} e^{-\frac{m_1 r_1^2}{\Omega_1}} \frac{2m_2 m_2 r_2^{2m_2-1}}{\Omega_2^{m_2} \Gamma(m_2)} e^{-\frac{m_2 r_2^2}{\Omega_2}} \cdot \\
 & \cdot \left[ 1 - Q_{m_1} \left( \frac{\sqrt{2m_1 \rho_1} r_1}{\sqrt{\Omega_1(1-\rho_1)}}, \frac{\sqrt{2m_1} r_i}{\sqrt{\Omega_1(1-\rho_1)}} \right) \right] \left[ 1 - Q_{m_2} \left( \frac{\sqrt{2m_2 \rho_2} r_2}{\sqrt{\Omega_2(1-\rho_2)}}, \frac{\sqrt{2m_2} r_i}{\sqrt{\Omega_2(1-\rho_2)}} \right) \right] \quad (3.4.17)
 \end{aligned}$$

Za  $r_1 \geq r_T, r_2 < r_T$

$$\begin{aligned}
 p_{r_1 r_2}(r_1, r_2) = & P_1 \frac{2m_1 m_1 r_1^{2m_1-1}}{\Omega_1^{m_1} \Gamma(m_1)} e^{-\frac{m_1 r_1^2}{\Omega_1}} \frac{2m_2 m_2 r_2^{2m_2-1}}{\Omega_2^{m_2} \Gamma(m_2)} e^{-\frac{m_2 r_2^2}{\Omega_2}} \left[ 1 - Q_{m_1} \left( \frac{\sqrt{2m_1 \rho_1} r_1}{\sqrt{\Omega_1(1-\rho_1)}}, \frac{\sqrt{2m_1} r_i}{\sqrt{\Omega_1(1-\rho_1)}} \right) \right] + \\
 & + P_1 \frac{2m_2 m_2 r_1^{2m_2-1}}{\Omega_2^{m_2} \Gamma(m_2)} e^{-\frac{m_2 r_1^2}{\Omega_2}} \frac{2m_1 m_1 r_2^{2m_1-1}}{\Omega_1^{m_1} \Gamma(m_1)} e^{-\frac{m_1 r_2^2}{\Omega_1}} \cdot \\
 & \cdot \left[ 1 - Q_{m_2} \left( \frac{\sqrt{2m_2 \rho_1} r_1}{\sqrt{\Omega_2(1-\rho_1)}}, \frac{\sqrt{2m_2} r_T}{\sqrt{\Omega_2(1-\rho_1)}} \right) \right] \left[ 1 - Q_{m_1} \left( \frac{\sqrt{2m_1 \rho_1} r_2}{\sqrt{\Omega_1(1-\rho_1)}}, \frac{\sqrt{2m_1} r_T}{\sqrt{\Omega_1(1-\rho_1)}} \right) \right] + \\
 & + P_2 \frac{2m_2 m_2 r_1^{2m_2-1}}{\Omega_2^{m_2} \Gamma(m_2)} e^{-\frac{m_2 r_1^2}{\Omega_2}} \frac{2m_1 m_1 r_2^{2m_1-1}}{\Omega_1^{m_1} \Gamma(m_1)} e^{-\frac{m_1 r_2^2}{\Omega_1}} \left[ 1 - Q_{m_2} \left( \frac{\sqrt{2m_2 \rho_2} r_1}{\sqrt{\Omega_2(1-\rho_2)}}, \frac{\sqrt{2m_2} r_i}{\sqrt{\Omega_2(1-\rho_2)}} \right) \right] + \\
 & + P_2 \frac{2m_1 m_1 r_1^{2m_1-1}}{\Omega_1^{m_1} \Gamma(m_1)} e^{-\frac{m_1 r_1^2}{\Omega_1}} \frac{2m_2 m_2 r_2^{2m_2-1}}{\Omega_2^{m_2} \Gamma(m_2)} e^{-\frac{m_2 r_2^2}{\Omega_2}} \cdot \\
 & \cdot \left[ 1 - Q_{m_1} \left( \frac{\sqrt{2m_1 \rho_1} r_1}{\sqrt{\Omega_1(1-\rho_1)}}, \frac{\sqrt{2m_1} r_i}{\sqrt{\Omega_1(1-\rho_1)}} \right) \right] \left[ 1 - Q_{m_2} \left( \frac{\sqrt{2m_2 \rho_2} r_2}{\sqrt{\Omega_2(1-\rho_2)}}, \frac{\sqrt{2m_2} r_i}{\sqrt{\Omega_2(1-\rho_2)}} \right) \right] \quad (3.4.18)
 \end{aligned}$$

Za  $r_1 < r_T, r_2 \geq r_T$

$$p_{r_1 r_2}(r_1, r_2) = P_1 \gamma \left( \frac{m_1}{\Omega_1} r_T^2, m_1 \right) \frac{4(r_1 r_2)^{m_2}}{\Gamma(m_2)(1-\rho_2)\rho_2^{(m_2-1)/2}} \left( \frac{m_2}{\Omega_2} \right)^{m_2+1} I_{m_2-1} \left( \frac{2m_2 \sqrt{\rho_2} r_1 r_2}{\Omega_2(1-\rho_2)} \right) e^{-\frac{m_2(r_1^2+r_2^2)}{\Omega_2(1-\rho_2)}} +$$

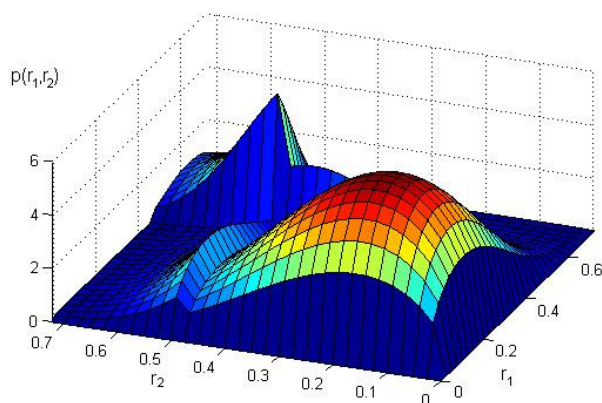
$$\begin{aligned}
 & + P_1 \frac{2m_2}{\Omega_2} \frac{m_2}{\Gamma(m_2)} r_1^{2m_2-1} e^{-\frac{m_2 r_1^2}{\Omega_2}} \frac{2m_1}{\Omega_1} \frac{m_1}{\Gamma(m_1)} r_2^{2m_1-1} e^{-\frac{m_1 r_2^2}{\Omega_1}} . \\
 & \cdot \left[ 1 - Q_{m_2} \left( \frac{\sqrt{2m_2 \rho_1} r_1}{\sqrt{\Omega_2(1-\rho_1)}}, \frac{\sqrt{2m_2} r_T}{\sqrt{\Omega_2(1-\rho_1)}} \right) \right] \left[ 1 - Q_{m_1} \left( \frac{\sqrt{2m_1 \rho_1} r_2}{\sqrt{\Omega_1(1-\rho_1)}}, \frac{\sqrt{2m_1} r_T}{\sqrt{\Omega_1(1-\rho_1)}} \right) \right] + \\
 & + P_2 \gamma \left( \frac{m_2}{\Omega_2} r_T^2, m_2 \right) \cdot \frac{4(r_1 r_2)^{m_1}}{\Gamma(m_1)(1-\rho_1)\rho_1^{(m_1-1)/2}} \left( \frac{m_1}{\Omega_1} \right)^{m_1+1} I_{m_1-1} \left( \frac{2m_1 \sqrt{\rho_1} r_1 r_2}{\Omega_1(1-\rho_1)} \right) e^{-\frac{m_1(r_1^2+r_2^2)}{\Omega_1(1-\rho_1)}} + \\
 & + P_2 \frac{2m_1}{\Omega_1} \frac{m_1}{\Gamma(m_1)} r_1^{2m_1-1} e^{-\frac{m_1 r_1^2}{\Omega_1}} \frac{2m_2}{\Omega_2} \frac{m_2}{\Gamma(m_2)} r_2^{2m_2-1} e^{-\frac{m_2 r_2^2}{\Omega_2}} . \\
 & \cdot \left[ 1 - Q_{m_1} \left( \frac{\sqrt{2m_1 \rho_1} r_1}{\sqrt{\Omega_1(1-\rho_1)}}, \frac{\sqrt{2m_1} r_T}{\sqrt{\Omega_1(1-\rho_1)}} \right) \right] \left[ 1 - Q_{m_2} \left( \frac{\sqrt{2m_2 \rho_2} r_2}{\sqrt{\Omega_2(1-\rho_2)}}, \frac{\sqrt{2m_2} r_T}{\sqrt{\Omega_2(1-\rho_2)}} \right) \right] \quad (3.4.19)
 \end{aligned}$$

Za  $r_1 \geq r_T, r_2 \geq r_T$

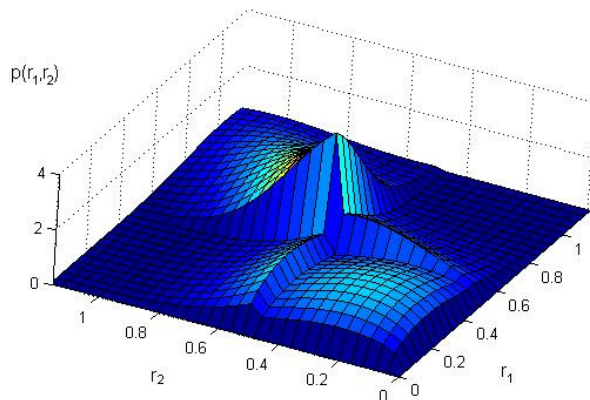
$$\begin{aligned}
 p_{r_1 r_2}(r_1, r_2) & = P_1 \frac{4(r_1 r_2)^{m_1}}{\Gamma(m_1)(1-\rho_1)\rho_1^{(m_1-1)/2}} \left( \frac{m_1}{\Omega_1} \right)^{m_1+1} I_{m_1-1} \left( \frac{2m_1 \sqrt{\rho_1} r_1 r_2}{\Omega_1(1-\rho_1)} \right) e^{-\frac{m_1(r_1^2+r_2^2)}{\Omega_1(1-\rho_1)}} + \\
 & + P_1 \frac{2m_1}{\Omega_1} \frac{m_1}{\Gamma(m_1)} r_1^{2m_1-1} e^{-\frac{m_1 r_1^2}{\Omega_1}} \frac{2m_2}{\Omega_2} \frac{m_2}{\Gamma(m_2)} r_2^{2m_2-1} e^{-\frac{m_2 r_2^2}{\Omega_2}} \left[ 1 - Q_{m_1} \left( \frac{\sqrt{2m_1 \rho_1} r_1}{\sqrt{\Omega_1(1-\rho_1)}}, \frac{\sqrt{2m_1} r_T}{\sqrt{\Omega_1(1-\rho_1)}} \right) \right] + \\
 & + P_1 \gamma \left( \frac{m_1}{\Omega_1} r_T^2, m_1 \right) \frac{4(r_1 r_2)^{m_2}}{\Gamma(m_2)(1-\rho_2)\rho_2^{(m_2-1)/2}} \left( \frac{m_2}{\Omega_2} \right)^{m_2+1} I_{m_2-1} \left( \frac{2m_2 \sqrt{\rho_2} r_1 r_2}{\Omega_2(1-\rho_2)} \right) e^{-\frac{m_2(r_1^2+r_2^2)}{\Omega_2(1-\rho_2)}} \\
 & + P_1 \frac{2m_2}{\Omega_2} \frac{m_2}{\Gamma(m_2)} r_1^{2m_2-1} e^{-\frac{m_2 r_1^2}{\Omega_2}} \frac{2m_1}{\Omega_1} \frac{m_1}{\Gamma(m_1)} r_2^{2m_1-1} e^{-\frac{m_1 r_2^2}{\Omega_1}} . \\
 & \cdot \left[ 1 - Q_{m_2} \left( \frac{\sqrt{2m_2 \rho_1} r_1}{\sqrt{\Omega_2(1-\rho_1)}}, \frac{\sqrt{2m_2} r_T}{\sqrt{\Omega_2(1-\rho_1)}} \right) \right] \left[ 1 - Q_{m_1} \left( \frac{\sqrt{2m_1 \rho_1} r_2}{\sqrt{\Omega_1(1-\rho_1)}}, \frac{\sqrt{2m_1} r_T}{\sqrt{\Omega_1(1-\rho_1)}} \right) \right] + \\
 & + P_2 \frac{4(r_1 r_2)^{m_2}}{\Gamma(m_2)(1-\rho_2)\rho_2^{(m_2-1)/2}} \left( \frac{m_2}{\Omega_2} \right)^{m_2+1} I_{m_2-1} \left( \frac{2m_2 \sqrt{\rho_2} r_1 r_2}{\Omega_2(1-\rho_2)} \right) e^{-\frac{m_2(r_1^2+r_2^2)}{\Omega_2(1-\rho_2)}} + \\
 & + P_2 \frac{2m_2}{\Omega_2} \frac{m_2}{\Gamma(m_2)} r_1^{2m_2-1} e^{-\frac{m_2 r_1^2}{\Omega_2}} \frac{2m_1}{\Omega_1} \frac{m_1}{\Gamma(m_1)} r_2^{2m_1-1} e^{-\frac{m_1 r_2^2}{\Omega_1}} \left[ 1 - Q_{m_2} \left( \frac{\sqrt{2m_2 \rho_2} r_1}{\sqrt{\Omega_2(1-\rho_2)}}, \frac{\sqrt{2m_2} r_T}{\sqrt{\Omega_2(1-\rho_2)}} \right) \right] + \\
 & + P_2 \gamma \left( \frac{m_2}{\Omega_2} r_T^2, m_2 \right) \cdot \frac{4(r_1 r_2)^{m_1}}{\Gamma(m_1)(1-\rho_1)\rho_1^{(m_1-1)/2}} \left( \frac{m_1}{\Omega_1} \right)^{m_1+1} I_{m_1-1} \left( \frac{2m_1 \sqrt{\rho_1} r_1 r_2}{\Omega_1(1-\rho_1)} \right) e^{-\frac{m_1(r_1^2+r_2^2)}{\Omega_1(1-\rho_1)}} + \\
 & + P_2 \frac{2m_1}{\Omega_1} \frac{m_1}{\Gamma(m_1)} r_1^{2m_1-1} e^{-\frac{m_1 r_1^2}{\Omega_1}} \frac{2m_2}{\Omega_2} \frac{m_2}{\Gamma(m_2)} r_2^{2m_2-1} e^{-\frac{m_2 r_2^2}{\Omega_2}} .
 \end{aligned}$$

$$\cdot \left[ 1 - Q_{m_1} \left( \frac{\sqrt{2m_1\rho_1}r_1}{\sqrt{\Omega_1(1-\rho_1)}}, \frac{\sqrt{2m_1}r_i}{\sqrt{\Omega_1(1-\rho_1)}} \right) \right] \left[ 1 - Q_{m_2} \left( \frac{\sqrt{2m_2\rho_2}r_2}{\sqrt{\Omega_2(1-\rho_2)}}, \frac{\sqrt{2m_2}r_i}{\sqrt{\Omega_2(1-\rho_2)}} \right) \right] \quad (3.4.20)$$

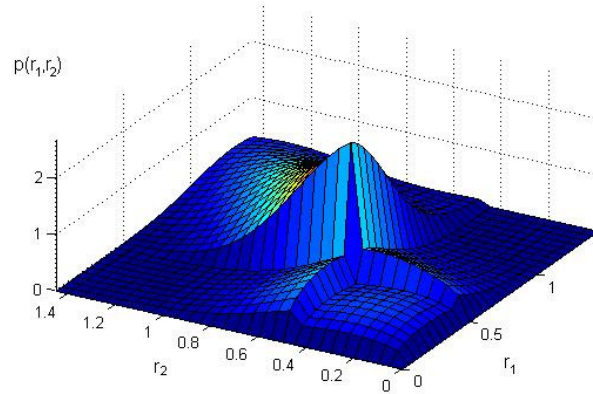
Na slikama 3.3.4.-6. predstavljena je zavisnost PDF od vrednosti signala za različite vrednosti parametara raspodele i praga odlučivanja, gde je pretpostavljeno je da su parametri raspodele isti za obe grane kombinera.



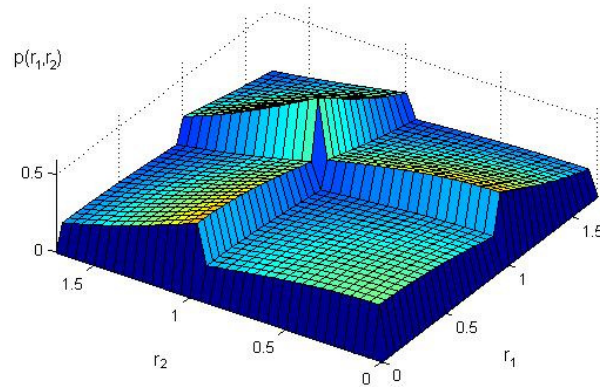
Slika 3.4.1. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Nakagami-m fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 0.5$ ,  $m = 0.7$ ,  $\Omega = 0.1$



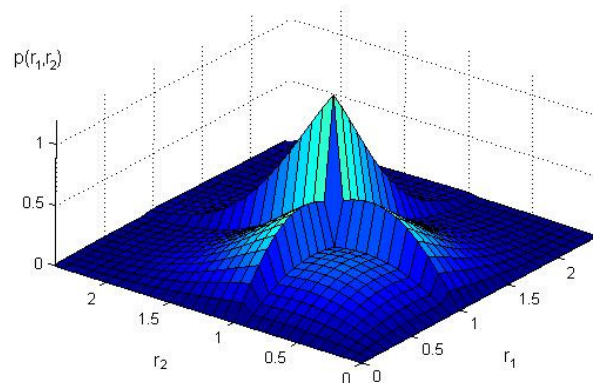
Slika 3.4.2. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Nakagami-m fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 0.5$ ,  $m = 0.7$ ,  $\Omega = 0.3$



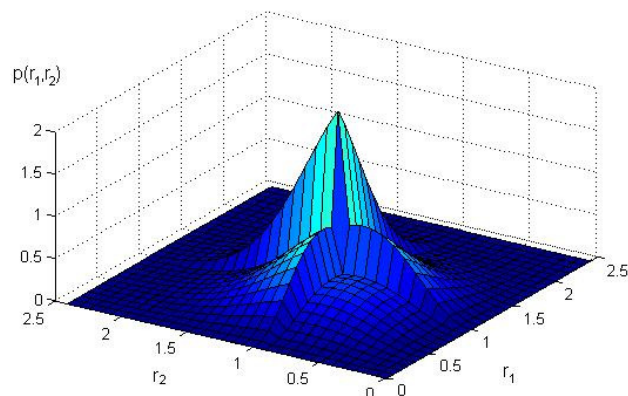
Slika 3.4.3. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Nakagami-m fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 0.5$ ,  $m = 0.7$ ,  $\Omega = 0.6$



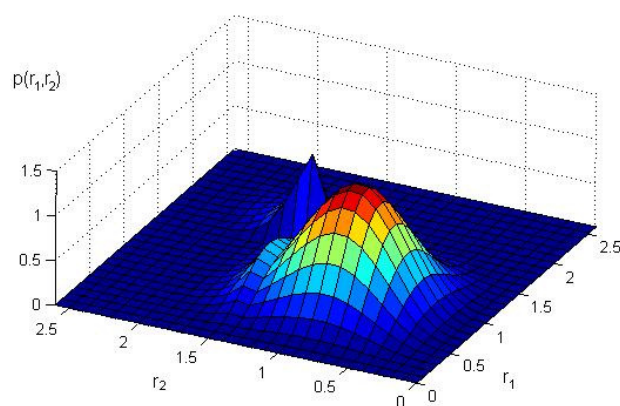
Slika 3.4.4. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Nakagami-m fedinga za parametre:  $\rho = 0.1$ ,  $r_T = 1$ ,  $\Omega = 1$ ,  $m = 0.5$



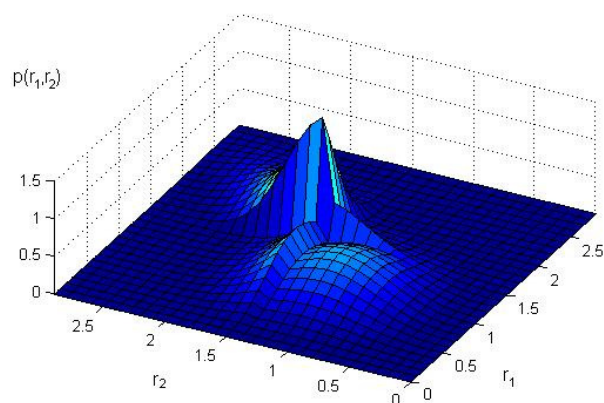
Slika 3.4.5. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Nakagami-m fedinga za parametre:  $\rho = 0.1$ ,  $r_T = 1$ ,  $\Omega = 1$ ,  $m = 1$



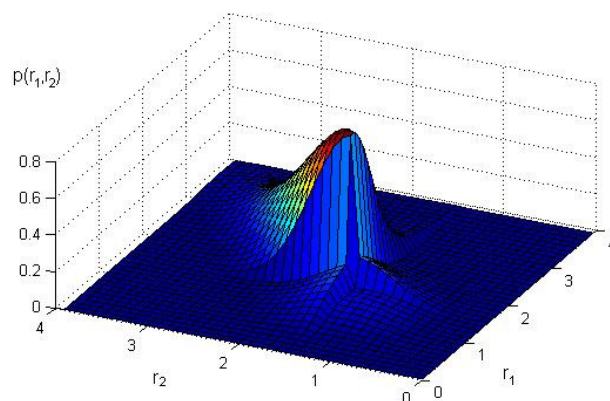
Slika 3.4.6. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Nakagami-m fedinga za parametre:  $\rho = 0.1$ ,  $r_T = 1$ ,  $\Omega = 1$ ,  $m = 1.5$



Slika 3.4.7. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Nakagami-m fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 1.5$ ,  $m = 2$ ,  $\Omega = 1$



Slika 3.4.8. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Nakagami-m fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 1.5$ ,  $m = 2$ ,  $\Omega = 2$



Slika 3.4.9. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Nakagami- $m$  fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 1.5$ ,  $m = 2$ ,  $\Omega = 4$

### 3.5 Zdužena gustina raspodele verovatnoće na izlazu SSC kombinera u dva trenutka vremena u prisustvu Rice-ovog fedinga

Gustina raspodele verovatnoće i kumulativna raspodela verovatnoće (CDF) signala na izlazu iz kombinera  $r_{i,j}$  u prisustvu Rice-ovog fedinga su [6], [7]:

$$p_{r_i}(r_{i,j}) = \frac{r_{i,j}}{\sigma_i^2} e^{-\frac{r_{i,j}^2 + A_i^2}{2\sigma_i^2}} I_0\left(\frac{r_{i,j}A_i}{\sigma_i^2}\right), \quad r_{i,j} \geq 0 \quad (3.5.1)$$

$$F_{r_i}(r_{i,j}) = 1 - Q_1(A_i/\sigma_i, r_{i,j}/\sigma_i), \quad r_{i,j} \geq 0 \quad (3.5.2)$$

gde su  $i=1,2$   $j=1,2$ , pri čemu je  $\sigma_i$  standardna devijacija, parametar  $A_i^2/(2\sigma_i^2)$  predstavlja odnos snaga direktne i reflektovanih komponenti,  $I_0(\ )$  je modifikovana Bessel-ova funkcija prve vrste nultog reda, a  $Q_1(\ )$  je Marcum-ova  $Q$ -funkcija prvog reda.

Verovatnoće  $P_1$  i  $P_2$  se dobijaju ako se u (3.1.17-18) stavi (3.3.35):

$$P_1 = \frac{F_{r_2}(r_T)}{F_{r_1}(r_T) + F_{r_2}(r_T)} = \frac{1 - Q_1(A/\sigma_2, r_T/\sigma_2)}{2 - [Q_1(A/\sigma_1, r_T/\sigma_1) + Q_1(A/\sigma_2, r_T/\sigma_2)]} \quad (3.5.3)$$

$$P_2 = \frac{F_{r_1}(r_T)}{F_{r_1}(r_T) + F_{r_2}(r_T)} = \frac{1 - Q_1(A/\sigma_1, r_T/\sigma_1)}{2 - [Q_1(A/\sigma_1, r_T/\sigma_1) + Q_1(A/\sigma_2, r_T/\sigma_2)]} \quad (3.5.4)$$

Zdužena gustina raspodele verovatnoće korelisanih signala  $x_1$  i  $x_2$  sa Rice-ovom raspodelom i istim parametrima raspodele je [7]:



$$p_{x_1x_2}(x_1, x_2) = \frac{x_1x_2}{\sigma^4(1-\rho^2)} e^{-\frac{x_1^2+x_2^2+2A^2(1-\rho)}{2\sigma^2(1-\rho^2)}} \cdot \sum_{i=0}^{\infty} \varepsilon_i I_i\left(\frac{\rho x_1x_2}{\sigma^2(1-\rho^2)}\right) I_i\left(\frac{Ax_1}{\sigma^2(1+\rho)}\right) I_i\left(\frac{Ax_2}{\sigma^2(1+\rho)}\right) \quad (3.5.5)$$

gde je  $\rho$  koeficijent korelacije,  $I_i(\ )$  je modifikovana Bessel-ova funkcija prve vrste  $i$ -tog reda (3.3.20), [51], a  $\varepsilon_i$  je Neumann-ov faktor definisan sa:

$$\varepsilon_i = \begin{cases} 1, & i=0 \\ 2, & i>0 \end{cases} \quad (3.5.6)$$

Združena gustina raspodele verovatnoće signala  $r_1$  i  $r_2$  na izlazu SSC kombinera u dva trenutka vremena u prisustvu Rice-ovog fedinga kada su signali na ulazu u grane kombinera nezavisni, može se dobiti ako se u (3.2.5-8) stave izrazi (3.3.34) i (3.3.38)

Za  $r_1 < r_T, r_2 < r_T$

$$\begin{aligned} p_{r_1r_2}(r_1, r_2) = & P_1 \int_0^{r_T} \frac{r_{11}r_{12}}{\sigma_1^4(1-\rho_1^2)} e^{-\frac{r_{11}^2+r_{12}^2+2A_1^2(1-\rho_1)}{2\sigma_1^2(1-\rho_1^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i\left(\frac{\rho_1 r_{11}r_{12}}{\sigma_1^2(1-\rho_1^2)}\right) I_i\left(\frac{A_1 r_{11}}{\sigma_1^2(1+\rho_1)}\right) I_i\left(\frac{A_1 r_{12}}{\sigma_1^2(1+\rho_1)}\right) dr_{11} \cdot \\ & \cdot \int_0^{r_T} \frac{r_{22}r_{21}}{\sigma_2^4(1-\rho_2^2)} e^{-\frac{r_{22}^2+r_{21}^2+2A_2^2(1-\rho_2)}{2\sigma_2^2(1-\rho_2^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i\left(\frac{\rho_2 r_{22}r_{21}}{\sigma_2^2(1-\rho_2^2)}\right) I_i\left(\frac{A_2 r_{22}}{\sigma_2^2(1+\rho_2)}\right) I_i\left(\frac{A_2 r_{21}}{\sigma_2^2(1+\rho_2)}\right) dr_{22} + \\ & + P_2 \int_0^{r_T} \frac{r_{21}r_{22}}{\sigma_2^4(1-\rho_2^2)} e^{-\frac{r_{21}^2+r_{22}^2+2A_2^2(1-\rho_2)}{2\sigma_2^2(1-\rho_2^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i\left(\frac{\rho_2 r_{21}r_{22}}{\sigma_2^2(1-\rho_2^2)}\right) I_i\left(\frac{A_2 r_{21}}{\sigma_2^2(1+\rho_2)}\right) I_i\left(\frac{A_2 r_{22}}{\sigma_2^2(1+\rho_2)}\right) dr_{21} \cdot \\ & \cdot \int_0^{r_T} \frac{r_{12}r_{11}}{\sigma_1^4(1-\rho_1^2)} e^{-\frac{r_{12}^2+r_{11}^2+2A_1^2(1-\rho_1)}{2\sigma_1^2(1-\rho_1^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i\left(\frac{\rho_1 r_{12}r_{11}}{\sigma_1^2(1-\rho_1^2)}\right) I_i\left(\frac{A_1 r_{12}}{\sigma_1^2(1+\rho_1)}\right) I_i\left(\frac{A_1 r_{11}}{\sigma_1^2(1+\rho_1)}\right) dr_{12} \quad (3.5.7) \end{aligned}$$

Za  $r_1 \geq r_T, r_2 < r_T$

$$\begin{aligned} p_{r_1r_2}(r_1, r_2) = & P_1 \frac{r_2}{\sigma_2^2} e^{-\frac{r_2^2+A_2^2}{2\sigma_2^2}} I_0\left(\frac{r_2 A_2}{\sigma_2^2}\right) \cdot \\ & \cdot \int_0^{r_T} \frac{r_{12}r_{11}}{\sigma_1^4(1-\rho_1^2)} e^{-\frac{r_{12}^2+r_{11}^2+2A_1^2(1-\rho_1)}{2\sigma_1^2(1-\rho_1^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i\left(\frac{\rho_1 r_{12}r_{11}}{\sigma_1^2(1-\rho_1^2)}\right) I_i\left(\frac{A_1 r_{12}}{\sigma_1^2(1+\rho_1)}\right) I_i\left(\frac{A_1 r_{11}}{\sigma_1^2(1+\rho_1)}\right) dr_{12} + \\ & + P_1 \int_0^{r_T} \frac{r_{11}r_{12}}{\sigma_1^4(1-\rho_1^2)} e^{-\frac{r_{11}^2+r_{12}^2+2A_1^2(1-\rho_1)}{2\sigma_1^2(1-\rho_1^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i\left(\frac{\rho_1 r_{11}r_{12}}{\sigma_1^2(1-\rho_1^2)}\right) I_i\left(\frac{A_1 r_{11}}{\sigma_1^2(1+\rho_1)}\right) I_i\left(\frac{A_1 r_{12}}{\sigma_1^2(1+\rho_1)}\right) dr_{11} \cdot \end{aligned}$$

$$\begin{aligned}
 & \cdot \int_0^{r_T} \frac{r_{22}r_1}{\sigma_2^4(1-\rho_2^2)} e^{-\frac{r_{22}^2+r_1^2+2A_2^2(1-\rho_2)}{2\sigma_2^2(1-\rho_2^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho_2 r_{22} r_1}{\sigma_2^2(1-\rho_2^2)} \right) I_i \left( \frac{A_2 r_{22}}{\sigma_2^2(1+\rho_2)} \right) I_i \left( \frac{A_2 r_1}{\sigma_2^2(1+\rho_2)} \right) dr_{22} + \\
 & \quad + P_2 \frac{r_2}{\sigma_1^2} e^{-\frac{r_2^2+A_1^2}{2\sigma_1^2}} I_0 \left( \frac{r_2 A_1}{\sigma_1} \right). \\
 & \cdot \int_0^{r_T} \frac{r_{22}r_1}{\sigma_2^4(1-\rho_2^2)} e^{-\frac{r_{22}^2+r_1^2+2A_2^2(1-\rho_2)}{2\sigma_2^2(1-\rho_2^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho_2 r_{22} r_1}{\sigma_2^2(1-\rho_2^2)} \right) I_i \left( \frac{A_2 r_{22}}{\sigma_2^2(1+\rho_2)} \right) I_i \left( \frac{A_2 r_1}{\sigma_2^2(1+\rho_2)} \right) dr_{22} + \\
 & + P_2 \int_0^{r_T} \frac{r_{21}r_2}{\sigma_2^4(1-\rho_2^2)} e^{-\frac{r_{21}^2+r_2^2+2A_2^2(1-\rho_2)}{2\sigma_2^2(1-\rho_2^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho_2 r_{21} r_2}{\sigma_2^2(1-\rho_2^2)} \right) I_i \left( \frac{A_2 r_{21}}{\sigma_2^2(1+\rho_2)} \right) I_i \left( \frac{A_2 r_2}{\sigma_2^2(1+\rho_2)} \right) dr_{21} \cdot \\
 & \cdot \int_0^{r_T} \frac{r_{12}r_1}{\sigma_1^4(1-\rho_1^2)} e^{-\frac{r_{12}^2+r_1^2+2A_1^2(1-\rho_1)}{2\sigma_1^2(1-\rho_1^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho_1 r_{12} r_1}{\sigma_1^2(1-\rho_1^2)} \right) I_i \left( \frac{A_1 r_{12}}{\sigma_1^2(1+\rho_1)} \right) I_i \left( \frac{A_1 r_1}{\sigma_1^2(1+\rho_1)} \right) dr_{12} \quad (3.5.8)
 \end{aligned}$$

Za  $r_1 < r_T, r_2 \geq r_T$

$$\begin{aligned}
 & p_{r_1 r_2}(r_1, r_2) = P_1(1 - Q_1(A/\sigma_1, r_1/\sigma_1)) \cdot \\
 & \cdot \frac{r_1 r_2}{\sigma_2^4(1-\rho_2^2)} e^{-\frac{r_1^2+r_2^2+2A_2^2(1-\rho_2)}{2\sigma_2^2(1-\rho_2^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho_2 r_1 r_2}{\sigma_2^2(1-\rho_2^2)} \right) I_i \left( \frac{A_2 r_1}{\sigma_2^2(1+\rho_2)} \right) I_i \left( \frac{A_2 r_2}{\sigma_2^2(1+\rho_2)} \right) + \\
 & + P_1 \int_0^{r_T} \frac{r_{11}r_2}{\sigma_1^4(1-\rho_1^2)} e^{-\frac{r_{11}^2+r_2^2+2A_1^2(1-\rho_1)}{2\sigma_1^2(1-\rho_1^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho_1 r_{11} r_2}{\sigma_1^2(1-\rho_1^2)} \right) I_i \left( \frac{A_1 r_{11}}{\sigma_1^2(1+\rho_1)} \right) I_i \left( \frac{A_1 r_2}{\sigma_1^2(1+\rho_1)} \right) dr_{11} \cdot \\
 & \cdot \int_0^{r_T} \frac{r_{22}r_1}{\sigma_2^4(1-\rho_2^2)} e^{-\frac{r_{22}^2+r_1^2+2A_2^2(1-\rho_2)}{2\sigma_2^2(1-\rho_2^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho_2 r_{22} r_1}{\sigma_2^2(1-\rho_2^2)} \right) I_i \left( \frac{A_2 r_{22}}{\sigma_2^2(1+\rho_2)} \right) I_i \left( \frac{A_2 r_1}{\sigma_2^2(1+\rho_2)} \right) dr_{22} + \\
 & \quad + P_2(1 - Q_1(A/\sigma_2, r_1/\sigma_2)) \cdot \\
 & \cdot \frac{r_1 r_2}{\sigma_1^4(1-\rho_1^2)} e^{-\frac{r_1^2+r_2^2+2A_1^2(1-\rho_1)}{2\sigma_1^2(1-\rho_1^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho_1 r_1 r_2}{\sigma_1^2(1-\rho_1^2)} \right) I_i \left( \frac{A_1 r_1}{\sigma_1^2(1+\rho_1)} \right) I_i \left( \frac{A_1 r_2}{\sigma_1^2(1+\rho_1)} \right) + \\
 & + P_2 \int_0^{r_T} \frac{r_{21}r_2}{\sigma_2^4(1-\rho_2^2)} e^{-\frac{r_{21}^2+r_2^2+2A_2^2(1-\rho_2)}{2\sigma_2^2(1-\rho_2^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho_2 r_{21} r_2}{\sigma_2^2(1-\rho_2^2)} \right) I_i \left( \frac{A_2 r_{21}}{\sigma_2^2(1+\rho_2)} \right) I_i \left( \frac{A_2 r_2}{\sigma_2^2(1+\rho_2)} \right) dr_{21} \cdot \\
 & \cdot \int_0^{r_T} \frac{r_{12}r_1}{\sigma_1^4(1-\rho_1^2)} e^{-\frac{r_{12}^2+r_1^2+2A_1^2(1-\rho_1)}{2\sigma_1^2(1-\rho_1^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho_1 r_{12} r_1}{\sigma_1^2(1-\rho_1^2)} \right) I_i \left( \frac{A_1 r_{12}}{\sigma_1^2(1+\rho_1)} \right) I_i \left( \frac{A_1 r_1}{\sigma_1^2(1+\rho_1)} \right) dr_{12} \quad (3.5.9)
 \end{aligned}$$

Za  $r_1 \geq r_T, r_2 \geq r_T$

$$\begin{aligned}
 p_{r_1 r_2}(r_1, r_2) = & P_1 \frac{r_1 r_2}{\sigma_1^4 (1 - \rho_1^2)} e^{-\frac{r_1^2 + r_2^2 + 2A_1^2 (1 - \rho_1)}{2\sigma_1^2 (1 - \rho_1^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho_1 r_1 r_2}{\sigma_1^2 (1 - \rho_1^2)} \right) I_i \left( \frac{A_1 r_1}{\sigma_1^2 (1 + \rho_1)} \right) I_i \left( \frac{A_1 r_2}{\sigma_1^2 (1 + \rho_1)} \right) + \\
 & + P_1 \frac{r_2}{\sigma_2^2} e^{-\frac{r_2^2 + A_2^2}{2\sigma_2^2}} I_0 \left( \frac{r_2 A_2}{\sigma_2^2} \right) \cdot \\
 & \cdot \int_0^{r_T} \frac{r_{12} r_1}{\sigma_1^4 (1 - \rho_1^2)} e^{-\frac{r_{12}^2 + r_1^2 + 2A_1^2 (1 - \rho_1)}{2\sigma_1^2 (1 - \rho_1^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho_1 r_{12} r_1}{\sigma_1^2 (1 - \rho_1^2)} \right) I_i \left( \frac{A_1 r_{12}}{\sigma_1^2 (1 + \rho_1)} \right) I_i \left( \frac{A_1 r_1}{\sigma_1^2 (1 + \rho_1)} \right) dr_{12} + \\
 & + P_1 (1 - Q_1(A / \sigma_1, r_1 / \sigma_1)) \cdot \\
 & \cdot \frac{r_1 r_2}{\sigma_2^4 (1 - \rho_2^2)} e^{-\frac{r_1^2 + r_2^2 + 2A_2^2 (1 - \rho_2)}{2\sigma_2^2 (1 - \rho_2^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho_2 r_1 r_2}{\sigma_2^2 (1 - \rho_2^2)} \right) I_i \left( \frac{A_2 r_1}{\sigma_2^2 (1 + \rho_2)} \right) I_i \left( \frac{A_2 r_2}{\sigma_2^2 (1 + \rho_2)} \right) + \\
 & + P_1 \int_0^{r_T} \frac{r_{11} r_2}{\sigma_1^4 (1 - \rho_1^2)} e^{-\frac{r_{11}^2 + r_2^2 + 2A_1^2 (1 - \rho_1)}{2\sigma_1^2 (1 - \rho_1^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho_1 r_{11} r_2}{\sigma_1^2 (1 - \rho_1^2)} \right) I_i \left( \frac{A_1 r_{11}}{\sigma_1^2 (1 + \rho_1)} \right) I_i \left( \frac{A_1 r_2}{\sigma_1^2 (1 + \rho_1)} \right) dr_{11} \cdot \\
 & \cdot \int_0^{r_T} \frac{r_{22} r_1}{\sigma_2^4 (1 - \rho_2^2)} e^{-\frac{r_{22}^2 + r_1^2 + 2A_2^2 (1 - \rho_2)}{2\sigma_2^2 (1 - \rho_2^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho_2 r_{22} r_1}{\sigma_2^2 (1 - \rho_2^2)} \right) I_i \left( \frac{A_2 r_{22}}{\sigma_2^2 (1 + \rho_2)} \right) I_i \left( \frac{A_2 r_1}{\sigma_2^2 (1 + \rho_2)} \right) dr_{22} + \\
 & + P_2 \frac{r_1 r_2}{\sigma_2^4 (1 - \rho_2^2)} e^{-\frac{r_1^2 + r_2^2 + 2A_2^2 (1 - \rho_2)}{2\sigma_2^2 (1 - \rho_2^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho_2 r_1 r_2}{\sigma_2^2 (1 - \rho_2^2)} \right) I_i \left( \frac{A_2 r_1}{\sigma_2^2 (1 + \rho_2)} \right) I_i \left( \frac{A_2 r_2}{\sigma_2^2 (1 + \rho_2)} \right) + \\
 & + P_2 \frac{r_2}{\sigma_1^2} e^{-\frac{r_2^2 + A_1^2}{2\sigma_1^2}} I_0 \left( \frac{r_2 A_1}{\sigma_1^2} \right) \cdot \\
 & \cdot \int_0^{r_T} \frac{r_{22} r_1}{\sigma_2^4 (1 - \rho_2^2)} e^{-\frac{r_{22}^2 + r_1^2 + 2A_2^2 (1 - \rho_2)}{2\sigma_2^2 (1 - \rho_2^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho_2 r_{22} r_1}{\sigma_2^2 (1 - \rho_2^2)} \right) I_i \left( \frac{A_2 r_{22}}{\sigma_2^2 (1 + \rho_2)} \right) I_i \left( \frac{A_2 r_1}{\sigma_2^2 (1 + \rho_2)} \right) dr_{22} + \\
 & + P_2 (1 - Q_1(A / \sigma_2, r_1 / \sigma_2)) \cdot \\
 & \cdot \frac{r_1 r_2}{\sigma_1^4 (1 - \rho_1^2)} e^{-\frac{r_1^2 + r_2^2 + 2A_1^2 (1 - \rho_1)}{2\sigma_1^2 (1 - \rho_1^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho_1 r_1 r_2}{\sigma_1^2 (1 - \rho_1^2)} \right) I_i \left( \frac{A_1 r_1}{\sigma_1^2 (1 + \rho_1)} \right) I_i \left( \frac{A_1 r_2}{\sigma_1^2 (1 + \rho_1)} \right) + \\
 & + P_2 \int_0^{r_T} \frac{r_{21} r_2}{\sigma_2^4 (1 - \rho_2^2)} e^{-\frac{r_{21}^2 + r_2^2 + 2A_2^2 (1 - \rho_2)}{2\sigma_2^2 (1 - \rho_2^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho_2 r_{21} r_2}{\sigma_2^2 (1 - \rho_2^2)} \right) I_i \left( \frac{A_2 r_{21}}{\sigma_2^2 (1 + \rho_2)} \right) I_i \left( \frac{A_2 r_2}{\sigma_2^2 (1 + \rho_2)} \right) dr_{21} \cdot \\
 & \cdot \int_0^{r_T} \frac{r_{12} r_1}{\sigma_1^4 (1 - \rho_1^2)} e^{-\frac{r_{12}^2 + r_1^2 + 2A_1^2 (1 - \rho_1)}{2\sigma_1^2 (1 - \rho_1^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho_1 r_{12} r_1}{\sigma_1^2 (1 - \rho_1^2)} \right) I_i \left( \frac{A_1 r_{12}}{\sigma_1^2 (1 + \rho_1)} \right) I_i \left( \frac{A_1 r_1}{\sigma_1^2 (1 + \rho_1)} \right) dr_{12} \quad (3.5.10)
 \end{aligned}$$

Za celobrojne pozitivne vrednosti  $m$  i  $k$ , modifikovana Bessel-ova funkcija prve vrste  $m$ -tog reda se može predstaviti u obliku sledećeg reda [7]:

$$I_m(x) = \sum_{k=0}^{\infty} \frac{1}{k!(m+k)!} \left(\frac{x}{2}\right)^{m+2k} \quad (3.5.11)$$

Izrazi (3.3.40-43) su u obliku jednostrukog integrala sa konačnim granicama. Združena gustina raspodele verovatnoće se može dobiti u zatvorenom obliku korišćenjem nekompletne gamma funkcije [1]:

$$\gamma(\alpha, z) = \int_0^z x^{\alpha-1} \exp(-x) dx \quad \text{Re}(\alpha) > 0 \quad (3.5.12)$$

Za predstavljanje združene PDF u zatvorenom obliku potrebno je rešiti integral  $\int_{r_T}^{\infty} p_{x_1 x_2}(x_1, x_2) dx_1$ , gde je  $p_{x_1 x_2}(x_1, x_2)$  dato u (3.3.38). Transformacijom  $p_{x_1 x_2}(x_1, x_2)$ , ona se može predstaviti u obliku koji u podintegralnom delu predstavlja podintegralni deo nekompletne gamma funkcije, tako što se sve modifikovane Bessel-ove funkcije prve vrste razviju u red i izraz preuredi u odgovarajući oblik.

$$p_{x_1 x_2}(x_1, x_2) = \frac{1}{\sigma^4(1-\rho^2)} e^{-\frac{A^2}{\sigma^2(1+\rho)}} \sum_{i, l_1, l_2, l_3=0}^{\infty} \mathcal{E}_i \cdot \frac{1}{l_1! l_2! l_3! (i+l_1)! (i+l_2)! (i+l_3)!} \cdot \frac{\rho^{i+2l_1}}{(2\sigma^2(1-\rho^2))^{3i+2l_1+2l_2+2l_3}} A^{2i+2l_2+2l_3} (1-\rho)^{2i+2l_2+2l_3} x_1^{2i+2l_1+2l_2+1} x_2^{2i+2l_1+2l_3+1} e^{-\frac{x_1^2+x_2^2}{2\sigma^2(1-\rho^2)}} \quad (3.5.13)$$

Integral se rešava uvođenjem smene:

$$x_1 = \sigma \sqrt{2(1-\rho^2)} \sqrt{x} \quad x = \frac{x_1^2}{2\sigma^2(1-\rho^2)} \quad (3.5.14)$$

$$\int_0^{r_T} p_{x_1 x_2}(x_1, x_2) dx_1 = \frac{1}{\sigma^4(1-\rho^2)} e^{-\frac{A^2}{\sigma^2(1+\rho)}} \cdot \sum_{i, l_1, l_2, l_3=0}^{\infty} \mathcal{E}_i \cdot \frac{1}{l_1! l_2! l_3! (i+l_1)! (i+l_2)! (i+l_3)!} \frac{\rho^{i+2l_1}}{(2\sigma^2(1-\rho^2))^{3i+2l_1+2l_2+2l_3}} A^{2i+2l_2+2l_3} (1-\rho)^{2i+2l_2+2l_3} \cdot x_2^{2i+2l_1+2l_3+1} e^{-\frac{x_2^2}{2\sigma^2(1-\rho^2)}} \frac{r_T^2}{2\sigma^2(1-\rho^2)} \int_0^{\frac{r_T^2}{2\sigma^2(1-\rho^2)}} \left(\sigma \sqrt{2(1-\rho^2)} \sqrt{x}\right)^{2i+2l_1+2l_2+1} e^{-x} \sigma \sqrt{2(1-\rho^2)} \frac{1}{2} x^{-1/2} dx \quad (3.5.15)$$

Nakon određenih algebarskih preuređivanja dobija se oblik koji odgovara nekompletnoj gamma funkciji.

$$\int_0^{r_i} p_{x_1 x_2}(x_1, x_2) dx_1 = \frac{1}{\sigma^2} e^{-\frac{A^2}{\sigma^2(1+\rho)}} \sum_{i, l_1, l_2, l_3=0}^{\infty} \varepsilon_i \cdot \frac{1}{l_1! l_2! l_3! (i+l_1)! (i+l_2)! (i+l_3)!} \cdot \frac{\rho^{i+2l_1}}{(2\sigma^2(1-\rho^2))^{2i+l_1+l_2+2l_3}} A^{2i+2l_2+2l_3} (1-\rho)^{2i+2l_2+2l_3} \cdot x_2^{2i+2l_1+2l_3+1} e^{-\frac{x_2^2}{2\sigma^2(1-\rho^2)}} \frac{r_i^2}{2\sigma^2(1-\rho^2)} \int_0^{r_i} (x)^{i+l_1+l_2+1-1} e^{-x} dx \quad (3.5.16)$$

Krajnje rešenje je u zatvorenom obliku uz korišćenje 4 beskonačne sume.

$$\int_0^{r_T} p_{x_1 x_2}(x_1, x_2) dx_1 = \frac{1}{\sigma^2} e^{-\frac{A^2}{\sigma^2(1+\rho)}} \sum_{i, l_1, l_2, l_3=0}^{\infty} \varepsilon_i \cdot \frac{1}{l_1! l_2! l_3! (i+l_1)! (i+l_2)! (i+l_3)!} \frac{\rho^{i+2l_1}}{(2\sigma^2(1-\rho^2))^{2i+l_1+l_2+2l_3}} \cdot A^{2i+2l_2+2l_3} (1-\rho)^{2i+2l_2+2l_3} x_2^{2i+2l_1+2l_3+1} e^{-\frac{x_2^2}{2\sigma^2(1-\rho^2)}} \gamma\left(i+l_1+l_2+1, \frac{r_i^2}{2\sigma^2(1-\rho^2)}\right) \quad (3.5.17)$$

Zamenom (3.5.17) u izrazima (3.5.7-10) dobija se konačni oblik za združenu gustinu raspodele verovatnoće na izlazu iz SSC kombinera

Za  $r_1 < r_T$ ,  $r_2 < r_T$

$$p_{r_1 r_2}(r_1, r_2) = P_1 \left[ \frac{1}{\sigma_2^2} e^{-\frac{A_2^2}{\sigma_2^2(1+\rho_2)}} \sum_{i, l_1, l_2, l_3=0}^{\infty} \varepsilon_i \cdot \frac{1}{l_1! l_2! l_3! (i+l_1)! (i+l_2)! (i+l_3)!} \frac{\rho_2^{i+2l_1}}{(2\sigma_2^2(1-\rho_2^2))^{2i+l_1+l_2+2l_3}} \cdot A_2^{2i+2l_2+2l_3} (1-\rho_2)^{2i+2l_2+2l_3} \cdot r_1^{2i+2l_1+2l_3+1} e^{-\frac{r_1^2}{2\sigma_2^2(1-\rho_2^2)}} \gamma\left(i+l_1+l_2+1, \frac{r_T^2}{2\sigma_2^2(1-\rho_2^2)}\right) \right] \cdot \left[ \frac{1}{\sigma_1^2} e^{-\frac{A_1^2}{\sigma_1^2(1+\rho_1)}} \sum_{i, l_1, l_2, l_3=0}^{\infty} \varepsilon_i \cdot \frac{1}{l_1! l_2! l_3! (i+l_1)! (i+l_2)! (i+l_3)!} \frac{\rho_1^{i+2l_1}}{(2\sigma_1^2(1-\rho_1^2))^{2i+l_1+l_2+2l_3}} \cdot A_1^{2i+2l_2+2l_3} (1-\rho_1)^{2i+2l_2+2l_3} \cdot r_2^{2i+2l_1+2l_3+1} e^{-\frac{r_2^2}{2\sigma_1^2(1-\rho_1^2)}} \gamma\left(i+l_1+l_2+1, \frac{r_T^2}{2\sigma_1^2(1-\rho_1^2)}\right) \right] + P_2 \left[ \frac{1}{\sigma_1^2} e^{-\frac{A_1^2}{\sigma_1^2(1+\rho_1)}} \sum_{i, l_1, l_2, l_3=0}^{\infty} \varepsilon_i \cdot \frac{1}{l_1! l_2! l_3! (i+l_1)! (i+l_2)! (i+l_3)!} \frac{\rho_1^{i+2l_1}}{(2\sigma_1^2(1-\rho_1^2))^{2i+l_1+l_2+2l_3}} \right]$$

$$\begin{aligned}
 & \cdot A_1^{2i+2l_2+2l_3} (1-\rho_1)^{2i+2l_2+2l_3} \cdot r_1^{2i+2l_1+2l_3+1} e^{-\frac{r_1^2}{2\sigma_1^2(1-\rho_1^2)}} \gamma\left(i+l_1+l_2+1, \frac{r_T^2}{2\sigma_1^2(1-\rho_1^2)}\right) \Bigg] \cdot \\
 & \cdot \left[ \frac{1}{\sigma_2^2} e^{-\frac{A_2^2}{\sigma_2^2(1+\rho_2)}} \sum_{i,l_1,l_2,l_3=0}^{\infty} \mathcal{E}_i \cdot \frac{1}{l_1!l_2!l_3!(i+l_1)!(i+l_2)!(i+l_3)!} \frac{\rho_2^{i+2l_1}}{(2\sigma_2^2(1-\rho_2^2))^{2i+l_1+l_2+2l_3}} \cdot \right. \\
 & \cdot A_2^{2i+2l_2+2l_3} (1-\rho_2)^{2i+2l_2+2l_3} \cdot r_2^{2i+2l_1+2l_3+1} e^{-\frac{r_2^2}{2\sigma_2^2(1-\rho_2^2)}} \gamma\left(i+l_1+l_2+1, \frac{r_T^2}{2\sigma_2^2(1-\rho_2^2)}\right) \Bigg] \quad (3.5.18)
 \end{aligned}$$

Za  $r_1 \geq r_T, r_2 < r_T$

$$\begin{aligned}
 p_{r_1 r_2}(r_1, r_2) &= P_1 \frac{r_2}{\sigma_2^2} e^{-\frac{r_2^2 + A_2^2}{2\sigma_2^2}} I_0\left(\frac{r_2 A_2}{\sigma_2^2}\right) \cdot \\
 & \cdot \left[ \frac{1}{\sigma_1^2} e^{-\frac{A_1^2}{\sigma_1^2(1+\rho_1)}} \sum_{i,l_1,l_2,l_3=0}^{\infty} \mathcal{E}_i \cdot \frac{1}{l_1!l_2!l_3!(i+l_1)!(i+l_2)!(i+l_3)!} \frac{\rho_1^{i+2l_1}}{(2\sigma_1^2(1-\rho_1^2))^{2i+l_1+l_2+2l_3}} \cdot \right. \\
 & \cdot A_1^{2i+2l_2+2l_3} (1-\rho_1)^{2i+2l_2+2l_3} \cdot r_1^{2i+2l_1+2l_3+1} e^{-\frac{r_1^2}{2\sigma_1^2(1-\rho_1^2)}} \gamma\left(i+l_1+l_2+1, \frac{r_T^2}{2\sigma_1^2(1-\rho_1^2)}\right) \Bigg] + \\
 & + P_1 \left[ \frac{1}{\sigma_2^2} e^{-\frac{A_2^2}{\sigma_2^2(1+\rho_2)}} \sum_{i,l_1,l_2,l_3=0}^{\infty} \mathcal{E}_i \cdot \frac{1}{l_1!l_2!l_3!(i+l_1)!(i+l_2)!(i+l_3)!} \frac{\rho_2^{i+2l_1}}{(2\sigma_2^2(1-\rho_2^2))^{2i+l_1+l_2+2l_3}} \cdot \right. \\
 & \cdot A_2^{2i+2l_2+2l_3} (1-\rho_2)^{2i+2l_2+2l_3} \cdot r_1^{2i+2l_1+2l_3+1} e^{-\frac{r_1^2}{2\sigma_2^2(1-\rho_2^2)}} \gamma\left(i+l_1+l_2+1, \frac{r_T^2}{2\sigma_2^2(1-\rho_2^2)}\right) \Bigg] \cdot \\
 & \cdot \left[ \frac{1}{\sigma_1^2} e^{-\frac{A_1^2}{\sigma_1^2(1+\rho_1)}} \sum_{i,l_1,l_2,l_3=0}^{\infty} \mathcal{E}_i \cdot \frac{1}{l_1!l_2!l_3!(i+l_1)!(i+l_2)!(i+l_3)!} \frac{\rho_1^{i+2l_1}}{(2\sigma_1^2(1-\rho_1^2))^{2i+l_1+l_2+2l_3}} \cdot \right. \\
 & \cdot A_1^{2i+2l_2+2l_3} (1-\rho_1)^{2i+2l_2+2l_3} \cdot r_2^{2i+2l_1+2l_3+1} e^{-\frac{r_2^2}{2\sigma_1^2(1-\rho_1^2)}} \gamma\left(i+l_1+l_2+1, \frac{r_T^2}{2\sigma_1^2(1-\rho_1^2)}\right) \Bigg] + \\
 & + P_2 \frac{r_2}{\sigma_1^2} e^{-\frac{r_2^2 + A_1^2}{2\sigma_1^2}} I_0\left(\frac{r_2 A_1}{\sigma_1^2}\right) \cdot
 \end{aligned}$$

$$\begin{aligned}
 & \cdot \left[ \frac{1}{\sigma_2^2} e^{-\frac{A_2^2}{\sigma_2^2(1+\rho_2)}} \sum_{i,l_1,l_2,l_3=0}^{\infty} \varepsilon_i \cdot \frac{1}{l_1!l_2!l_3!(i+l_1)!(i+l_2)!(i+l_3)!} \frac{\rho_2^{i+2l_1}}{(2\sigma_2^2(1-\rho_2^2))^{2i+l_1+l_2+2l_3}} \cdot \right. \\
 & \cdot A_2^{2i+2l_2+2l_3} (1-\rho_2)^{2i+2l_2+2l_3} \cdot r_1^{2i+2l_1+2l_3+1} e^{-\frac{r_1^2}{2\sigma_2^2(1-\rho_2^2)}} \gamma\left(i+l_1+l_2+1, \frac{r_T^2}{2\sigma_2^2(1-\rho_2^2)}\right) \left. \right] \\
 & + P_2 \left[ \frac{1}{\sigma_1^2} e^{-\frac{A_1^2}{\sigma_1^2(1+\rho_1)}} \sum_{i,l_1,l_2,l_3=0}^{\infty} \varepsilon_i \cdot \frac{1}{l_1!l_2!l_3!(i+l_1)!(i+l_2)!(i+l_3)!} \frac{\rho_1^{i+2l_1}}{(2\sigma_1^2(1-\rho_1^2))^{2i+l_1+l_2+2l_3}} \cdot \right. \\
 & \cdot A_1^{2i+2l_2+2l_3} (1-\rho_1)^{2i+2l_2+2l_3} \cdot r_1^{2i+2l_1+2l_3+1} e^{-\frac{r_1^2}{2\sigma_1^2(1-\rho_1^2)}} \gamma\left(i+l_1+l_2+1, \frac{r_T^2}{2\sigma_1^2(1-\rho_1^2)}\right) \left. \right] \\
 & \cdot A_2^{2i+2l_2+2l_3} (1-\rho_2)^{2i+2l_2+2l_3} \cdot r_2^{2i+2l_1+2l_3+1} e^{-\frac{r_2^2}{2\sigma_2^2(1-\rho_2^2)}} \gamma\left(i+l_1+l_2+1, \frac{r_T^2}{2\sigma_2^2(1-\rho_2^2)}\right) \left. \right] \\
 & \cdot \left[ \frac{1}{\sigma_2^2} e^{-\frac{A_2^2}{\sigma_2^2(1+\rho_2)}} \sum_{i,l_1,l_2,l_3=0}^{\infty} \varepsilon_i \cdot \frac{1}{l_1!l_2!l_3!(i+l_1)!(i+l_2)!(i+l_3)!} \frac{\rho_2^{i+2l_1}}{(2\sigma_2^2(1-\rho_2^2))^{2i+l_1+l_2+2l_3}} \cdot \right. \\
 & \cdot A_2^{2i+2l_2+2l_3} (1-\rho_2)^{2i+2l_2+2l_3} \cdot r_2^{2i+2l_1+2l_3+1} e^{-\frac{r_2^2}{2\sigma_2^2(1-\rho_2^2)}} \gamma\left(i+l_1+l_2+1, \frac{r_T^2}{2\sigma_2^2(1-\rho_2^2)}\right) \left. \right] \quad (3.5.19)
 \end{aligned}$$

Za  $r_1 < r_T, r_2 \geq r_T$

$$\begin{aligned}
 & p_{r_1 r_2}(r_1, r_2) = P_1(1 - Q_1(A/\sigma_1, r_T/\sigma_1)) \cdot \\
 & \cdot \frac{r_1 r_2}{\sigma_2^4(1-\rho_2^2)} e^{-\frac{r_1^2+r_2^2+2A_2^2(1-\rho_2)}{2\sigma_2^2(1-\rho_2^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i\left(\frac{\rho r_1 r_2}{\sigma_2^2(1-\rho_2^2)}\right) I_i\left(\frac{A_2 r_1}{\sigma_2^2(1+\rho_2)}\right) I_i\left(\frac{A_2 r_2}{\sigma_2^2(1+\rho_2)}\right) + \\
 & + P_1 \left[ \frac{1}{\sigma_2^2} e^{-\frac{A_2^2}{\sigma_2^2(1+\rho_2)}} \sum_{i,l_1,l_2,l_3=0}^{\infty} \varepsilon_i \cdot \frac{1}{l_1!l_2!l_3!(i+l_1)!(i+l_2)!(i+l_3)!} \frac{\rho_2^{i+2l_1}}{(2\sigma_2^2(1-\rho_2^2))^{2i+l_1+l_2+2l_3}} \cdot \right. \\
 & \cdot A_2^{2i+2l_2+2l_3} (1-\rho_2)^{2i+2l_2+2l_3} \cdot r_1^{2i+2l_1+2l_3+1} e^{-\frac{r_1^2}{2\sigma_2^2(1-\rho_2^2)}} \gamma\left(i+l_1+l_2+1, \frac{r_T^2}{2\sigma_2^2(1-\rho_2^2)}\right) \left. \right] \\
 & \cdot \left[ \frac{1}{\sigma_1^2} e^{-\frac{A_1^2}{\sigma_1^2(1+\rho_1)}} \sum_{i,l_1,l_2,l_3=0}^{\infty} \varepsilon_i \cdot \frac{1}{l_1!l_2!l_3!(i+l_1)!(i+l_2)!(i+l_3)!} \frac{\rho_1^{i+2l_1}}{(2\sigma_1^2(1-\rho_1^2))^{2i+l_1+l_2+2l_3}} \cdot \right.
 \end{aligned}$$

$$\begin{aligned}
 & \cdot A_1^{2i+2l_2+2l_3} (1-\rho_1)^{2i+2l_2+2l_3} \cdot r_2^{2i+2l_1+2l_3+1} e^{-\frac{r_2^2}{2\sigma_1^2(1-\rho_1^2)}} \gamma\left(i+l_1+l_2+1, \frac{r_T^2}{2\sigma_1^2(1-\rho_1^2)}\right) \Bigg] + \\
 & \quad + P_2(1-Q_1(A/\sigma_2, r_T/\sigma_2)) \cdot \\
 & \cdot \frac{r_1 r_2}{\sigma_1^4(1-\rho_1^2)} e^{-\frac{r_1^2+r_2^2+2A_1^2(1-\rho_1)}{2\sigma_1^2(1-\rho_1^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i\left(\frac{\rho_1 r_1 r_2}{\sigma_1^2(1-\rho_1^2)}\right) I_i\left(\frac{A_1 r_1}{\sigma_1^2(1+\rho_1)}\right) I_i\left(\frac{A_1 r_2}{\sigma_1^2(1+\rho_1)}\right) + \\
 & + P_2 \left[ \frac{1}{\sigma_1^2} e^{-\frac{A_1^2}{\sigma_1^2(1+\rho_1)}} \sum_{i, l_1, l_2, l_3=0}^{\infty} \varepsilon_i \cdot \frac{1}{l_1! l_2! l_3! (i+l_1)! (i+l_2)! (i+l_3)!} \frac{\rho_1^{i+2l_1}}{(2\sigma_1^2(1-\rho_1^2))^{2i+l_1+l_2+2l_3}} \cdot \right. \\
 & \cdot A_1^{2i+2l_2+2l_3} (1-\rho_1)^{2i+2l_2+2l_3} \cdot r_1^{2i+2l_1+2l_3+1} e^{-\frac{r_1^2}{2\sigma_1^2(1-\rho_1^2)}} \gamma\left(i+l_1+l_2+1, \frac{r_T^2}{2\sigma_1^2(1-\rho_1^2)}\right) \Bigg] \cdot \\
 & \cdot \left[ \frac{1}{\sigma_2^2} e^{-\frac{A_2^2}{\sigma_2^2(1+\rho_2)}} \sum_{i, l_1, l_2, l_3=0}^{\infty} \varepsilon_i \cdot \frac{1}{l_1! l_2! l_3! (i+l_1)! (i+l_2)! (i+l_3)!} \frac{\rho_2^{i+2l_1}}{(2\sigma_2^2(1-\rho_2^2))^{2i+l_1+l_2+2l_3}} \cdot \right. \\
 & \cdot A_2^{2i+2l_2+2l_3} (1-\rho_2)^{2i+2l_2+2l_3} \cdot r_2^{2i+2l_1+2l_3+1} e^{-\frac{r_2^2}{2\sigma_2^2(1-\rho_2^2)}} \gamma\left(i+l_1+l_2+1, \frac{r_T^2}{2\sigma_2^2(1-\rho_2^2)}\right) \Bigg] \quad (3.5.20)
 \end{aligned}$$

Za  $r_1 \geq r_T, r_2 \geq r_T$

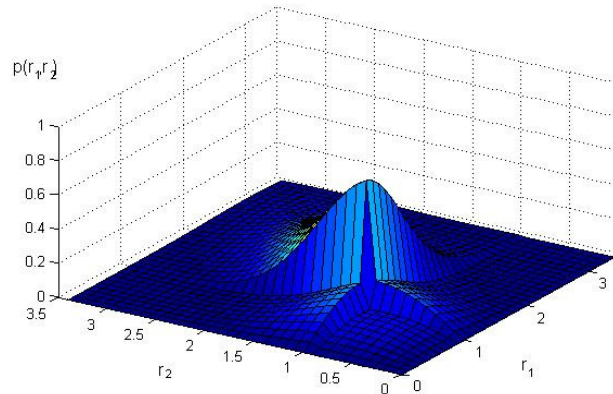
$$\begin{aligned}
 p_{r_1 r_2}(r_1, r_2) &= P_1 \frac{r_1 r_2}{\sigma_1^4(1-\rho_1^2)} e^{-\frac{r_1^2+r_2^2+2A_1^2(1-\rho_1)}{2\sigma_1^2(1-\rho_1^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i\left(\frac{\rho_1 r_1 r_2}{\sigma_1^2(1-\rho_1^2)}\right) I_i\left(\frac{A_1 r_1}{\sigma_1^2(1+\rho_1)}\right) I_i\left(\frac{A_1 r_2}{\sigma_1^2(1+\rho_1)}\right) + \\
 & \quad + P_1 \frac{r_2}{\sigma_2^2} e^{-\frac{r_2^2+A_2^2}{2\sigma_2^2}} I_0\left(\frac{r_2 A_2}{\sigma_2^2}\right) \cdot \\
 & \cdot \left[ \frac{1}{\sigma_1^2} e^{-\frac{A_1^2}{\sigma_1^2(1+\rho_1)}} \sum_{i, l_1, l_2, l_3=0}^{\infty} \varepsilon_i \cdot \frac{1}{l_1! l_2! l_3! (i+l_1)! (i+l_2)! (i+l_3)!} \frac{\rho_1^{i+2l_1}}{(2\sigma_1^2(1-\rho_1^2))^{2i+l_1+l_2+2l_3}} \cdot \right. \\
 & \cdot A_1^{2i+2l_2+2l_3} (1-\rho_1)^{2i+2l_2+2l_3} \cdot r_1^{2i+2l_1+2l_3+1} e^{-\frac{r_1^2}{2\sigma_1^2(1-\rho_1^2)}} \gamma\left(i+l_1+l_2+1, \frac{r_T^2}{2\sigma_1^2(1-\rho_1^2)}\right) \Bigg] + \\
 & \quad + P_1(1-Q_1(A/\sigma_1, r_T/\sigma_1)) \cdot \\
 & \cdot \frac{r_1 r_2}{\sigma_2^4(1-\rho_1^2)} e^{-\frac{r_1^2+r_2^2+2A_2^2(1-\rho_1)}{2\sigma_2^2(1-\rho_1^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i\left(\frac{\rho_1 r_1 r_2}{\sigma_2^2(1-\rho_1^2)}\right) I_i\left(\frac{A_2 r_1}{\sigma_2^2(1+\rho_1)}\right) I_i\left(\frac{A_2 r_2}{\sigma_2^2(1+\rho_1)}\right) +
 \end{aligned}$$



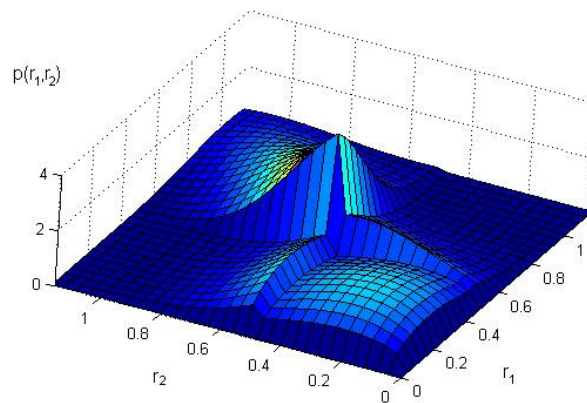
$$\begin{aligned}
 & + P_1 \left[ \frac{1}{\sigma_2^2} e^{-\frac{A_2^2}{\sigma_2^2(1+\rho_2)}} \sum_{i,l_1,l_2,l_3=0}^{\infty} \varepsilon_i \cdot \frac{1}{l_1!l_2!l_3!(i+l_1)!(i+l_2)!(i+l_3)!} \frac{\rho_2^{i+2l_1}}{(2\sigma_2^2(1-\rho_2^2))^{2i+l_1+l_2+2l_3}} \cdot \right. \\
 & \cdot A_2^{2i+2l_2+2l_3} (1-\rho_2)^{2i+2l_2+2l_3} \cdot r_1^{2i+2l_1+2l_3+1} e^{-\frac{r_1^2}{2\sigma_2^2(1-\rho_2^2)}} \gamma \left( i+l_1+l_2+1, \frac{r_T^2}{2\sigma_2^2(1-\rho_2^2)} \right) \left. \right] \\
 & \cdot \left[ \frac{1}{\sigma_1^2} e^{-\frac{A_1^2}{\sigma_1^2(1+\rho_1)}} \sum_{i,l_1,l_2,l_3=0}^{\infty} \varepsilon_i \cdot \frac{1}{l_1!l_2!l_3!(i+l_1)!(i+l_2)!(i+l_3)!} \frac{\rho_1^{i+2l_1}}{(2\sigma_1^2(1-\rho_1^2))^{2i+l_1+l_2+2l_3}} \cdot \right. \\
 & \cdot A_1^{2i+2l_2+2l_3} (1-\rho_1)^{2i+2l_2+2l_3} \cdot r_2^{2i+2l_1+2l_3+1} e^{-\frac{r_2^2}{2\sigma_1^2(1-\rho_1^2)}} \gamma \left( i+l_1+l_2+1, \frac{r_T^2}{2\sigma_1^2(1-\rho_1^2)} \right) \left. \right] + \\
 & + P_2 \frac{r_1 r_2}{\sigma_2^4 (1-\rho_2^2)} e^{-\frac{r_1^2+r_2^2+2A_2^2(1-\rho_2)}{2\sigma_2^2(1-\rho_2^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho_2 r_1 r_2}{\sigma_2^2 (1-\rho_2^2)} \right) I_i \left( \frac{A_2 r_1}{\sigma_2^2 (1+\rho_2)} \right) I_i \left( \frac{A_2 r_2}{\sigma_2^2 (1+\rho_2)} \right) + \\
 & + P_2 \frac{r_2}{\sigma_1^2} e^{-\frac{r_2^2+A_1^2}{2\sigma_1^2}} I_0 \left( \frac{r_2 A_1}{\sigma_1^2} \right). \\
 & \cdot \left[ \frac{1}{\sigma_2^2} e^{-\frac{A_2^2}{\sigma_2^2(1+\rho_2)}} \sum_{i,l_1,l_2,l_3=0}^{\infty} \varepsilon_i \cdot \frac{1}{l_1!l_2!l_3!(i+l_1)!(i+l_2)!(i+l_3)!} \frac{\rho_2^{i+2l_1}}{(2\sigma_2^2(1-\rho_2^2))^{2i+l_1+l_2+2l_3}} \cdot \right. \\
 & \cdot A_2^{2i+2l_2+2l_3} (1-\rho_2)^{2i+2l_2+2l_3} \cdot r_1^{2i+2l_1+2l_3+1} e^{-\frac{r_1^2}{2\sigma_2^2(1-\rho_2^2)}} \gamma \left( i+l_1+l_2+1, \frac{r_T^2}{2\sigma_2^2(1-\rho_2^2)} \right) \left. \right] \\
 & + P_2 (1-Q_1(A/\sigma_2, r_T/\sigma_2)) \cdot \\
 & \cdot \frac{r_1 r_2}{\sigma_1^4 (1-\rho_1^2)} e^{-\frac{r_1^2+r_2^2+2A_1^2(1-\rho_1)}{2\sigma_1^2(1-\rho_1^2)}} \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho_1 r_1 r_2}{\sigma_1^2 (1-\rho_1^2)} \right) I_i \left( \frac{A_1 r_1}{\sigma_1^2 (1+\rho_1)} \right) I_i \left( \frac{A_1 r_2}{\sigma_1^2 (1+\rho_1)} \right) + \\
 & + P_2 \left[ \frac{1}{\sigma_1^2} e^{-\frac{A_1^2}{\sigma_1^2(1+\rho_1)}} \sum_{i,l_1,l_2,l_3=0}^{\infty} \varepsilon_i \cdot \frac{1}{l_1!l_2!l_3!(i+l_1)!(i+l_2)!(i+l_3)!} \frac{\rho_1^{i+2l_1}}{(2\sigma_1^2(1-\rho_1^2))^{2i+l_1+l_2+2l_3}} \cdot \right. \\
 & \cdot A_1^{2i+2l_2+2l_3} (1-\rho_1)^{2i+2l_2+2l_3} \cdot r_1^{2i+2l_1+2l_3+1} e^{-\frac{r_1^2}{2\sigma_1^2(1-\rho_1^2)}} \gamma \left( i+l_1+l_2+1, \frac{r_T^2}{2\sigma_1^2(1-\rho_1^2)} \right) \left. \right] \\
 & \cdot \left[ \frac{1}{\sigma_2^2} e^{-\frac{A_2^2}{\sigma_2^2(1+\rho_2)}} \sum_{i,l_1,l_2,l_3=0}^{\infty} \varepsilon_i \cdot \frac{1}{l_1!l_2!l_3!(i+l_1)!(i+l_2)!(i+l_3)!} \frac{\rho_2^{i+2l_1}}{(2\sigma_2^2(1-\rho_2^2))^{2i+l_1+l_2+2l_3}} \cdot \right.
 \end{aligned}$$

$$\cdot A_2^{2i+2l_2+2l_3} (1-\rho_2)^{2i+2l_2+2l_3} \cdot r_2^{2i+2l_1+2l_3+1} e^{-\frac{r_2^2}{2\sigma_2^2(1-\rho_2^2)}} \gamma\left(i+l_1+l_2+1, \frac{r_T^2}{2\sigma_2^2(1-\rho_2^2)}\right) \quad (3.5.21)$$

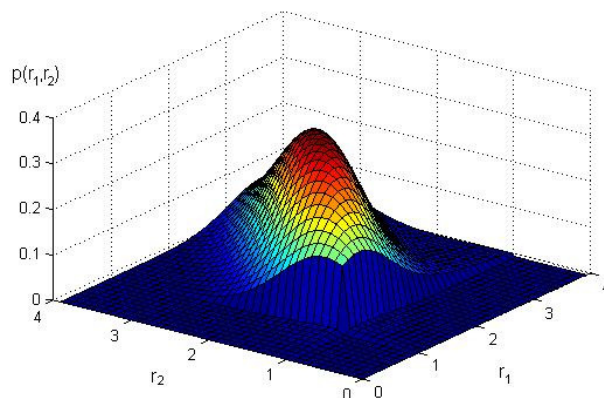
Na slikama 3.5.1.-9. predstavljena je zavisnost PDF od vrednosti signala za različite vrednosti parametara raspodele, korelacije i praga odlučivanja. Radi uproštavanja, a ne gubeći uopštenost, pretpostavljeno je da su parametri raspodele isti za obe grane kombinera



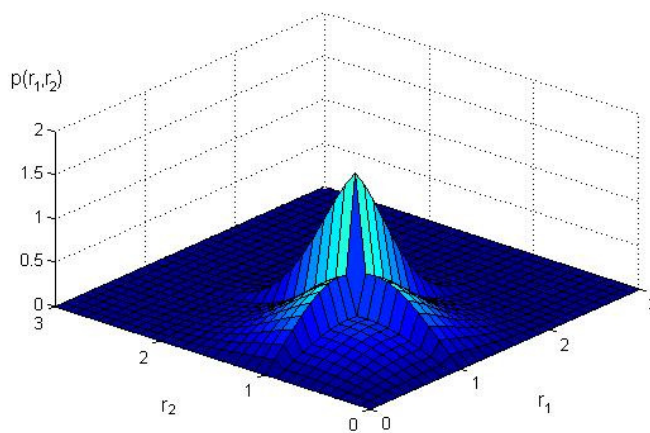
Slika 3.5.1. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Rice-ovog fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 0.5$ ,  $\sigma = 1$ ,  $A = 0.5$



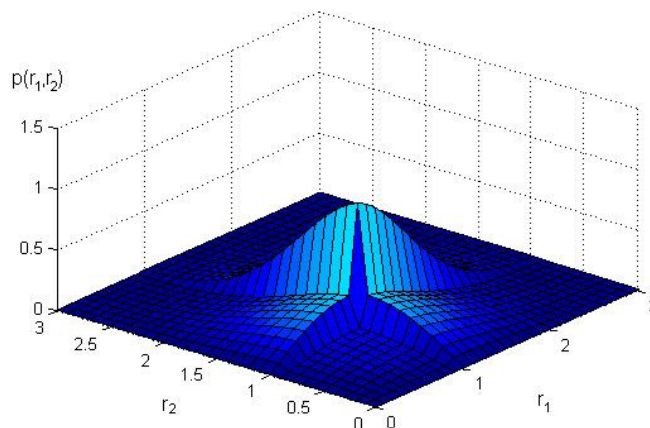
Slika 3.5.2. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Rice-ovog fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 0.5$ ,  $\sigma = 1$ ,  $A = 1$



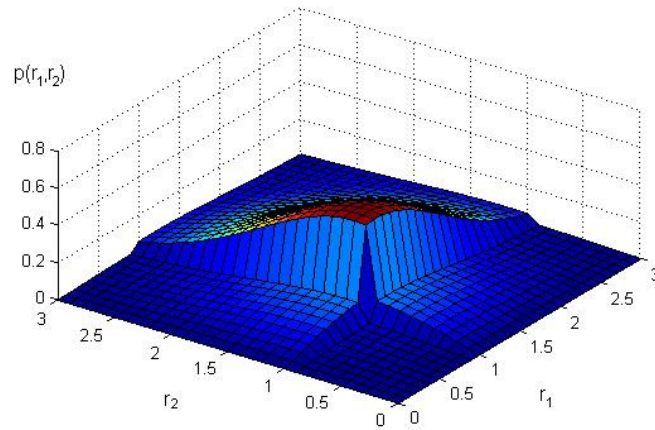
Slika 3.5.3. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Rice-ovog fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 0.5$ ,  $\sigma = 1$ ,  $A = 2$



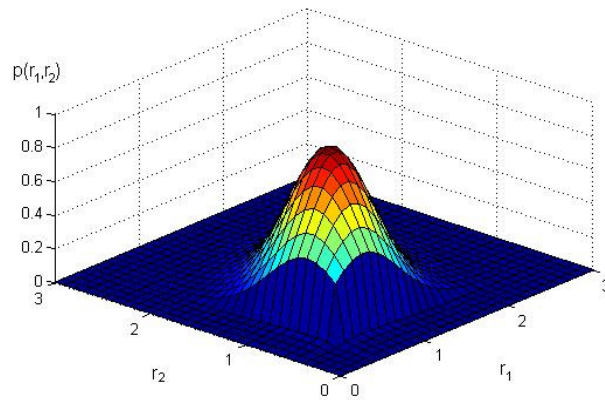
Slika 3.5.4. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Rice-ovog fedinga za parametre:  $\rho = 0.1$ ,  $r_T = 1$ ,  $A = 0.7$ ,  $\sigma = 0.5$



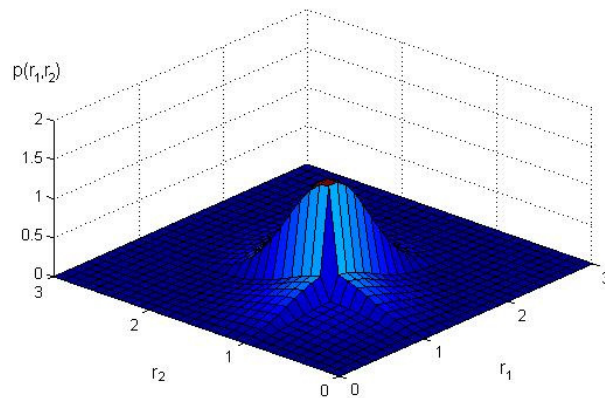
Slika 3.5.5. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Rice-ovog fedinga za parametre:  $\rho = 0.1$ ,  $r_T = 1$ ,  $A = 0.7$ ,  $\sigma = 0.7$



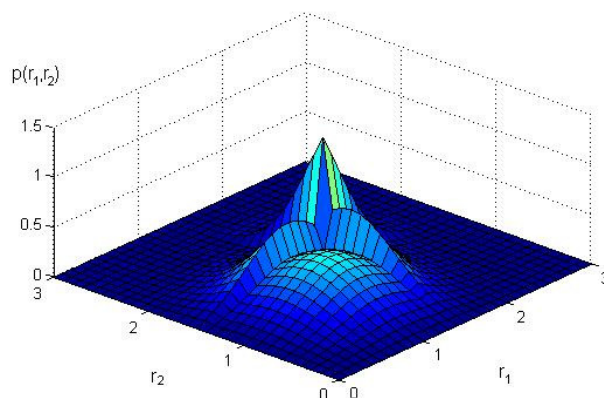
Slika 3.5.6. Združena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Rice-ovog fedinga za parametre:  $\rho = 0.1$ ,  $r_T = 1$ ,  $A = 0.7$ ,  $\sigma = 1$



Slika 3.5.7. Združena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Rice-ovog fedinga za parametre:  $\rho = 0.5$ ,  $A = 1$ ,  $\sigma = 0.5$ ,  $r_T = 0.5$



Slika 3.5.9. Združena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Rice-ovog fedinga za parametre:  $\rho = 0.5$ ,  $A = 1$ ,  $\sigma = 0.5$ ,  $r_T = 1$



Slika 3.5.9. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Rice-ovog fedinga za parametre:  $\rho = 0.5$ ,  $A = 1$ ,  $\sigma = 0.5$ ,  $r_T = 1.5$

### 3.6 Zdužena gustina raspodele verovatnoće na izlazu SSC kombinera u dva trenutka vremena u prisustvu Weibull-ovog fedinga

Gustina raspodele verovatnoće i kumulativna raspodela verovatnoće (CDF) signala na izlazu iz kombinera  $r_{i,j}$  u prisustvu Weibull -ovog fedinga su [13], [ 8]:

$$p_{r_i}(r_{i,j}) = \frac{\beta_i}{\Omega_i} r_{i,j}^{\beta_i-1} e^{-\frac{r_{i,j}^{\beta_i}}{\Omega_i}}, \quad r_{i,j} \geq 0 \quad (3.6.1)$$

$$F_{r_i}(r_{i,j}) = 1 - e^{-\frac{r_{i,j}^{\beta_i}}{\Omega_i}}, \quad r_{i,j} \geq 0 \quad (3.6.2)$$

gde su  $i=1,2$   $j=1,2$ ,  $\beta_i$  predstavlja Weibull-ov feding parametar i pozitivna je realna konstanta i  $\Omega_i = E(r_{i,j}^{\beta_i})$ .

Verovatnoće  $P_1$  i  $P_2$  se dobijaju ako se u (3.1.17-18) stavi (3.6.2):

$$P_1 = \frac{F_{r_2}(r_T)}{F_{r_1}(r_T) + F_{r_2}(r_T)} = \frac{1 - e^{-\frac{r_T^{\beta_2}}{\Omega_2}}}{e^{-\frac{r_T^{\beta_1}}{\Omega_1}} + e^{-\frac{r_T^{\beta_2}}{\Omega_2}}} \quad (3.6.3)$$

$$P_2 = \frac{F_{r_1}(r_T)}{F_{r_1}(r_T) + F_{r_2}(r_T)} = \frac{1 - e^{-\frac{r_T^{\beta_1}}{\Omega_1}}}{e^{-\frac{r_T^{\beta_1}}{\Omega_1}} + e^{-\frac{r_T^{\beta_2}}{\Omega_2}}} \quad (3.6.4)$$

Združena gustina raspodele verovatnoće korelisanih signala  $x_1$  i  $x_2$  sa Weibull-ovom raspodelom i istim parametrima raspodele je [8]:

$$p_{x_1x_2}(x_1, x_2) = \frac{\beta^2 (x_1 x_2)^{\beta-1}}{\Omega^2 (1-\rho)} \exp\left[-\frac{1}{1-\rho} \left(\frac{x_1^\beta}{\Omega} + \frac{x_2^\beta}{\Omega}\right)\right] I_0\left[\frac{2\sqrt{\rho} x_1^{\beta/2} x_2^{\beta/2}}{(1-\rho)\Omega}\right] \quad (3.6.5)$$

gde je  $\rho$  koeficijent korelacije,  $I_i(\cdot)$  je modifikovana Bessel-ova funkcija prve vrste  $i$ -tog reda (3.3.20), [51].

Združena gustina raspodele verovatnoće signala  $r_1$  i  $r_2$  na izlazu SSC kombinera u dva trenutka vremena u prisustvu Weibull-ovog fedinga kada su signali na ulazu u grane kombinera nezavisni, može se dobiti ako se u (3.2.5-8) stave izrazi (3.3.55) i (3.3.59)

Za  $r_1 < r_T, r_2 < r_T$

$$\begin{aligned} p_{r_1r_2}(r_1, r_2) = & P_1 \int_0^{r_T} \frac{\beta_1^2 (r_{11} r_2)^{\beta_1-1}}{\Omega_1^2 (1-\rho_1)} e^{-\frac{1}{1-\rho_1} \left(\frac{r_{11}^{\beta_1}}{\Omega_1} + \frac{r_2^{\beta_1}}{\Omega_1}\right)} I_0\left[\frac{2\sqrt{\rho_1} r_{11}^{\beta_1/2} r_2^{\beta_1/2}}{(1-\rho_1)\Omega_1}\right] dr_{11} \cdot \\ & \cdot \int_0^{r_T} \frac{\beta_2^2 (r_{22} r_1)^{\beta_2-1}}{\Omega_2^2 (1-\rho_2)} e^{-\frac{1}{1-\rho_2} \left(\frac{r_{22}^{\beta_2}}{\Omega_2} + \frac{r_1^{\beta_2}}{\Omega_2}\right)} I_0\left[\frac{2\sqrt{\rho_2} r_{22}^{\beta_2/2} r_1^{\beta_2/2}}{(1-\rho_2)\Omega_2}\right] dr_{22} + \\ & + P_2 \int_0^{r_T} \frac{\beta_2^2 (r_{21} r_2)^{\beta_2-1}}{\Omega_2^2 (1-\rho_2)} e^{-\frac{1}{1-\rho_2} \left(\frac{r_{21}^{\beta_2}}{\Omega_2} + \frac{r_2^{\beta_2}}{\Omega_2}\right)} I_0\left[\frac{2\sqrt{\rho_2} r_{21}^{\beta_2/2} r_2^{\beta_2/2}}{(1-\rho_2)\Omega_2}\right] dr_{21} \cdot \\ & \cdot \int_0^{r_T} \frac{\beta_1^2 (r_{12} r_1)^{\beta_1-1}}{\Omega_1^2 (1-\rho_1)} e^{-\frac{1}{1-\rho_1} \left(\frac{r_{12}^{\beta_1}}{\Omega_1} + \frac{r_1^{\beta_1}}{\Omega_1}\right)} I_0\left[\frac{2\sqrt{\rho_1} r_{12}^{\beta_1/2} r_1^{\beta_1/2}}{(1-\rho_1)\Omega_1}\right] dr_{12} \end{aligned} \quad (3.6.6)$$

Za  $r_1 \geq r_T, r_2 < r_T$

$$\begin{aligned} p_{r_1r_2}(r_1, r_2) = & P_1 \frac{\beta_2}{\Omega_2} r_2^{\beta_2-1} e^{-\frac{r_2^{\beta_2}}{\Omega_2}} \int_0^{r_T} \frac{\beta_1^2 (r_{12} r_1)^{\beta_1-1}}{\Omega_1^2 (1-\rho_1)} e^{-\frac{1}{1-\rho_1} \left(\frac{r_{12}^{\beta_1}}{\Omega_1} + \frac{r_1^{\beta_1}}{\Omega_1}\right)} I_0\left[\frac{2\sqrt{\rho_1} r_{12}^{\beta_1/2} r_1^{\beta_1/2}}{(1-\rho_1)\Omega_1}\right] dr_{12} + \\ & + P_1 \int_0^{r_T} \frac{\beta_1^2 (r_{11} r_2)^{\beta_1-1}}{\Omega_1^2 (1-\rho_1)} e^{-\frac{1}{1-\rho_1} \left(\frac{r_{11}^{\beta_1}}{\Omega_1} + \frac{r_2^{\beta_1}}{\Omega_1}\right)} I_0\left[\frac{2\sqrt{\rho_1} r_{11}^{\beta_1/2} r_2^{\beta_1/2}}{(1-\rho_1)\Omega_1}\right] dr_{11} \cdot \\ & \cdot \int_0^{r_T} \frac{\beta_2^2 (r_{22} r_1)^{\beta_2-1}}{\Omega_2^2 (1-\rho_2)} e^{-\frac{1}{1-\rho_2} \left(\frac{r_{22}^{\beta_2}}{\Omega_2} + \frac{r_1^{\beta_2}}{\Omega_2}\right)} I_0\left[\frac{2\sqrt{\rho_2} r_{22}^{\beta_2/2} r_1^{\beta_2/2}}{(1-\rho_2)\Omega_2}\right] dr_{22} + \\ & + P_2 \frac{\beta_1}{\Omega_1} r_2^{\beta_1-1} e^{-\frac{r_2^{\beta_1}}{\Omega_1}} \int_0^{r_T} \frac{\beta_2^2 (r_{22} r_1)^{\beta_2-1}}{\Omega_2^2 (1-\rho_2)} e^{-\frac{1}{1-\rho_2} \left(\frac{r_{22}^{\beta_2}}{\Omega_2} + \frac{r_1^{\beta_2}}{\Omega_2}\right)} I_0\left[\frac{2\sqrt{\rho_2} r_{22}^{\beta_2/2} r_1^{\beta_2/2}}{(1-\rho_2)\Omega_2}\right] dr_{22} + \end{aligned}$$

$$\begin{aligned}
 & + P_2 \int_0^{r_T} \frac{\beta_2^2 (r_{21} r_2)^{\beta_1 - 1}}{\Omega_2^2 (1 - \rho_2)} e^{-\frac{1}{1 - \rho_2} \left( \frac{r_{21}^{\beta_2}}{\Omega_2} + \frac{r_2^{\beta_2}}{\Omega_2} \right)} I_0 \left[ \frac{2\sqrt{\rho_2} r_{21}^{\beta_2/2} r_2^{\beta_2/2}}{(1 - \rho_2)\Omega_2} \right] dr_{21} \cdot \\
 & \cdot \int_0^{r_T} \frac{\beta_1^2 (r_{12} r_1)^{\beta_1 - 1}}{\Omega_1^2 (1 - \rho_1)} e^{-\frac{1}{1 - \rho_1} \left( \frac{r_{12}^{\beta_1}}{\Omega_1} + \frac{r_1^{\beta_1}}{\Omega_1} \right)} I_0 \left[ \frac{2\sqrt{\rho_1} r_{12}^{\beta_1/2} r_1^{\beta_1/2}}{(1 - \rho_1)\Omega_1} \right] dr_{12}
 \end{aligned} \tag{3.6.7}$$

Za  $r_1 < r_T, r_2 \geq r_T$

$$\begin{aligned}
 p_{r_1 r_2}(r_1, r_2) & = P_1 \left( 1 - e^{-\frac{r_T^{\beta_1}}{\Omega_1}} \right) \frac{\beta_2^2 (r_1 r_2)^{\beta_1 - 1}}{\Omega_2^2 (1 - \rho_2)} e^{-\frac{1}{1 - \rho_2} \left( \frac{r_1^{\beta_2}}{\Omega_2} + \frac{r_2^{\beta_2}}{\Omega_2} \right)} I_0 \left[ \frac{2\sqrt{\rho_2} r_1^{\beta_2/2} r_2^{\beta_2/2}}{(1 - \rho_2)\Omega_2} \right] + \\
 & + P_1 \int_0^{r_T} \frac{\beta_1^2 (r_{11} r_2)^{\beta_1 - 1}}{\Omega_1^2 (1 - \rho_1)} e^{-\frac{1}{1 - \rho_1} \left( \frac{r_{11}^{\beta_1}}{\Omega_1} + \frac{r_2^{\beta_1}}{\Omega_1} \right)} I_0 \left[ \frac{2\sqrt{\rho_1} r_{11}^{\beta_1/2} r_2^{\beta_1/2}}{(1 - \rho_1)\Omega_1} \right] dr_{11} \cdot \\
 & \cdot \int_0^{r_T} \frac{\beta_2^2 (r_{22} r_1)^{\beta_1 - 1}}{\Omega_2^2 (1 - \rho_2)} e^{-\frac{1}{1 - \rho_2} \left( \frac{r_{22}^{\beta_2}}{\Omega_2} + \frac{r_1^{\beta_2}}{\Omega_2} \right)} I_0 \left[ \frac{2\sqrt{\rho_2} r_{22}^{\beta_2/2} r_1^{\beta_2/2}}{(1 - \rho_2)\Omega_2} \right] dr_{22} + \\
 & + P_2 \left( 1 - e^{-\frac{r_T^{\beta_2}}{\Omega_2}} \right) \frac{\beta_1^2 (r_1 r_2)^{\beta_1 - 1}}{\Omega_1^2 (1 - \rho_1)} e^{-\frac{1}{1 - \rho_1} \left( \frac{r_1^{\beta_1}}{\Omega_1} + \frac{r_2^{\beta_1}}{\Omega_1} \right)} I_0 \left[ \frac{2\sqrt{\rho_1} r_1^{\beta_1/2} r_2^{\beta_1/2}}{(1 - \rho_1)\Omega_1} \right] + \\
 & + P_2 \int_0^{r_T} \frac{\beta_2^2 (r_{21} r_2)^{\beta_1 - 1}}{\Omega_2^2 (1 - \rho_2)} e^{-\frac{1}{1 - \rho_2} \left( \frac{r_{21}^{\beta_2}}{\Omega_2} + \frac{r_2^{\beta_2}}{\Omega_2} \right)} I_0 \left[ \frac{2\sqrt{\rho_2} r_{21}^{\beta_2/2} r_2^{\beta_2/2}}{(1 - \rho_2)\Omega_2} \right] dr_{21} \cdot \\
 & \cdot \int_0^{r_T} \frac{\beta_1^2 (r_{12} r_1)^{\beta_1 - 1}}{\Omega_1^2 (1 - \rho_1)} e^{-\frac{1}{1 - \rho_1} \left( \frac{r_{12}^{\beta_1}}{\Omega_1} + \frac{r_1^{\beta_1}}{\Omega_1} \right)} I_0 \left[ \frac{2\sqrt{\rho_1} r_{12}^{\beta_1/2} r_1^{\beta_1/2}}{(1 - \rho_1)\Omega_1} \right] dr_{12}
 \end{aligned} \tag{3.6.8}$$

Za  $r_1 \geq r_T, r_2 \geq r_T$

$$\begin{aligned}
 p_{r_1 r_2}(r_1, r_2) & = P_1 \frac{\beta_1^2 (r_1 r_2)^{\beta_1 - 1}}{\Omega_1^2 (1 - \rho_1)} e^{-\frac{1}{1 - \rho_1} \left( \frac{r_1^{\beta_1}}{\Omega_1} + \frac{r_2^{\beta_1}}{\Omega_1} \right)} I_0 \left[ \frac{2\sqrt{\rho_1} r_1^{\beta_1/2} r_2^{\beta_1/2}}{(1 - \rho_1)\Omega_1} \right] + \\
 & + P_1 \frac{\beta_2}{\Omega_2} r_2^{\beta_2 - 1} e^{-\frac{r_2^{\beta_2}}{\Omega_2}} \int_0^{r_T} \frac{\beta_1^2 (r_{12} r_1)^{\beta_1 - 1}}{\Omega_1^2 (1 - \rho_1)} e^{-\frac{1}{1 - \rho_1} \left( \frac{r_{12}^{\beta_1}}{\Omega_1} + \frac{r_1^{\beta_1}}{\Omega_1} \right)} I_0 \left[ \frac{2\sqrt{\rho_1} r_{12}^{\beta_1/2} r_1^{\beta_1/2}}{(1 - \rho_1)\Omega_1} \right] dr_{12} + \\
 & + P_1 \left( 1 - e^{-\frac{r_T^{\beta_1}}{\Omega_1}} \right) \frac{\beta_2^2 (r_1 r_2)^{\beta_1 - 1}}{\Omega_2^2 (1 - \rho_2)} e^{-\frac{1}{1 - \rho_2} \left( \frac{r_1^{\beta_2}}{\Omega_2} + \frac{r_2^{\beta_2}}{\Omega_2} \right)} I_0 \left[ \frac{2\sqrt{\rho_2} r_1^{\beta_2/2} r_2^{\beta_2/2}}{(1 - \rho_2)\Omega_2} \right] + \\
 & + P_1 \int_0^{r_T} \frac{\beta_1^2 (r_{11} r_2)^{\beta_1 - 1}}{\Omega_1^2 (1 - \rho_1)} e^{-\frac{1}{1 - \rho_1} \left( \frac{r_{11}^{\beta_1}}{\Omega_1} + \frac{r_2^{\beta_1}}{\Omega_1} \right)} I_0 \left[ \frac{2\sqrt{\rho_1} r_{11}^{\beta_1/2} r_2^{\beta_1/2}}{(1 - \rho_1)\Omega_1} \right] dr_{11} \cdot
 \end{aligned}$$

$$\begin{aligned}
& \int_0^{r_T} \frac{\beta_2^2 (r_{22} r_1)^{\beta_1 - 1}}{\Omega_2^2 (1 - \rho_2)} e^{-\frac{1}{1 - \rho_2} \left( \frac{r_{22}^{\beta_2}}{\Omega_2} + \frac{r_1^{\beta_2}}{\Omega_2} \right)} I_0 \left[ \frac{2\sqrt{\rho_2} r_{22}^{\beta_2/2} r_1^{\beta_2/2}}{(1 - \rho_2)\Omega_2} \right] dr_{22} + \\
& + P_2 \frac{\beta_1^2 (r_1 r_2)^{\beta_1 - 1}}{\Omega_1^2 (1 - \rho_1)} e^{-\frac{1}{1 - \rho_1} \left( \frac{r_1^{\beta_1}}{\Omega_1} + \frac{r_2^{\beta_1}}{\Omega_1} \right)} I_0 \left[ \frac{2\sqrt{\rho_1} r_1^{\beta_1/2} r_2^{\beta_1/2}}{(1 - \rho_1)\Omega_1} \right] + \\
& + P_2 \frac{\beta_1}{\Omega_1} r_2^{\beta_1 - 1} e^{-\frac{r_2^{\beta_1}}{\Omega_1}} \int_0^{r_T} \frac{\beta_2^2 (r_{22} r_1)^{\beta_1 - 1}}{\Omega_2^2 (1 - \rho_2)} e^{-\frac{1}{1 - \rho_2} \left( \frac{r_{22}^{\beta_2}}{\Omega_2} + \frac{r_1^{\beta_2}}{\Omega_2} \right)} I_0 \left[ \frac{2\sqrt{\rho_2} r_{22}^{\beta_2/2} r_1^{\beta_2/2}}{(1 - \rho_2)\Omega_2} \right] dr_{22} + \\
& + P_2 \left( 1 - e^{-\frac{r_T^{\beta_2}}{\Omega_2}} \right) \frac{\beta_1^2 (r_1 r_2)^{\beta_1 - 1}}{\Omega_1^2 (1 - \rho_1)} e^{-\frac{1}{1 - \rho_1} \left( \frac{r_1^{\beta_1}}{\Omega_1} + \frac{r_2^{\beta_1}}{\Omega_1} \right)} I_0 \left[ \frac{2\sqrt{\rho_1} r_1^{\beta_1/2} r_2^{\beta_1/2}}{(1 - \rho_1)\Omega_1} \right] + \\
& + P_2 \int_0^{r_T} \frac{\beta_2^2 (r_{21} r_2)^{\beta_1 - 1}}{\Omega_2^2 (1 - \rho_2)} e^{-\frac{1}{1 - \rho_2} \left( \frac{r_{21}^{\beta_2}}{\Omega_2} + \frac{r_2^{\beta_2}}{\Omega_2} \right)} I_0 \left[ \frac{2\sqrt{\rho_2} r_{21}^{\beta_2/2} r_2^{\beta_2/2}}{(1 - \rho_2)\Omega_2} \right] dr_{21} \cdot \\
& \cdot \int_0^{r_T} \frac{\beta_1^2 (r_{12} r_1)^{\beta_1 - 1}}{\Omega_1^2 (1 - \rho_1)} e^{-\frac{1}{1 - \rho_1} \left( \frac{r_{12}^{\beta_1}}{\Omega_1} + \frac{r_1^{\beta_1}}{\Omega_1} \right)} I_0 \left[ \frac{2\sqrt{\rho_1} r_{12}^{\beta_1/2} r_1^{\beta_1/2}}{(1 - \rho_1)\Omega_1} \right] dr_{12} \quad (3.6.9)
\end{aligned}$$

Izrazi (3.6.6-9) su u obliku jednostrukog integrala sa konačnim granicama. Združena gustina raspodele verovatnoće se može dobiti u zatvorenom obliku korišćenjem Marcum-ove  $Q$ -funkcije prvog reda.

Za predstavljanje združene PDF u zatvorenom obliku potrebno je rešiti integral  $\int_{r_T}^{\infty} p_{x_1 x_2}(x_1, x_2) dx_1$ , gde je  $p_{x_1 x_2}(x_1, x_2)$  dato u (3.3.59). Transformacijom  $p_{x_1 x_2}(x_1, x_2)$ , ona se može predstaviti u obliku koji u podintegralnom delu predstavlja podintegralni deo Marcum-ove  $Q$ -funkcije prvog reda.

$$x_1 = x^{2/\beta} \left( \frac{\Omega(1-\rho)}{2} \right)^{1/\beta} \quad x = \frac{\sqrt{2}}{\sqrt{\Omega(1-\rho)}} x_1^{\beta/2} \quad dx_1 = \left( \frac{\Omega(1-\rho)}{2} \right)^{1/\beta} \frac{2}{\beta} x^{2/\beta-1} \quad (3.6.10)$$

$$x_2 = a^{2/\beta} \left( \frac{\Omega(1-\rho)}{2\rho} \right)^{1/\beta} \quad a = \frac{\sqrt{2\rho}}{\sqrt{\Omega(1-\rho)}} x_2^{\beta/2} \quad (3.6.11)$$

$$p_{x_1 x_2}(x_1, x_2) = \frac{\beta^2 \left( \frac{\Omega(1-\rho)}{2} \right)^{\frac{2(\beta-1)}{\beta}} \rho^{\frac{\beta}{\beta-1}}}{\Omega^2(1-\rho)} a^{\frac{2(\beta-1)}{\beta}} e^{-\frac{1-\rho}{2\rho} a^2} x^{\frac{2(\beta-1)}{\beta}} e^{-\frac{x^2+a^2}{2}} \cdot I_0(xa) \quad (3.6.12)$$



$$\begin{aligned}
\int_{r_T}^{\infty} p_{x_1 x_2}(x_1, x_2) dx_1 &= \frac{\beta^2 \left( \frac{\Omega(1-\rho)}{2} \right)^{\frac{2(\beta-1)}{\beta}} \rho^{\frac{\beta}{\beta-1}} a^{\frac{2\beta-2}{\beta}} e^{-\frac{1-\rho}{2\rho} a^2}}{\Omega^2(1-\rho)} \cdot \\
&\cdot \int_{\frac{\sqrt{2}}{\sqrt{\Omega(1-\rho)}} r_T^{\beta/2}}^{\infty} x^{\frac{2(\beta-1)}{\beta}} e^{-\frac{x^2+a^2}{2}} I_0(ax) \left( \frac{\Omega(1-\rho)}{2} \right)^{1/\beta} \frac{2}{\beta} x^{\frac{2-\beta}{\beta}} dx = \\
&= \frac{\beta \left( \frac{\Omega(1-\rho)}{2} \right)^{\frac{\beta-1}{\beta}} \rho^{\frac{\beta}{\beta-1}} a^{\frac{2\beta-2}{\beta}} e^{-\frac{1-\rho}{2\rho} a^2}}{\Omega} \int_{\frac{\sqrt{2}}{\sqrt{\Omega(1-\rho)}} r_T^{\beta/2}}^{\infty} x e^{-\frac{x^2+a^2}{2}} I_0(ax) dx = \\
&= \frac{\beta}{\Omega} x_2^{\beta-1} e^{-\frac{x_2^\beta}{\Omega}} Q_1 \left( \frac{\sqrt{2\rho}}{\sqrt{\Omega(1-\rho)}} x_2^{\beta/2}, \frac{\sqrt{2}}{\sqrt{\Omega(1-\rho)}} r_T^{\beta/2} \right) \quad (3.6.13)
\end{aligned}$$

Na osnovu (3.6.13) se dobija:

$$\int_0^{r_T} p_{x_1 x_2}(x_1, x_2) dx_1 = \frac{\beta}{\Omega} x_2^{\beta-1} e^{-\frac{x_2^\beta}{\Omega}} \left[ 1 - Q_1 \left( \frac{\sqrt{2\rho}}{\sqrt{\Omega(1-\rho)}} x_2^{\beta/2}, \frac{\sqrt{2}}{\sqrt{\Omega(1-\rho)}} r_T^{\beta/2} \right) \right] \quad (3.6.14)$$

Zamenom (3.6.14) u izrazima (3.6.6-9) dobija se konačni oblik za združenu gustinu raspodele verovatnoće na izlazu iz SSC kombinera

Za  $r_1 < r_T, r_2 < r_T$

$$\begin{aligned}
p_{r_1 r_2}(r_1, r_2) &= P_1 \frac{\beta_2}{\Omega_2} r_1^{\beta_2-1} e^{-\frac{r_1^{\beta_2}}{\Omega_2}} \left[ 1 - Q_1 \left( \frac{\sqrt{2\rho_2}}{\sqrt{\Omega_2(1-\rho_2)}} r_1^{\beta_2/2}, \frac{\sqrt{2}}{\sqrt{\Omega_2(1-\rho_2)}} r_T^{\beta_2/2} \right) \right] \cdot \\
&\cdot \frac{\beta_1}{\Omega_1} r_2^{\beta_1-1} e^{-\frac{r_2^{\beta_1}}{\Omega_1}} \left[ 1 - Q_1 \left( \frac{\sqrt{2\rho_1}}{\sqrt{\Omega_1(1-\rho_1)}} r_2^{\beta_1/2}, \frac{\sqrt{2}}{\sqrt{\Omega_1(1-\rho_1)}} r_T^{\beta_1/2} \right) \right] + \\
&+ P_2 \frac{\beta_1}{\Omega_1} r_1^{\beta_1-1} e^{-\frac{r_1^{\beta_1}}{\Omega_1}} \left[ 1 - Q_1 \left( \frac{\sqrt{2\rho_1}}{\sqrt{\Omega_1(1-\rho_1)}} r_1^{\beta_1/2}, \frac{\sqrt{2}}{\sqrt{\Omega_1(1-\rho_1)}} r_T^{\beta_1/2} \right) \right] \cdot \\
&\cdot \frac{\beta_2}{\Omega_2} r_2^{\beta_2-1} e^{-\frac{r_2^{\beta_2}}{\Omega_2}} \left[ 1 - Q_1 \left( \frac{\sqrt{2\rho_2}}{\sqrt{\Omega_2(1-\rho_2)}} r_2^{\beta_2/2}, \frac{\sqrt{2}}{\sqrt{\Omega_2(1-\rho_2)}} r_T^{\beta_2/2} \right) \right] \quad (3.6.15)
\end{aligned}$$

Za  $r_1 \geq r_T, r_2 < r_T$

$$p_{r_1 r_2}(r_1, r_2) = P_1 \frac{\beta_1}{\Omega_1} r_1^{\beta_1-1} e^{-\frac{r_1^{\beta_1}}{\Omega_1}} \frac{\beta_2}{\Omega_2} r_2^{\beta_2-1} e^{-\frac{r_2^{\beta_2}}{\Omega_2}} \left[ 1 - Q_1 \left( \frac{\sqrt{2\rho_1}}{\sqrt{\Omega_1(1-\rho_1)}} r_1^{\beta_1/2}, \frac{\sqrt{2}}{\sqrt{\Omega_1(1-\rho_1)}} r_T^{\beta_1/2} \right) \right] +$$

$$\begin{aligned}
 & + P_1 \frac{\beta_2}{\Omega_2} r_1^{\beta_2-1} e^{-\frac{r_1^{\beta_2}}{\Omega_2}} \left[ 1 - Q_1 \left( \frac{\sqrt{2\rho_2}}{\sqrt{\Omega_2(1-\rho_2)}} r_1^{\beta_2/2}, \frac{\sqrt{2}}{\sqrt{\Omega_2(1-\rho_2)}} r_T^{\beta_2/2} \right) \right] \\
 & \cdot \frac{\beta_1}{\Omega_1} r_2^{\beta_1-1} e^{-\frac{r_2^{\beta_1}}{\Omega_1}} \left[ 1 - Q_1 \left( \frac{\sqrt{2\rho_1}}{\sqrt{\Omega_1(1-\rho_1)}} r_2^{\beta_1/2}, \frac{\sqrt{2}}{\sqrt{\Omega_1(1-\rho_1)}} r_T^{\beta_1/2} \right) \right] + \\
 & + P_2 \frac{\beta_2}{\Omega_2} r_1^{\beta_2-1} e^{-\frac{r_1^{\beta_2}}{\Omega_2}} \frac{\beta_1}{\Omega_1} r_2^{\beta_1-1} e^{-\frac{r_2^{\beta_1}}{\Omega_1}} \left[ 1 - Q_1 \left( \frac{\sqrt{2\rho_2}}{\sqrt{\Omega_2(1-\rho_2)}} r_1^{\beta_2/2}, \frac{\sqrt{2}}{\sqrt{\Omega_2(1-\rho_2)}} r_T^{\beta_2/2} \right) \right] + \\
 & + P_2 \frac{\beta_1}{\Omega_1} r_1^{\beta_1-1} e^{-\frac{r_1^{\beta_1}}{\Omega_1}} \left[ 1 - Q_1 \left( \frac{\sqrt{2\rho_1}}{\sqrt{\Omega_1(1-\rho_1)}} r_1^{\beta_1/2}, \frac{\sqrt{2}}{\sqrt{\Omega_1(1-\rho_1)}} r_T^{\beta_1/2} \right) \right] \\
 & \cdot \frac{\beta_2}{\Omega_2} r_2^{\beta_2-1} e^{-\frac{r_2^{\beta_2}}{\Omega_2}} \left[ 1 - Q_1 \left( \frac{\sqrt{2\rho_2}}{\sqrt{\Omega_2(1-\rho_2)}} r_2^{\beta_2/2}, \frac{\sqrt{2}}{\sqrt{\Omega_2(1-\rho_2)}} r_T^{\beta_2/2} \right) \right] \tag{3.6.16}
 \end{aligned}$$

Za  $r_1 < r_T, r_2 \geq r_T$

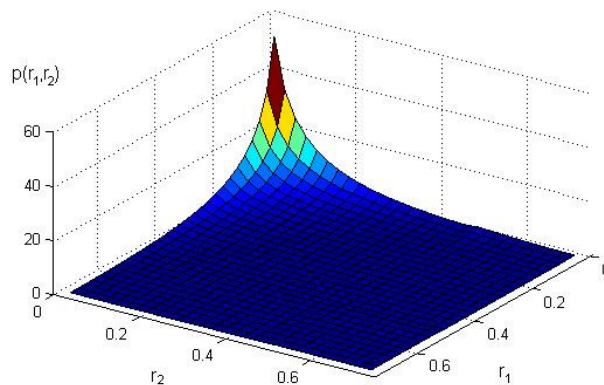
$$\begin{aligned}
 P_{r_1 r_2}(r_1, r_2) & = P_1 \left( 1 - e^{-\frac{r_T^{\beta_1}}{\Omega_1}} \right) \frac{\beta_2^2 (r_1 r_2)^{\beta_1-1}}{\Omega_2^2 (1-\rho_2)} e^{-\frac{1}{1-\rho_2} \left( \frac{r_1^{\beta_2}}{\Omega_2} + \frac{r_2^{\beta_2}}{\Omega_2} \right)} I_0 \left[ \frac{2\sqrt{\rho_2} r_1^{\beta_2/2} r_2^{\beta_2/2}}{(1-\rho_2)\Omega_2} \right] + \\
 & + P_1 \frac{\beta_2}{\Omega_2} r_1^{\beta_2-1} e^{-\frac{r_1^{\beta_2}}{\Omega_2}} \left[ 1 - Q_1 \left( \frac{\sqrt{2\rho_2}}{\sqrt{\Omega_2(1-\rho_2)}} r_1^{\beta_2/2}, \frac{\sqrt{2}}{\sqrt{\Omega_2(1-\rho_2)}} r_T^{\beta_2/2} \right) \right] \\
 & \cdot \frac{\beta_1}{\Omega_1} r_2^{\beta_1-1} e^{-\frac{r_2^{\beta_1}}{\Omega_1}} \left[ 1 - Q_1 \left( \frac{\sqrt{2\rho_1}}{\sqrt{\Omega_1(1-\rho_1)}} r_2^{\beta_1/2}, \frac{\sqrt{2}}{\sqrt{\Omega_1(1-\rho_1)}} r_T^{\beta_1/2} \right) \right] + \\
 & + P_2 \left( 1 - e^{-\frac{r_T^{\beta_2}}{\Omega_2}} \right) \frac{\beta_1^2 (r_1 r_2)^{\beta_1-1}}{\Omega_1^2 (1-\rho_1)} e^{-\frac{1}{1-\rho_1} \left( \frac{r_1^{\beta_1}}{\Omega_1} + \frac{r_2^{\beta_1}}{\Omega_1} \right)} I_0 \left[ \frac{2\sqrt{\rho_1} r_1^{\beta_1/2} r_2^{\beta_1/2}}{(1-\rho_1)\Omega_1} \right] + \\
 & + P_2 \frac{\beta_1}{\Omega_1} r_1^{\beta_1-1} e^{-\frac{r_1^{\beta_1}}{\Omega_1}} \left[ 1 - Q_1 \left( \frac{\sqrt{2\rho_1}}{\sqrt{\Omega_1(1-\rho_1)}} r_1^{\beta_1/2}, \frac{\sqrt{2}}{\sqrt{\Omega_1(1-\rho_1)}} r_T^{\beta_1/2} \right) \right] \\
 & \cdot \frac{\beta_2}{\Omega_2} r_2^{\beta_2-1} e^{-\frac{r_2^{\beta_2}}{\Omega_2}} \left[ 1 - Q_1 \left( \frac{\sqrt{2\rho_2}}{\sqrt{\Omega_2(1-\rho_2)}} r_2^{\beta_2/2}, \frac{\sqrt{2}}{\sqrt{\Omega_2(1-\rho_2)}} r_T^{\beta_2/2} \right) \right] \tag{3.6.17}
 \end{aligned}$$

Za  $r_1 \geq r_T, r_2 \geq r_T$

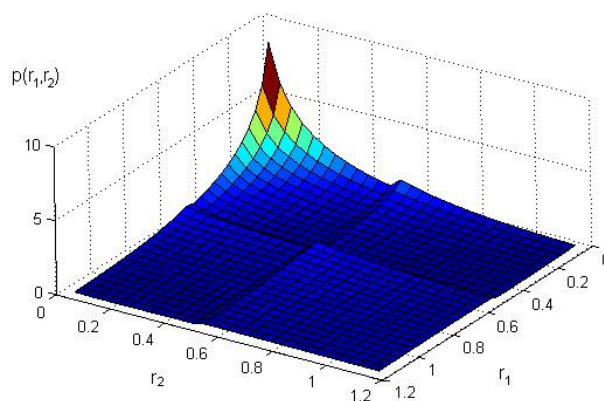
$$P_{r_1 r_2}(r_1, r_2) = P_1 \frac{\beta_1^2 (r_1 r_2)^{\beta_1-1}}{\Omega_1^2 (1-\rho_1)} e^{-\frac{1}{1-\rho_1} \left( \frac{r_1^{\beta_1}}{\Omega_1} + \frac{r_2^{\beta_1}}{\Omega_1} \right)} I_0 \left[ \frac{2\sqrt{\rho_1} r_1^{\beta_1/2} r_2^{\beta_1/2}}{(1-\rho_1)\Omega_1} \right] +$$

$$\begin{aligned}
& + P_1 \frac{\beta_1}{\Omega_1} r_1^{\beta_1-1} e^{-\frac{r_1^{\beta_1}}{\Omega_1}} \frac{\beta_2}{\Omega_2} r_2^{\beta_2-1} e^{-\frac{r_2^{\beta_2}}{\Omega_2}} \left[ 1 - Q_1 \left( \frac{\sqrt{2\rho_1}}{\sqrt{\Omega_1(1-\rho_1)}} r_1^{\beta_1/2}, \frac{\sqrt{2}}{\sqrt{\Omega_1(1-\rho_1)}} r_T^{\beta_1/2} \right) \right] + \\
& + P_1 \left( 1 - e^{-\frac{r_T^{\beta_1}}{\Omega_1}} \right) \frac{\beta_2^2 (r_1 r_2)^{\beta_1-1}}{\Omega_2^2 (1-\rho_2)} e^{-\frac{1}{1-\rho_2} \left( \frac{r_1^{\beta_2}}{\Omega_2} + \frac{r_2^{\beta_2}}{\Omega_2} \right)} I_0 \left[ \frac{2\sqrt{\rho_2} r_1^{\beta_2/2} r_2^{\beta_2/2}}{(1-\rho_2)\Omega_2} \right] + \\
& + P_1 \frac{\beta_2}{\Omega_2} r_1^{\beta_2-1} e^{-\frac{r_1^{\beta_2}}{\Omega_2}} \left[ 1 - Q_1 \left( \frac{\sqrt{2\rho_2}}{\sqrt{\Omega_2(1-\rho_2)}} r_1^{\beta_2/2}, \frac{\sqrt{2}}{\sqrt{\Omega_2(1-\rho_2)}} r_T^{\beta_2/2} \right) \right] + \\
& \cdot \frac{\beta_1}{\Omega_1} r_2^{\beta_1-1} e^{-\frac{r_2^{\beta_1}}{\Omega_1}} \left[ 1 - Q_1 \left( \frac{\sqrt{2\rho_1}}{\sqrt{\Omega_1(1-\rho_1)}} r_2^{\beta_1/2}, \frac{\sqrt{2}}{\sqrt{\Omega_1(1-\rho_1)}} r_T^{\beta_1/2} \right) \right] + \\
& + P_2 \frac{\beta_1^2 (r_1 r_2)^{\beta_1-1}}{\Omega_1^2 (1-\rho_1)} e^{-\frac{1}{1-\rho_1} \left( \frac{r_1^{\beta_1}}{\Omega_1} + \frac{r_2^{\beta_1}}{\Omega_1} \right)} I_0 \left[ \frac{2\sqrt{\rho_1} r_1^{\beta_1/2} r_2^{\beta_1/2}}{(1-\rho_1)\Omega_1} \right] + \\
& + P_2 \frac{\beta_2}{\Omega_2} r_1^{\beta_2-1} e^{-\frac{r_1^{\beta_2}}{\Omega_2}} \frac{\beta_1}{\Omega_1} r_2^{\beta_1-1} e^{-\frac{r_2^{\beta_1}}{\Omega_1}} \left[ 1 - Q_1 \left( \frac{\sqrt{2\rho_2}}{\sqrt{\Omega_2(1-\rho_2)}} r_1^{\beta_2/2}, \frac{\sqrt{2}}{\sqrt{\Omega_2(1-\rho_2)}} r_T^{\beta_2/2} \right) \right] + \\
& + P_2 \left( 1 - e^{-\frac{r_T^{\beta_2}}{\Omega_2}} \right) \frac{\beta_1^2 (r_1 r_2)^{\beta_1-1}}{\Omega_1^2 (1-\rho_1)} e^{-\frac{1}{1-\rho_1} \left( \frac{r_1^{\beta_1}}{\Omega_1} + \frac{r_2^{\beta_1}}{\Omega_1} \right)} I_0 \left[ \frac{2\sqrt{\rho_1} r_1^{\beta_1/2} r_2^{\beta_1/2}}{(1-\rho_1)\Omega_1} \right] + \\
& + P_2 \frac{\beta_1}{\Omega_1} r_1^{\beta_1-1} e^{-\frac{r_1^{\beta_1}}{\Omega_1}} \left[ 1 - Q_1 \left( \frac{\sqrt{2\rho_1}}{\sqrt{\Omega_1(1-\rho_1)}} r_1^{\beta_1/2}, \frac{\sqrt{2}}{\sqrt{\Omega_1(1-\rho_1)}} r_T^{\beta_1/2} \right) \right] + \\
& \cdot \frac{\beta_2}{\Omega_2} r_2^{\beta_2-1} e^{-\frac{r_2^{\beta_2}}{\Omega_2}} \left[ 1 - Q_1 \left( \frac{\sqrt{2\rho_2}}{\sqrt{\Omega_2(1-\rho_2)}} r_2^{\beta_2/2}, \frac{\sqrt{2}}{\sqrt{\Omega_2(1-\rho_2)}} r_T^{\beta_2/2} \right) \right] \tag{3.6.18}
\end{aligned}$$

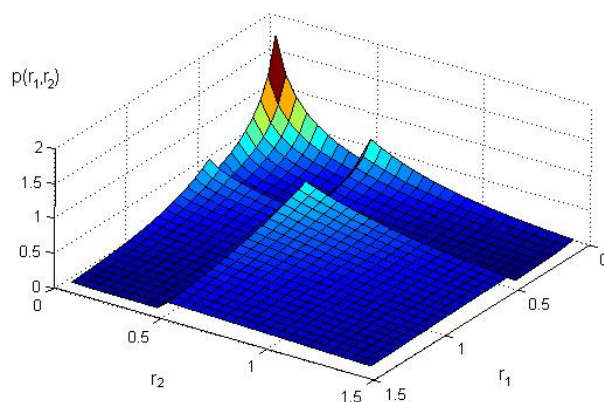
Na slikama 3.6.1.-9. predstavljena je zavisnost PDF od vrednosti signala za različite vrednosti parametara raspodele, korelacije i praga odlučivanja. Radi uprošćavanja, a ne gubeći uopštenost, pretpostavljeno je da su parametri raspodele isti za obe grane kombinera.



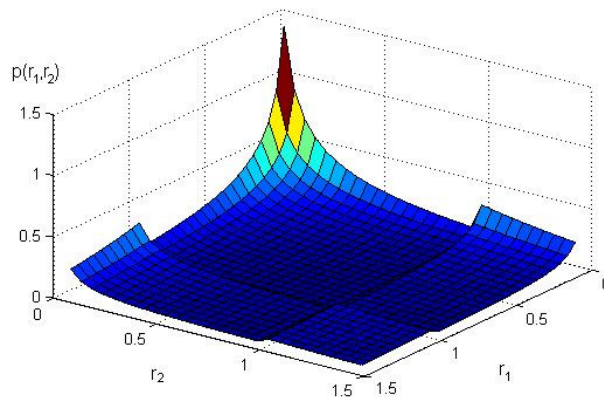
Slika 3.6.1. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Weibull-ovog fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 0.5$ ,  $\beta = 0.7$ ,  $\Omega = 0.2$



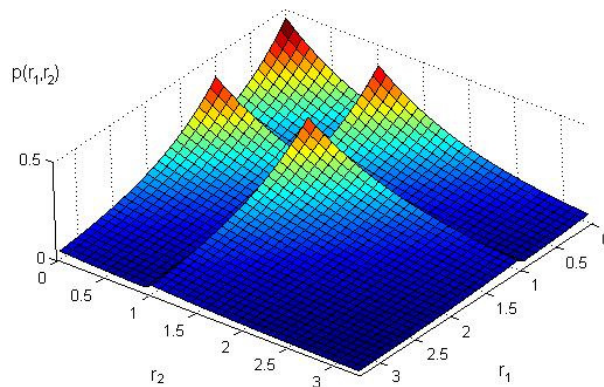
Slika 3.6.2. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Weibull-ovog fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 0.5$ ,  $\beta = 0.7$ ,  $\Omega = 0.5$



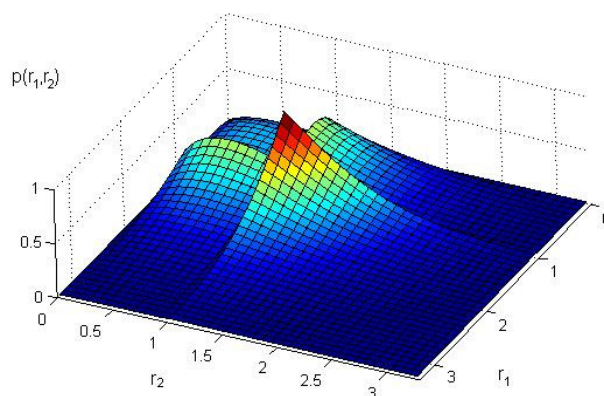
Slika 3.6.3. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Weibull-ovog fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 0.5$ ,  $\beta = 0.7$ ,  $\Omega = 1$



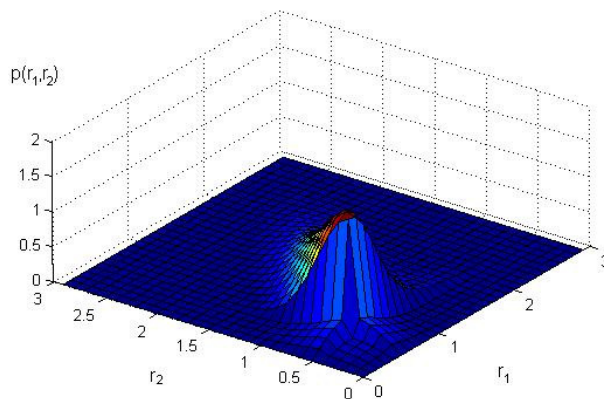
Slika 3.6.4. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Weibull-ovog fedinga za parametre:  $\rho = 0.1$ ,  $r_T = 1$ ,  $\Omega = 1$ ,  $\beta = 0.5$



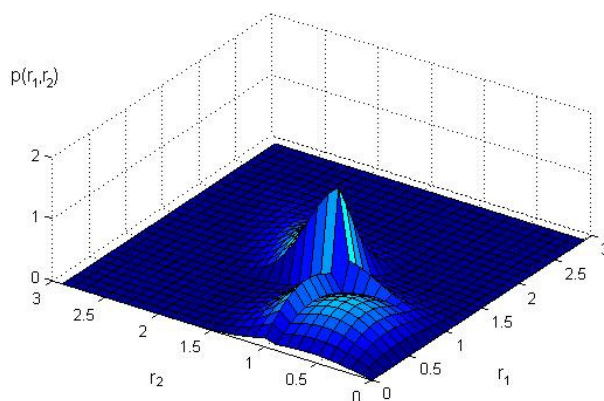
Slika 3.6.5. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Weibull-ovog fedinga za parametre:  $\rho = 0.1$ ,  $r_T = 1$ ,  $\Omega = 1$ ,  $\beta = 1$



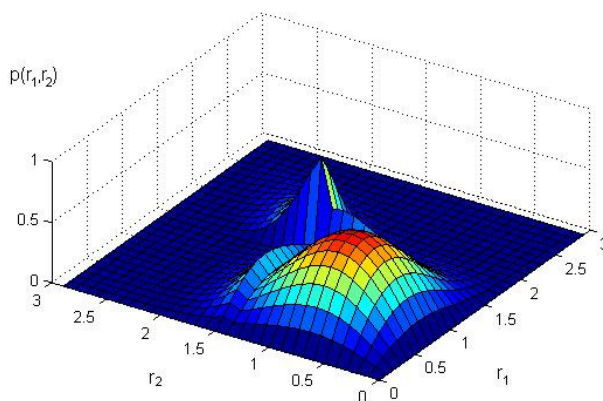
Slika 3.6.6. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Weibull-ovog fedinga za parametre:  $\rho = 0.1$ ,  $r_T = 1$ ,  $\Omega = 1$ ,  $\beta = 1.5$



Slika 3.6.7. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Weibull-ovog fedinga za parametre:  $\rho = 0.8$ ,  $\beta = 2$ ,  $\Omega = 1$ ,  $r_T = 0.5$



Slika 3.6.8. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Weibull-ovog fedinga za parametre:  $\rho = 0.8$ ,  $\beta = 2$ ,  $\Omega = 1$ ,  $r_T = 1$



Slika 3.6.9. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Weibull-ovog fedinga za parametre:  $\rho = 0.8$ ,  $\beta = 2$ ,  $\Omega = 1$ ,  $r_T = 1.5$

### 3.7 Zdržena gustina raspodele verovatnoće na izlazu SSC kombinera u dva trenutka vremena u prisustvu log-normalnog fedinga

Gustina raspodele verovatnoće i kumulativna raspodela verovatnoće (CDF) signala na izlazu iz kombinera  $r_{i,j}$  u prisustvu log-normalnog fedinga su [9], [10]:

$$p_{r_i}(r_{i,j}) = \frac{1}{\sqrt{2\pi}\sigma_i r_{i,j}} e^{-\frac{(\ln r_{i,j} - \mu_i)^2}{2\sigma_i^2}}, \quad r_{i,j} \geq 0 \quad (3.7.1)$$

$$F_{r_i}(r_{i,j}) = \frac{1}{2} + \frac{1}{2} \operatorname{erf}\left(\frac{\ln r_{i,j} - \mu_i}{\sigma_i \sqrt{2}}\right), \quad r_{i,j} \geq 0 \quad (3.7.2)$$

gde su  $i=1,2$   $j=1,2$ ,  $\mu$  je srednja vrednost signal,  $\sigma$  je standardna devijacija, a  $\operatorname{erf}(x)$  je funkcija greške definisana sa [55]:

$$\operatorname{erf}(x) = \frac{2}{\sqrt{\pi}} \int_0^x e^{-t^2} dt \quad (3.7.3)$$

CDF se može dobiti i pomoću jednodimenzione Gauss-ove  $Q$  funkcije:

$$F_{r_i}(r_{i,j}) = 1 - Q\left(\frac{\ln r_{i,j} - \mu_i}{\sigma_i}\right), \quad r_{i,j} \geq 0 \quad (3.7.4)$$

gde je [1]:

$$Q(x) = \frac{1}{\sqrt{2\pi}} \int_x^\infty e^{-t^2/2} dt \quad (3.7.5)$$

Verovatnoće  $P_1$  i  $P_2$  se dobijaju ako se u (3.1.17-18) stavi (3.7.4):

$$P_1 = \frac{F_{r_2}(r_T)}{F_{r_1}(r_T) + F_{r_2}(r_T)} = \frac{1 - Q\left(\frac{\ln r_T - \mu_2}{\sigma_2}\right)}{2 - \left(Q\left(\frac{\ln r_T - \mu_1}{\sigma_1}\right) - Q\left(\frac{\ln r_T - \mu_2}{\sigma_2}\right)\right)} \quad (3.7.6)$$

$$P_2 = \frac{F_{r_1}(r_T)}{F_{r_1}(r_T) + F_{r_2}(r_T)} = \frac{1 - Q\left(\frac{\ln r_T - \mu_1}{\sigma_1}\right)}{2 - \left(Q\left(\frac{\ln r_T - \mu_1}{\sigma_1}\right) - Q\left(\frac{\ln r_T - \mu_2}{\sigma_2}\right)\right)} \quad (3.7.7)$$

Združena gustina raspodele verovatnoće korelisanih signala  $x_1$  i  $x_2$  sa log-normalnom raspodelom i istim parametrima raspodele  $\sigma$  je [10]:

$$p_{x_1 x_2}(x_1, x_2) = \frac{1}{2\pi\sigma^2\sqrt{1-\rho^2}} e^{-\frac{1}{2(1-\rho^2)}\left[\left(\frac{\ln x_1 - \mu}{\sigma}\right)^2 + \left(\frac{\ln x_2 - \mu}{\sigma}\right)^2 - 2\rho\left(\frac{\ln x_1 - \mu}{\sigma}\right)\left(\frac{\ln x_2 - \mu}{\sigma}\right)\right]} \quad (3.7.8)$$

gde je  $\rho$  koeficijent korelacije.

Združena gustina raspodele verovatnoće signala  $r_1$  i  $r_2$  na izlazu SSC kombinera u dva trenutka vremena u prisustvu log-normalnog fedinga kada su signali na ulazu u grane kombinera nezavisni, može se dobiti ako se u (3.2.5-8) stave izrazi (3.7.1) i (3.7.8).

Za  $r_1 < r_T, r_2 < r_T$

$$\begin{aligned} p_{r_1 r_2}(r_1, r_2) = & P_1 \int_0^{r_T} \frac{1}{2\pi\sigma_1^2\sqrt{1-\rho_1^2}} e^{-\frac{1}{2(1-\rho_1^2)}\left[\left(\frac{\ln r_1 - \mu_1}{\sigma_1}\right)^2 + \left(\frac{\ln r_2 - \mu_1}{\sigma_1}\right)^2 - 2\rho_1\left(\frac{\ln r_1 - \mu_1}{\sigma_1}\right)\left(\frac{\ln r_2 - \mu_1}{\sigma_1}\right)\right]} dr_{11} \cdot \\ & \cdot \int_0^{r_T} \frac{1}{2\pi\sigma_2^2\sqrt{1-\rho_2^2}} e^{-\frac{1}{2(1-\rho_2^2)}\left[\left(\frac{\ln r_2 - \mu_2}{\sigma_2}\right)^2 + \left(\frac{\ln r_1 - \mu_2}{\sigma_2}\right)^2 - 2\rho_2\left(\frac{\ln r_2 - \mu_2}{\sigma_2}\right)\left(\frac{\ln r_1 - \mu_2}{\sigma_2}\right)\right]} dr_{22} + \\ & + P_2 \int_0^{r_T} \frac{1}{2\pi\sigma_2^2\sqrt{1-\rho_2^2}} e^{-\frac{1}{2(1-\rho_2^2)}\left[\left(\frac{\ln r_2 - \mu_2}{\sigma_2}\right)^2 + \left(\frac{\ln r_2 - \mu_2}{\sigma_2}\right)^2 - 2\rho_2\left(\frac{\ln r_2 - \mu_2}{\sigma_2}\right)\left(\frac{\ln r_2 - \mu_2}{\sigma_2}\right)\right]} dr_{21} \cdot \\ & \cdot \int_0^{r_T} \frac{1}{2\pi\sigma_1^2\sqrt{1-\rho_1^2}} e^{-\frac{1}{2(1-\rho_1^2)}\left[\left(\frac{\ln r_2 - \mu_1}{\sigma_1}\right)^2 + \left(\frac{\ln r_1 - \mu_1}{\sigma_1}\right)^2 - 2\rho_1\left(\frac{\ln r_2 - \mu_1}{\sigma_1}\right)\left(\frac{\ln r_1 - \mu_1}{\sigma_1}\right)\right]} dr_{12} \end{aligned} \quad (3.7.9)$$

Za  $r_1 \geq r_T, r_2 < r_T$

$$\begin{aligned} & p_{r_1 r_2}(r_1, r_2) = \\ = & P_1 \frac{1}{\sqrt{2\pi\sigma_2 r_2}} e^{-\frac{(\ln r_2 - \mu_2)^2}{2\sigma_2^2}} \int_0^{r_T} \frac{1}{2\pi\sigma_1^2\sqrt{1-\rho_1^2}} e^{-\frac{1}{2(1-\rho_1^2)}\left[\left(\frac{\ln r_2 - \mu_1}{\sigma_1}\right)^2 + \left(\frac{\ln r_1 - \mu_1}{\sigma_1}\right)^2 - 2\rho_1\left(\frac{\ln r_2 - \mu_1}{\sigma_1}\right)\left(\frac{\ln r_1 - \mu_1}{\sigma_1}\right)\right]} dr_{12} + \\ & + P_1 \int_0^{r_T} \frac{1}{2\pi\sigma_1^2\sqrt{1-\rho_1^2}} e^{-\frac{1}{2(1-\rho_1^2)}\left[\left(\frac{\ln r_1 - \mu_1}{\sigma_1}\right)^2 + \left(\frac{\ln r_2 - \mu_1}{\sigma_1}\right)^2 - 2\rho_1\left(\frac{\ln r_1 - \mu_1}{\sigma_1}\right)\left(\frac{\ln r_2 - \mu_1}{\sigma_1}\right)\right]} dr_{11} \cdot \\ & \cdot \int_0^{r_T} \frac{1}{2\pi\sigma_2^2\sqrt{1-\rho_2^2}} e^{-\frac{1}{2(1-\rho_2^2)}\left[\left(\frac{\ln r_2 - \mu_2}{\sigma_2}\right)^2 + \left(\frac{\ln r_1 - \mu_2}{\sigma_2}\right)^2 - 2\rho_2\left(\frac{\ln r_2 - \mu_2}{\sigma_2}\right)\left(\frac{\ln r_1 - \mu_2}{\sigma_2}\right)\right]} dr_{22} + \end{aligned}$$



$$\begin{aligned}
& + P_2 \frac{1}{\sqrt{2\pi\sigma_1 r_2}} e^{-\frac{(\ln r_2 - \mu_1)^2}{2\sigma_1^2}} \int_0^{r_T} \frac{1}{2\pi\sigma_2^2 \sqrt{1-\rho_2^2} r_{22} r_1} e^{-\frac{1}{2(1-\rho_2^2)} \left[ \left( \frac{\ln r_{22} - \mu_2}{\sigma_2} \right)^2 + \left( \frac{\ln r_1 - \mu_2}{\sigma_2} \right)^2 - 2\rho_2 \left( \frac{\ln r_{22} - \mu_2}{\sigma_2} \right) \left( \frac{\ln r_1 - \mu_2}{\sigma_2} \right) \right]} dr_{22} + \\
& + P_2 \int_0^{r_T} \frac{1}{2\pi\sigma_2^2 \sqrt{1-\rho_2^2} r_{21} r_2} e^{-\frac{1}{2(1-\rho_2^2)} \left[ \left( \frac{\ln r_{21} - \mu_2}{\sigma_2} \right)^2 + \left( \frac{\ln r_2 - \mu_2}{\sigma_2} \right)^2 - 2\rho_2 \left( \frac{\ln r_{21} - \mu_2}{\sigma_2} \right) \left( \frac{\ln r_2 - \mu_2}{\sigma_2} \right) \right]} dr_{21} \cdot \\
& \cdot \int_0^{r_T} \frac{1}{2\pi\sigma_1^2 \sqrt{1-\rho_1^2} r_{12} r_1} e^{-\frac{1}{2(1-\rho_1^2)} \left[ \left( \frac{\ln r_{12} - \mu_1}{\sigma_1} \right)^2 + \left( \frac{\ln r_1 - \mu_1}{\sigma_1} \right)^2 - 2\rho_1 \left( \frac{\ln r_{12} - \mu_1}{\sigma_1} \right) \left( \frac{\ln r_1 - \mu_1}{\sigma_1} \right) \right]} dr_{12} \quad (3.7.10)
\end{aligned}$$

Za  $r_1 < r_T, r_2 \geq r_T$

$$\begin{aligned}
& p_{r_1 r_2}(r_1, r_2) = \\
& = P_1 \left( 1 - Q \left( \frac{\ln r_T - \mu_1}{\sigma_1} \right) \right) \frac{1}{2\pi\sigma_2^2 \sqrt{1-\rho_2^2} r_1 r_2} e^{-\frac{1}{2(1-\rho_2^2)} \left[ \left( \frac{\ln r_1 - \mu_2}{\sigma_2} \right)^2 + \left( \frac{\ln r_2 - \mu_2}{\sigma_2} \right)^2 - 2\rho_2 \left( \frac{\ln r_1 - \mu_2}{\sigma_2} \right) \left( \frac{\ln r_2 - \mu_2}{\sigma_2} \right) \right]} + \\
& + P_1 \int_0^{r_T} \frac{1}{2\pi\sigma_1^2 \sqrt{1-\rho_1^2} r_{11} r_2} e^{-\frac{1}{2(1-\rho_1^2)} \left[ \left( \frac{\ln r_{11} - \mu_1}{\sigma_1} \right)^2 + \left( \frac{\ln r_2 - \mu_1}{\sigma_1} \right)^2 - 2\rho_1 \left( \frac{\ln r_{11} - \mu_1}{\sigma_1} \right) \left( \frac{\ln r_2 - \mu_1}{\sigma_1} \right) \right]} dr_{11} \cdot \\
& \cdot \int_0^{r_T} \frac{1}{2\pi\sigma_2^2 \sqrt{1-\rho_2^2} r_{22} r_1} e^{-\frac{1}{2(1-\rho_2^2)} \left[ \left( \frac{\ln r_{22} - \mu_2}{\sigma_2} \right)^2 + \left( \frac{\ln r_1 - \mu_2}{\sigma_2} \right)^2 - 2\rho_2 \left( \frac{\ln r_{22} - \mu_2}{\sigma_2} \right) \left( \frac{\ln r_1 - \mu_2}{\sigma_2} \right) \right]} dr_{22} + \\
& + P_2 \left( 1 - Q \left( \frac{\ln r_T - \mu_2}{\sigma_2} \right) \right) \frac{1}{2\pi\sigma_1^2 \sqrt{1-\rho_1^2} r_1 r_2} e^{-\frac{1}{2(1-\rho_1^2)} \left[ \left( \frac{\ln r_1 - \mu_1}{\sigma_1} \right)^2 + \left( \frac{\ln r_2 - \mu_1}{\sigma_1} \right)^2 - 2\rho_1 \left( \frac{\ln r_1 - \mu_1}{\sigma_1} \right) \left( \frac{\ln r_2 - \mu_1}{\sigma_1} \right) \right]} + \\
& + P_2 \int_0^{r_T} \frac{1}{2\pi\sigma_2^2 \sqrt{1-\rho_2^2} r_{21} r_2} e^{-\frac{1}{2(1-\rho_2^2)} \left[ \left( \frac{\ln r_{21} - \mu_2}{\sigma_2} \right)^2 + \left( \frac{\ln r_2 - \mu_2}{\sigma_2} \right)^2 - 2\rho_2 \left( \frac{\ln r_{21} - \mu_2}{\sigma_2} \right) \left( \frac{\ln r_2 - \mu_2}{\sigma_2} \right) \right]} dr_{21} \cdot \\
& \cdot \int_0^{r_T} \frac{1}{2\pi\sigma_1^2 \sqrt{1-\rho_1^2} r_{12} r_1} e^{-\frac{1}{2(1-\rho_1^2)} \left[ \left( \frac{\ln r_{12} - \mu_1}{\sigma_1} \right)^2 + \left( \frac{\ln r_1 - \mu_1}{\sigma_1} \right)^2 - 2\rho_1 \left( \frac{\ln r_{12} - \mu_1}{\sigma_1} \right) \left( \frac{\ln r_1 - \mu_1}{\sigma_1} \right) \right]} dr_{12} \quad (3.7.11)
\end{aligned}$$

Za  $r_1 \geq r_T, r_2 \geq r_T$

$$\begin{aligned}
& p_{r_1 r_2}(r_1, r_2) = P_1 \frac{1}{2\pi\sigma_1^2 \sqrt{1-\rho_1^2} r_1 r_2} e^{-\frac{1}{2(1-\rho_1^2)} \left[ \left( \frac{\ln r_1 - \mu_1}{\sigma_1} \right)^2 + \left( \frac{\ln r_2 - \mu_1}{\sigma_1} \right)^2 - 2\rho_1 \left( \frac{\ln r_1 - \mu_1}{\sigma_1} \right) \left( \frac{\ln r_2 - \mu_1}{\sigma_1} \right) \right]} + \\
& + P_1 \frac{1}{\sqrt{2\pi\sigma_2 r_2}} e^{-\frac{(\ln r_2 - \mu_2)^2}{2\sigma_2^2}} \int_0^{r_T} \frac{1}{2\pi\sigma_1^2 \sqrt{1-\rho_1^2} r_{12} r_1} e^{-\frac{1}{2(1-\rho_1^2)} \left[ \left( \frac{\ln r_{12} - \mu_1}{\sigma_1} \right)^2 + \left( \frac{\ln r_1 - \mu_1}{\sigma_1} \right)^2 - 2\rho_1 \left( \frac{\ln r_{12} - \mu_1}{\sigma_1} \right) \left( \frac{\ln r_1 - \mu_1}{\sigma_1} \right) \right]} dr_{12} +
\end{aligned}$$

$$\begin{aligned}
 & + P_1 \left( 1 - Q \left( \frac{\ln r_T - \mu_1}{\sigma_1} \right) \right) \frac{1}{2\pi\sigma_2^2 \sqrt{1-\rho_2^2} r_1 r_2} e^{-\frac{1}{2(1-\rho_2^2)} \left[ \left( \frac{\ln r_1 - \mu_2}{\sigma_2} \right)^2 + \left( \frac{\ln r_2 - \mu_2}{\sigma_2} \right)^2 - 2\rho_2 \left( \frac{\ln r_1 - \mu_2}{\sigma_2} \right) \left( \frac{\ln r_2 - \mu_2}{\sigma_2} \right) \right]} + \\
 & + P_1 \int_0^{r_T} \frac{1}{2\pi\sigma_1^2 \sqrt{1-\rho_1^2} r_1 r_2} e^{-\frac{1}{2(1-\rho_1^2)} \left[ \left( \frac{\ln r_1 - \mu_1}{\sigma_1} \right)^2 + \left( \frac{\ln r_2 - \mu_1}{\sigma_1} \right)^2 - 2\rho_1 \left( \frac{\ln r_1 - \mu_1}{\sigma_1} \right) \left( \frac{\ln r_2 - \mu_1}{\sigma_1} \right) \right]} dr_{11} \cdot \\
 & \cdot \int_0^{r_T} \frac{1}{2\pi\sigma_2^2 \sqrt{1-\rho_2^2} r_{22} r_1} e^{-\frac{1}{2(1-\rho_2^2)} \left[ \left( \frac{\ln r_{22} - \mu_2}{\sigma_2} \right)^2 + \left( \frac{\ln r_1 - \mu_2}{\sigma_2} \right)^2 - 2\rho_2 \left( \frac{\ln r_{22} - \mu_2}{\sigma_2} \right) \left( \frac{\ln r_1 - \mu_2}{\sigma_2} \right) \right]} dr_{22} + \\
 & + P_2 \frac{1}{2\pi\sigma_2^2 \sqrt{1-\rho_2^2} r_1 r_2} e^{-\frac{1}{2(1-\rho_2^2)} \left[ \left( \frac{\ln r_1 - \mu_2}{\sigma_2} \right)^2 + \left( \frac{\ln r_2 - \mu_2}{\sigma_2} \right)^2 - 2\rho_2 \left( \frac{\ln r_1 - \mu_2}{\sigma_2} \right) \left( \frac{\ln r_2 - \mu_2}{\sigma_2} \right) \right]} + \\
 & + P_2 \frac{1}{\sqrt{2\pi}\sigma_1 r_2} e^{-\frac{(\ln r_2 - \mu_1)^2}{2\sigma_1^2}} \int_0^{r_T} \frac{1}{2\pi\sigma_2^2 \sqrt{1-\rho_2^2} r_{22} r_1} e^{-\frac{1}{2(1-\rho_2^2)} \left[ \left( \frac{\ln r_{22} - \mu_2}{\sigma_2} \right)^2 + \left( \frac{\ln r_1 - \mu_2}{\sigma_2} \right)^2 - 2\rho_2 \left( \frac{\ln r_{22} - \mu_2}{\sigma_2} \right) \left( \frac{\ln r_1 - \mu_2}{\sigma_2} \right) \right]} dr_{22} + \\
 & + P_2 \left( 1 - Q \left( \frac{\ln r_T - \mu_2}{\sigma_2} \right) \right) \frac{1}{2\pi\sigma_1^2 \sqrt{1-\rho_1^2} r_1 r_2} e^{-\frac{1}{2(1-\rho_1^2)} \left[ \left( \frac{\ln r_1 - \mu_1}{\sigma_1} \right)^2 + \left( \frac{\ln r_2 - \mu_1}{\sigma_1} \right)^2 - 2\rho_1 \left( \frac{\ln r_1 - \mu_1}{\sigma_1} \right) \left( \frac{\ln r_2 - \mu_1}{\sigma_1} \right) \right]} + \\
 & + P_2 \int_0^{r_T} \frac{1}{2\pi\sigma_2^2 \sqrt{1-\rho_2^2} r_{21} r_2} e^{-\frac{1}{2(1-\rho_2^2)} \left[ \left( \frac{\ln r_{21} - \mu_2}{\sigma_2} \right)^2 + \left( \frac{\ln r_2 - \mu_2}{\sigma_2} \right)^2 - 2\rho_2 \left( \frac{\ln r_{21} - \mu_2}{\sigma_2} \right) \left( \frac{\ln r_2 - \mu_2}{\sigma_2} \right) \right]} dr_{21} \cdot \\
 & \cdot \int_0^{r_T} \frac{1}{2\pi\sigma_1^2 \sqrt{1-\rho_1^2} r_{12} r_1} e^{-\frac{1}{2(1-\rho_1^2)} \left[ \left( \frac{\ln r_{12} - \mu_1}{\sigma_1} \right)^2 + \left( \frac{\ln r_1 - \mu_1}{\sigma_1} \right)^2 - 2\rho_1 \left( \frac{\ln r_{12} - \mu_1}{\sigma_1} \right) \left( \frac{\ln r_1 - \mu_1}{\sigma_1} \right) \right]} dr_{12} \quad (3.7.12)
 \end{aligned}$$

Izrazi (3.3.81-84) su u obliku jednostrukog integrala sa konačnim granicama. Zdužena gustina raspodele verovatnoće se može dobiti u zatvorenom obliku korišćenjem jednodimenzione Gauss-ove  $Q$  funkcije.

Za predstavljanje zdužene PDF u zatvorenom obliku potrebno je rešiti integral

$\int_{r_T}^{\infty} p_{x_1 x_2}(x_1, x_2) dx_1$ , gde je  $p_{x_1 x_2}(x_1, x_2)$  dato u (3.3.80). Transformacijom  $p_{x_1 x_2}(x_1, x_2)$ , ona se

može predstaviti u obliku koji u podintegralnom delu predstavlja podintegralni deo jednodimenzione Gauss-ove  $Q$  funkcije.

$$\begin{aligned}
 x_1 & = e^{x\sqrt{(1-\rho^2)}\sigma} x_2 e^{\mu(1-\rho)} & x & = \frac{\ln x_1 - \mu(1-\rho) - \rho \ln x_2}{\sqrt{(1-\rho^2)}\sigma} \\
 dx_1 & = dx \sqrt{(1-\rho^2)}\sigma e^{x\sqrt{(1-\rho^2)}\sigma} x_2 e^{\mu(1-\rho)} & & (3.7.13)
 \end{aligned}$$

$p_{x_1x_2}(x_1, x_2)$  se može predstaviti u pogodnijem obliku:

$$p_{x_1x_2}(x_1, x_2) = \frac{1}{\sqrt{2\pi\alpha x_2}} e^{-\frac{(\ln x_2 - \mu)^2}{2\sigma^2}} \frac{1}{\sqrt{2\pi\sigma\sqrt{1-\rho^2}x_1}} e^{-\frac{(\ln x_1 - (\mu + \rho(\ln x_2 - \mu)))^2}{2(1-\rho^2)\sigma^2}} \quad (3.7.14)$$

$$\begin{aligned} \int_{r_T}^{\infty} p_{x_1x_2}(x_1, x_2) dx_1 &= \frac{1}{\sqrt{2\pi\alpha x_2}} e^{-\frac{(\ln x_2 - \mu)^2}{2\sigma^2}} \int_{r_T}^{\infty} \frac{1}{\sqrt{2\pi\sigma\sqrt{1-\rho^2}x_1}} e^{-\frac{(\ln x_1 - (\mu + \rho(\ln x_2 - \mu)))^2}{2(1-\rho^2)\sigma^2}} dx_1 = \\ &= \frac{1}{\sqrt{2\pi\alpha x_2}} e^{-\frac{(\ln x_2 - \mu)^2}{2\sigma^2}} \cdot \int_{\frac{\ln r_T - \mu(1-\rho) - \rho \ln x_2}{\sqrt{(1-\rho^2)\sigma}}^{\infty}} \frac{\sqrt{(1-\rho^2)\sigma} e^{x\sqrt{(1-\rho^2)\sigma}} x_2 e^{\mu(1-\rho)}}{\sqrt{2\pi\sigma\sqrt{1-\rho^2}x_2} e^{x\sqrt{(1-\rho^2)\sigma}} x_2 e^{\mu(1-\rho)}} e^{-\frac{x^2}{2}} dx = \\ &= \frac{1}{\sqrt{2\pi\alpha x_2}} e^{-\frac{(\ln x_2 - \mu)^2}{2\sigma^2}} Q\left(\frac{\ln r_T - \mu(1-\rho) - \rho \ln x_2}{\sqrt{(1-\rho^2)\sigma}}\right) \end{aligned} \quad (3.7.15)$$

Na osnovu (3.7.15) se dobija:

$$\int_0^{r_T} p_{x_1x_2}(x_1, x_2) dx_1 = \frac{1}{\sqrt{2\pi\alpha x_2}} e^{-\frac{(\ln x_2 - \mu)^2}{2\sigma^2}} \left[ 1 - Q\left(\frac{\ln r_T - \mu(1-\rho) - \rho \ln x_2}{\sigma\sqrt{1-\rho^2}}\right) \right] \quad (3.7.16)$$

Zamenom (3.7.16) u izrazima (3.7.9-12) dobija se konačni oblik za združenu gustinu raspodele verovatnoće na izlazu iz SSC kombinera.

Za  $r_1 < r_T, r_2 < r_T$

$$\begin{aligned} p_{r_1r_2}(r_1, r_2) &= P_1 \frac{1}{\sqrt{2\pi\sigma_2 r_1}} e^{-\frac{(\ln r_1 - \mu_2)^2}{2\sigma_2^2}} \left[ 1 - Q\left(\frac{\ln r_T - \mu_2(1-\rho_2) - \rho_2 \ln r_1}{\sigma_2\sqrt{1-\rho_2^2}}\right) \right] \cdot \\ &\cdot \frac{1}{\sqrt{2\pi\sigma_1 r_2}} e^{-\frac{(\ln r_2 - \mu_1)^2}{2\sigma_1^2}} \left[ 1 - Q\left(\frac{\ln r_T - \mu_1(1-\rho_1) - \rho_1 \ln r_2}{\sigma_1\sqrt{1-\rho_1^2}}\right) \right] + \\ &+ P_2 \frac{1}{\sqrt{2\pi\sigma_1 r_1}} e^{-\frac{(\ln r_1 - \mu_1)^2}{2\sigma_1^2}} \left[ 1 - Q\left(\frac{\ln r_T - \mu_1(1-\rho_1) - \rho_1 \ln r_1}{\sigma_1\sqrt{1-\rho_1^2}}\right) \right] \cdot \\ &\cdot \frac{1}{\sqrt{2\pi\sigma_2 r_2}} e^{-\frac{(\ln r_2 - \mu_2)^2}{2\sigma_2^2}} \left[ 1 - Q\left(\frac{\ln r_T - \mu_2(1-\rho_2) - \rho_2 \ln r_2}{\sigma_2\sqrt{1-\rho_2^2}}\right) \right] \end{aligned} \quad (3.7.17)$$

Za  $r_1 \geq r_T, r_2 < r_T$

$$\begin{aligned}
p_{r_1 r_2}(r_1, r_2) = & P_1 \frac{1}{\sqrt{2\pi}\sigma_1 r_1} e^{-\frac{(\ln r_1 - \mu_1)^2}{2\sigma_1^2}} \frac{1}{\sqrt{2\pi}\sigma_2 r_2} e^{-\frac{(\ln r_2 - \mu_2)^2}{2\sigma_2^2}} \left[ 1 - Q\left(\frac{\ln r_T - \mu_1(1 - \rho_1) - \rho_1 \ln r_1}{\sigma_1 \sqrt{1 - \rho_1^2}}\right) \right] + \\
& + P_1 \frac{1}{\sqrt{2\pi}\sigma_2 r_1} e^{-\frac{(\ln r_1 - \mu_2)^2}{2\sigma_2^2}} \left[ 1 - Q\left(\frac{\ln r_T - \mu_2(1 - \rho_2) - \rho_2 \ln r_1}{\sigma_2 \sqrt{1 - \rho_2^2}}\right) \right] \cdot \\
& \cdot \frac{1}{\sqrt{2\pi}\sigma_1 r_2} e^{-\frac{(\ln r_2 - \mu_1)^2}{2\sigma_1^2}} \left[ 1 - Q\left(\frac{\ln r_T - \mu_1(1 - \rho_1) - \rho_1 \ln r_2}{\sigma_1 \sqrt{1 - \rho_1^2}}\right) \right] + \\
& + P_2 \frac{1}{\sqrt{2\pi}\sigma_2 r_1} e^{-\frac{(\ln r_1 - \mu_2)^2}{2\sigma_2^2}} \frac{1}{\sqrt{2\pi}\sigma_1 r_2} e^{-\frac{(\ln r_2 - \mu_1)^2}{2\sigma_1^2}} \left[ 1 - Q\left(\frac{\ln r_T - \mu_2(1 - \rho_2) - \rho_2 \ln r_1}{\sigma_2 \sqrt{1 - \rho_2^2}}\right) \right] + \\
& + P_2 \frac{1}{\sqrt{2\pi}\sigma_1 r_1} e^{-\frac{(\ln r_1 - \mu_1)^2}{2\sigma_1^2}} \left[ 1 - Q\left(\frac{\ln r_T - \mu_1(1 - \rho_1) - \rho_1 \ln r_1}{\sigma_1 \sqrt{1 - \rho_1^2}}\right) \right] \cdot \\
& \cdot \frac{1}{\sqrt{2\pi}\sigma_2 r_2} e^{-\frac{(\ln r_2 - \mu_2)^2}{2\sigma_2^2}} \left[ 1 - Q\left(\frac{\ln r_T - \mu_2(1 - \rho_2) - \rho_2 \ln r_2}{\sigma_2 \sqrt{1 - \rho_2^2}}\right) \right] \tag{3.7.18}
\end{aligned}$$

Za  $r_1 < r_T, r_2 \geq r_T$

$$\begin{aligned}
& p_{r_1 r_2}(r_1, r_2) = \\
= & P_1 \left( 1 - Q\left(\frac{\ln r_T - \mu_1}{\sigma_1}\right) \right) \frac{1}{2\pi\sigma_2^2 \sqrt{1 - \rho_2^2} r_1 r_2} e^{-\frac{1}{2(1 - \rho_2^2)} \left[ \left(\frac{\ln r_1 - \mu_2}{\sigma_2}\right)^2 + \left(\frac{\ln r_2 - \mu_2}{\sigma_2}\right)^2 - 2\rho_2 \left(\frac{\ln r_1 - \mu_2}{\sigma_2}\right) \left(\frac{\ln r_2 - \mu_2}{\sigma_2}\right) \right]} + \\
& + P_1 \frac{1}{\sqrt{2\pi}\sigma_2 r_1} e^{-\frac{(\ln r_1 - \mu_2)^2}{2\sigma_2^2}} \left[ 1 - Q\left(\frac{\ln r_T - \mu_2(1 - \rho_2) - \rho_2 \ln r_1}{\sigma_2 \sqrt{1 - \rho_2^2}}\right) \right] \cdot \\
& \cdot \frac{1}{\sqrt{2\pi}\sigma_1 r_2} e^{-\frac{(\ln r_2 - \mu_1)^2}{2\sigma_1^2}} \left[ 1 - Q\left(\frac{\ln r_T - \mu_1(1 - \rho_1) - \rho_1 \ln r_2}{\sigma_1 \sqrt{1 - \rho_1^2}}\right) \right] + \\
& + P_2 \left( 1 - Q\left(\frac{\ln r_T - \mu_2}{\sigma_2}\right) \right) \frac{1}{2\pi\sigma_1^2 \sqrt{1 - \rho_1^2} r_1 r_2} e^{-\frac{1}{2(1 - \rho_1^2)} \left[ \left(\frac{\ln r_1 - \mu_1}{\sigma_1}\right)^2 + \left(\frac{\ln r_2 - \mu_1}{\sigma_1}\right)^2 - 2\rho_1 \left(\frac{\ln r_1 - \mu_1}{\sigma_1}\right) \left(\frac{\ln r_2 - \mu_1}{\sigma_1}\right) \right]} + \\
& + P_2 \frac{1}{\sqrt{2\pi}\sigma_1 r_1} e^{-\frac{(\ln r_1 - \mu_1)^2}{2\sigma_1^2}} \left[ 1 - Q\left(\frac{\ln r_T - \mu_1(1 - \rho_1) - \rho_1 \ln r_1}{\sigma_1 \sqrt{1 - \rho_1^2}}\right) \right] \cdot
\end{aligned}$$

$$\cdot \frac{1}{\sqrt{2\pi\sigma_2 r_2}} e^{-\frac{(\ln r_2 - \mu_2)^2}{2\sigma_2^2}} \left[ 1 - Q \left( \frac{\ln r_T - \mu_2(1 - \rho_2) - \rho_2 \ln r_2}{\sigma_2 \sqrt{1 - \rho_2^2}} \right) \right] \quad (3.7.19)$$

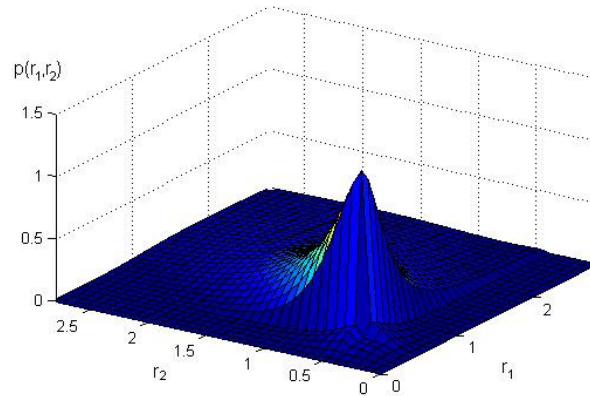
Za  $r_1 \geq r_T$ ,  $r_2 \geq r_T$

$$\begin{aligned} p_{r_1, r_2}(r_1, r_2) = & P_1 \frac{1}{2\pi\sigma_1^2 \sqrt{1 - \rho_1^2} r_1 r_2} e^{-\frac{1}{2(1 - \rho_1^2)} \left[ \left( \frac{\ln r_1 - \mu_1}{\sigma_1} \right)^2 + \left( \frac{\ln r_2 - \mu_1}{\sigma_1} \right)^2 - 2\rho_1 \left( \frac{\ln r_1 - \mu_1}{\sigma_1} \right) \left( \frac{\ln r_2 - \mu_1}{\sigma_1} \right) \right]} + \\ & + P_1 \frac{1}{\sqrt{2\pi\sigma_1 r_1}} e^{-\frac{(\ln r_1 - \mu_1)^2}{2\sigma_1^2}} \frac{1}{\sqrt{2\pi\sigma_2 r_2}} e^{-\frac{(\ln r_2 - \mu_2)^2}{2\sigma_2^2}} \left[ 1 - Q \left( \frac{\ln r_T - \mu_1(1 - \rho_1) - \rho_1 \ln r_1}{\sigma_1 \sqrt{1 - \rho_1^2}} \right) \right] + \\ & + P_1 \left( 1 - Q \left( \frac{\ln r_T - \mu_1}{\sigma_1} \right) \right) \frac{1}{2\pi\sigma_2^2 \sqrt{1 - \rho_2^2} r_1 r_2} e^{-\frac{1}{2(1 - \rho_2^2)} \left[ \left( \frac{\ln r_1 - \mu_2}{\sigma_2} \right)^2 + \left( \frac{\ln r_2 - \mu_2}{\sigma_2} \right)^2 - 2\rho_2 \left( \frac{\ln r_1 - \mu_2}{\sigma_2} \right) \left( \frac{\ln r_2 - \mu_2}{\sigma_2} \right) \right]} + \\ & + P_1 \frac{1}{\sqrt{2\pi\sigma_2 r_1}} e^{-\frac{(\ln r_1 - \mu_2)^2}{2\sigma_2^2}} \left[ 1 - Q \left( \frac{\ln r_T - \mu_2(1 - \rho_2) - \rho_2 \ln r_1}{\sigma_2 \sqrt{1 - \rho_2^2}} \right) \right] \cdot \\ & \cdot \frac{1}{\sqrt{2\pi\sigma_1 r_2}} e^{-\frac{(\ln r_2 - \mu_1)^2}{2\sigma_1^2}} \left[ 1 - Q \left( \frac{\ln r_T - \mu_1(1 - \rho_1) - \rho_1 \ln r_2}{\sigma_1 \sqrt{1 - \rho_1^2}} \right) \right] + \\ & + P_2 \frac{1}{2\pi\sigma_2^2 \sqrt{1 - \rho_2^2} r_1 r_2} e^{-\frac{1}{2(1 - \rho_2^2)} \left[ \left( \frac{\ln r_1 - \mu_2}{\sigma_2} \right)^2 + \left( \frac{\ln r_2 - \mu_2}{\sigma_2} \right)^2 - 2\rho_2 \left( \frac{\ln r_1 - \mu_2}{\sigma_2} \right) \left( \frac{\ln r_2 - \mu_2}{\sigma_2} \right) \right]} + \\ & + P_2 \frac{1}{\sqrt{2\pi\sigma_2 r_1}} e^{-\frac{(\ln r_1 - \mu_2)^2}{2\sigma_2^2}} \frac{1}{\sqrt{2\pi\sigma_1 r_2}} e^{-\frac{(\ln r_2 - \mu_1)^2}{2\sigma_1^2}} \left[ 1 - Q \left( \frac{\ln r_T - \mu_2(1 - \rho_2) - \rho_2 \ln r_1}{\sigma_2 \sqrt{1 - \rho_2^2}} \right) \right] + \\ & + P_2 \left( 1 - Q \left( \frac{\ln r_T - \mu_2}{\sigma_2} \right) \right) \frac{1}{2\pi\sigma_1^2 \sqrt{1 - \rho_1^2} r_1 r_2} e^{-\frac{1}{2(1 - \rho_1^2)} \left[ \left( \frac{\ln r_1 - \mu_1}{\sigma_1} \right)^2 + \left( \frac{\ln r_2 - \mu_1}{\sigma_1} \right)^2 - 2\rho_1 \left( \frac{\ln r_1 - \mu_1}{\sigma_1} \right) \left( \frac{\ln r_2 - \mu_1}{\sigma_1} \right) \right]} + \\ & + P_2 \frac{1}{\sqrt{2\pi\sigma_1 r_1}} e^{-\frac{(\ln r_1 - \mu_1)^2}{2\sigma_1^2}} \left[ 1 - Q \left( \frac{\ln r_T - \mu_1(1 - \rho_1) - \rho_1 \ln r_1}{\sigma_1 \sqrt{1 - \rho_1^2}} \right) \right] \cdot \\ & \cdot \frac{1}{\sqrt{2\pi\sigma_2 r_2}} e^{-\frac{(\ln r_2 - \mu_2)^2}{2\sigma_2^2}} \left[ 1 - Q \left( \frac{\ln r_T - \mu_2(1 - \rho_2) - \rho_2 \ln r_2}{\sigma_2 \sqrt{1 - \rho_2^2}} \right) \right] \end{aligned} \quad (3.7.20)$$

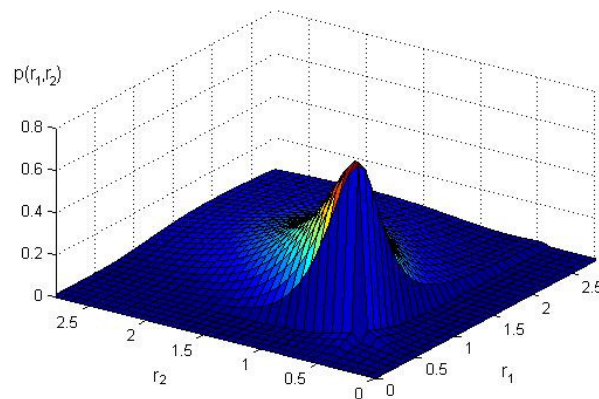
Združena gustina raspodele verovatnoće na izlazu iz SSC kombinera se može jednostavno predstaviti grafički upotrebom matematičkog softvera kao što je “MatLab”. Radi

uproštavanje, a ne gubeći uopštenost, pretpostavljeno je da su parametri raspodele isti za obe grane kombinera.

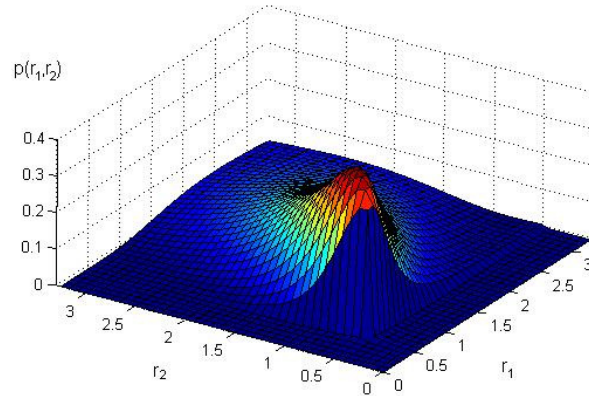
Na slikama 3.7.1.-9. predstavljena je zavisnost PDF od vrednosti signala za različite vrednosti parametara raspodele, korelacije i praga odlučivanja.



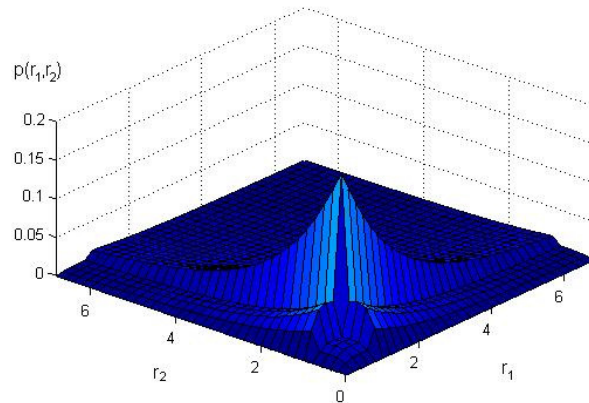
Slika 3.7.1. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu log-normalnog fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 0.5$ ,  $\sigma = 0.7$ ,  $\mu = 0.1$



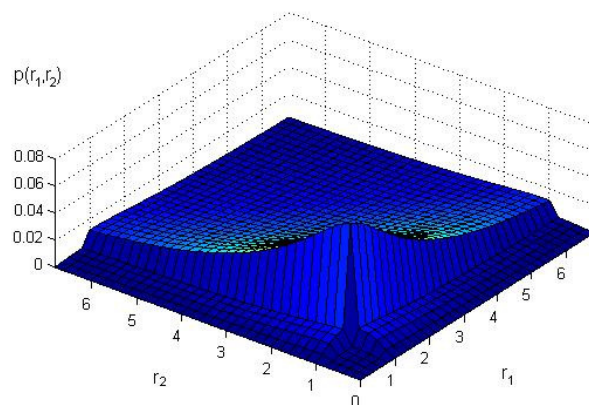
Slika 3.7.2. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu log-normalnog fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 0.5$ ,  $\sigma = 0.7$ ,  $\mu = 0.3$



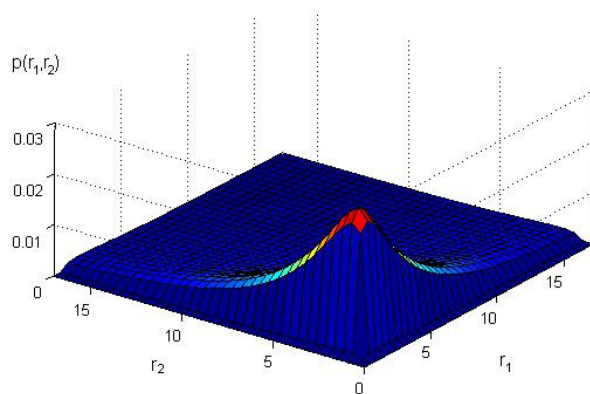
Slika 3.7.3. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu log-normalnog fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 0.5$ ,  $\sigma = 0.7$ ,  $\mu = 0.6$



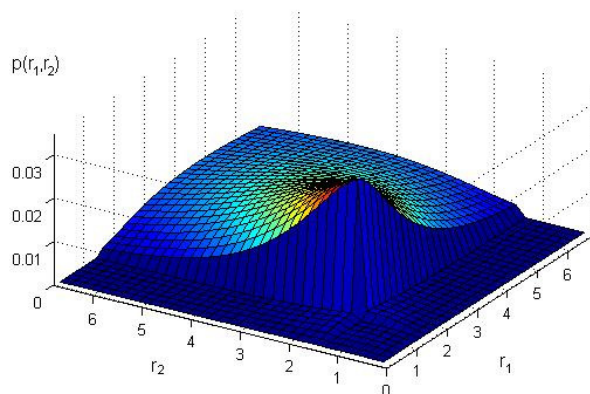
Slika 3.7.4. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu log-normalnog fedinga za parametre:  $\rho = 0.1$ ,  $r_T = 1$ ,  $\sigma = 1$ ,  $\mu = 0.5$



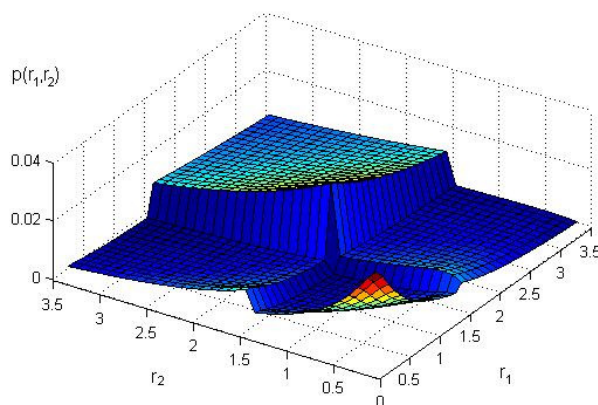
Slika 3.7.5. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu log-normalnog fedinga za parametre:  $\rho = 0.1$ ,  $r_T = 1$ ,  $\sigma = 1$ ,  $\mu = 1$



Slika 3.7.6. Združena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu log-normalnog fedinga za parametre:  $\rho = 0.1$ ,  $r_T = 1$ ,  $\sigma = 1$ ,  $\mu = 1.5$

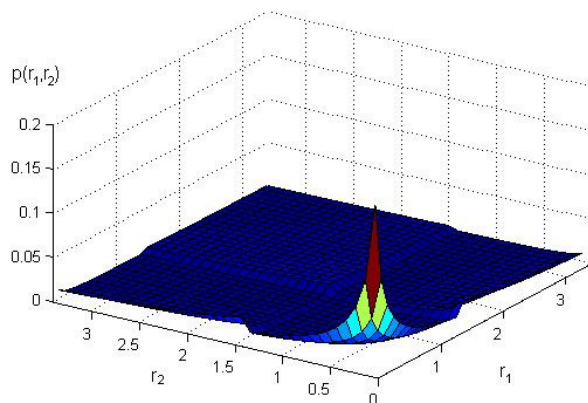


Slika 3.7.7. Združena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu log-normalnog fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 1.5$ ,  $\mu = 2$ ,  $\sigma = 1$



Slika 3.7.8. Združena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu log-normalnog fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 1.5$ ,  $\mu = 2$ ,  $\sigma = 2$





Slika 3.7.9. Združena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu log-normalnog fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 1.5$ ,  $\mu = 2$ ,  $\sigma = 4$

### 3.8 Združena gustina raspodele verovatnoće na izlazu SSC kombinera u dva trenutka vremena u prisustvu gamma fedinga

Gustina raspodele verovatnoće i kumulativna raspodela verovatnoće (CDF) signala na izlazu iz kombinera  $r_{i,j}$  u prisustvu gamma fedinga su [11]:

$$p_{r_i}(r_{i,j}) = \frac{1}{\Gamma(c_i)} \Omega_i^{-c_i} r_{i,j}^{c_i-1} e^{-\frac{r_{i,j}}{\Omega_i}} \quad , \quad r_{i,j} \geq 0 \quad (3.8.1)$$

$$F_{r_i}(r_{i,j}) = \gamma\left(c_i, \frac{r_{i,j}}{\Omega_i}\right) \quad , \quad r_{i,j} \geq 0 \quad (3.8.2)$$

gde su  $i=1,2$   $j=1,2$ ,  $c$  je red gamma raspodele,  $\Omega$  zavisi od srednje snage signala, a  $\gamma(x,a)$  je nekompletna gama funkcija.

Verovatnoće  $P_1$  i  $P_2$  se dobijaju ako se u (3.1.17-18) stavi (3.8.2):

$$P_1 = \frac{F_{r_2}(r_T)}{F_{r_1}(r_T) + F_{r_2}(r_T)} = \frac{\gamma\left(c_2, \frac{r_T}{\Omega_2}\right)}{\gamma\left(c_1, \frac{r_T}{\Omega_1}\right) + \gamma\left(c_2, \frac{r_T}{\Omega_2}\right)} \quad (3.8.3)$$

$$P_2 = \frac{F_{r_1}(r_T)}{F_{r_1}(r_T) + F_{r_2}(r_T)} = \frac{\gamma\left(c_1, \frac{r_T}{\Omega_1}\right)}{\gamma\left(c_1, \frac{r_T}{\Omega_1}\right) + \gamma\left(c_2, \frac{r_T}{\Omega_2}\right)} \quad (3.8.4)$$

Združena gustina raspodele verovatnoće korelisanih signala  $x_1$  i  $x_2$  sa gamma raspodelom i istim parametrima raspodele je [56], [57]:

$$p_{x_1 x_2}(x_1, x_2) = \frac{\rho^{-\frac{c-1}{2}}}{\Gamma(c)(1-\rho)\Omega^{c+1}} (x_1 x_2)^{\frac{c-1}{2}} e^{-\frac{x_1+x_2}{(1-\rho)\Omega}} I_{c-1} \left( \frac{2\sqrt{\rho x_1 x_2}}{(1-\rho)\Omega} \right) \quad (3.8.5)$$

gde je  $\rho$  koeficijent korelacije.

Združena gustina raspodele verovatnoće signala  $r_1$  i  $r_2$  na izlazu SSC kombinera u dva trenutka vremena u prisustvu log-normalnog fedinga kada su signali na ulazu u grane kombinera nezavisni, može se dobiti ako se u (3.2.5-8) stave izrazi (3.3.93) i (3.3.97).

Za  $r_1 < r_T, r_2 < r_T$

$$\begin{aligned} p_{r_1 r_2}(r_1, r_2) = & P_1 \int_0^{r_T} \frac{\rho_1^{-\frac{c_1-1}{2}}}{\Gamma(c_1)(1-\rho_1)\Omega_1^{c_1+1}} (r_{11} r_2)^{\frac{c_1-1}{2}} e^{-\frac{r_{11}+r_2}{(1-\rho_1)\Omega_1}} I_{c_1-1} \left( \frac{2\sqrt{\rho_1 r_{11} r_2}}{(1-\rho_1)\Omega_1} \right) dr_{11} \cdot \\ & \cdot \int_0^{r_T} \frac{\rho_2^{-\frac{c_2-1}{2}}}{\Gamma(c_2)(1-\rho_2)\Omega_2^{c_2+1}} (r_{22} r_1)^{\frac{c_2-1}{2}} e^{-\frac{r_{22}+r_1}{(1-\rho_2)\Omega_2}} I_{c_2-1} \left( \frac{2\sqrt{\rho_2 r_{22} r_1}}{(1-\rho_2)\Omega_2} \right) dr_{22} + \\ & + P_2 \int_0^{r_T} \frac{\rho_2^{-\frac{c_2-1}{2}}}{\Gamma(c_2)(1-\rho_2)\Omega_2^{c_2+1}} (r_{21} r_2)^{\frac{c_2-1}{2}} e^{-\frac{r_{21}+r_2}{(1-\rho_2)\Omega_2}} I_{c_2-1} \left( \frac{2\sqrt{\rho_2 r_{21} r_2}}{(1-\rho_2)\Omega_2} \right) dr_{21} \cdot \\ & \cdot \int_0^{r_T} \frac{\rho_1^{-\frac{c_1-1}{2}}}{\Gamma(c_1)(1-\rho_1)\Omega_1^{c_1+1}} (r_{12} r_1)^{\frac{c_1-1}{2}} e^{-\frac{r_{12}+r_1}{(1-\rho_1)\Omega_1}} I_{c_1-1} \left( \frac{2\sqrt{\rho_1 r_{12} r_1}}{(1-\rho_1)\Omega_1} \right) dr_{12} \end{aligned} \quad (3.8.6)$$

Za  $r_1 \geq r_T, r_2 < r_T$

$$\begin{aligned} p_{r_1 r_2}(r_1, r_2) = & P_1 \frac{1}{\Gamma(c_2)} \Omega_2^{-c_2} r_2^{c_2-1} e^{-\frac{r_2}{\Omega_2}} \int_0^{r_T} \frac{\rho_1^{-\frac{c_1-1}{2}}}{\Gamma(c_1)(1-\rho_1)\Omega_1^{c_1+1}} (r_{12} r_1)^{\frac{c_1-1}{2}} e^{-\frac{r_{12}+r_1}{(1-\rho_1)\Omega_1}} I_{c_1-1} \left( \frac{2\sqrt{\rho_1 r_{12} r_1}}{(1-\rho_1)\Omega_1} \right) dr_{12} + \\ & + P_1 \int_0^{r_T} \frac{\rho_1^{-\frac{c_1-1}{2}}}{\Gamma(c_1)(1-\rho_1)\Omega_1^{c_1+1}} (r_{11} r_2)^{\frac{c_1-1}{2}} e^{-\frac{r_{11}+r_2}{(1-\rho_1)\Omega_1}} I_{c_1-1} \left( \frac{2\sqrt{\rho_1 r_{11} r_2}}{(1-\rho_1)\Omega_1} \right) dr_{11} \cdot \\ & \cdot \int_0^{r_T} \frac{\rho_2^{-\frac{c_2-1}{2}}}{\Gamma(c_2)(1-\rho_2)\Omega_2^{c_2+1}} (r_{22} r_1)^{\frac{c_2-1}{2}} e^{-\frac{r_{22}+r_1}{(1-\rho_2)\Omega_2}} I_{c_2-1} \left( \frac{2\sqrt{\rho_2 r_{22} r_1}}{(1-\rho_2)\Omega_2} \right) dr_{22} + \\ & + P_2 \frac{1}{\Gamma(c_1)} \Omega_1^{-c_1} r_2^{c_1-1} e^{-\frac{r_2}{\Omega_1}} \int_0^{r_T} \frac{\rho_2^{-\frac{c_2-1}{2}}}{\Gamma(c_2)(1-\rho_2)\Omega_2^{c_2+1}} (r_{22} r_1)^{\frac{c_2-1}{2}} e^{-\frac{r_{22}+r_1}{(1-\rho_2)\Omega_2}} I_{c_2-1} \left( \frac{2\sqrt{\rho_2 r_{22} r_1}}{(1-\rho_2)\Omega_2} \right) dr_{22} + \\ & + P_2 \int_0^{r_T} \frac{\rho_2^{-\frac{c_2-1}{2}}}{\Gamma(c_2)(1-\rho_2)\Omega_2^{c_2+1}} (r_{21} r_2)^{\frac{c_2-1}{2}} e^{-\frac{r_{21}+r_2}{(1-\rho_2)\Omega_2}} I_{c_2-1} \left( \frac{2\sqrt{\rho_2 r_{21} r_2}}{(1-\rho_2)\Omega_2} \right) dr_{21} \cdot \end{aligned}$$

$$\cdot \int_0^{r_T} \frac{\rho_1^{-\frac{c_1-1}{2}}}{\Gamma(c_1)(1-\rho_1)\Omega_1^{c_1+1}} (r_{12}r_1)^{\frac{c_1-1}{2}} e^{-\frac{r_{12}+r_1}{(1-\rho_1)\Omega_1}} I_{c_1-1} \left( \frac{2\sqrt{\rho_1 r_{12} r_1}}{(1-\rho_1)\Omega_1} \right) dr_{12} \quad (3.8.7)$$

Za  $r_1 < r_T, r_2 \geq r_T$

$$\begin{aligned} p_{r_1 r_2}(r_1, r_2) = & P_1 \gamma \left( c_1, \frac{r_T}{\Omega_1} \right) \frac{\rho_2^{-\frac{c_2-1}{2}}}{\Gamma(c_2)(1-\rho_2)\Omega_2^{c_2+1}} (r_1 r_2)^{\frac{c_2-1}{2}} e^{-\frac{r_1+r_2}{(1-\rho_2)\Omega_2}} I_{c_2-1} \left( \frac{2\sqrt{\rho_2 r_1 r_2}}{(1-\rho_2)\Omega_2} \right) + \\ & + P_1 \int_0^{r_T} \frac{\rho_1^{-\frac{c_1-1}{2}}}{\Gamma(c_1)(1-\rho_1)\Omega_1^{c_1+1}} (r_{11}r_2)^{\frac{c_1-1}{2}} e^{-\frac{r_{11}+r_2}{(1-\rho_1)\Omega_1}} I_{c_1-1} \left( \frac{2\sqrt{\rho_1 r_{11} r_2}}{(1-\rho_1)\Omega_1} \right) dr_{11} \cdot \\ & \cdot \int_0^{r_T} \frac{\rho_2^{-\frac{c_2-1}{2}}}{\Gamma(c_2)(1-\rho_2)\Omega_2^{c_2+1}} (r_{22}r_1)^{\frac{c_2-1}{2}} e^{-\frac{r_{22}+r_1}{(1-\rho_2)\Omega_2}} I_{c_2-1} \left( \frac{2\sqrt{\rho_2 r_{22} r_1}}{(1-\rho_2)\Omega_2} \right) dr_{22} + \\ & + P_2 \gamma \left( c_2, \frac{r_T}{\Omega_2} \right) \frac{\rho_1^{-\frac{c_1-1}{2}}}{\Gamma(c_1)(1-\rho_1)\Omega_1^{c_1+1}} (r_1 r_2)^{\frac{c_1-1}{2}} e^{-\frac{r_1+r_2}{(1-\rho_1)\Omega_1}} I_{c_1-1} \left( \frac{2\sqrt{\rho_1 r_1 r_2}}{(1-\rho_1)\Omega_1} \right) + \\ & + P_2 \int_0^{r_T} \frac{\rho_2^{-\frac{c_2-1}{2}}}{\Gamma(c_2)(1-\rho_2)\Omega_2^{c_2+1}} (r_{21}r_2)^{\frac{c_2-1}{2}} e^{-\frac{r_{21}+r_2}{(1-\rho_2)\Omega_2}} I_{c_2-1} \left( \frac{2\sqrt{\rho_2 r_{21} r_2}}{(1-\rho_2)\Omega_2} \right) dr_{21} \cdot \\ & \cdot \int_0^{r_T} \frac{\rho_1^{-\frac{c_1-1}{2}}}{\Gamma(c_1)(1-\rho_1)\Omega_1^{c_1+1}} (r_{12}r_1)^{\frac{c_1-1}{2}} e^{-\frac{r_{12}+r_1}{(1-\rho_1)\Omega_1}} I_{c_1-1} \left( \frac{2\sqrt{\rho_1 r_{12} r_1}}{(1-\rho_1)\Omega_1} \right) dr_{12} \quad (3.8.8) \end{aligned}$$

Za  $r_1 \geq r_T, r_2 \geq r_T$

$$\begin{aligned} p_{r_1 r_2}(r_1, r_2) = & P_1 \frac{\rho_1^{-\frac{c_1-1}{2}}}{\Gamma(c_1)(1-\rho_1)\Omega_1^{c_1+1}} (r_1 r_2)^{\frac{c_1-1}{2}} e^{-\frac{r_1+r_2}{(1-\rho_1)\Omega_1}} I_{c_1-1} \left( \frac{2\sqrt{\rho_1 r_1 r_2}}{(1-\rho_1)\Omega_1} \right) + \\ & + P_1 \frac{1}{\Gamma(c_2)} \Omega_2^{-c_2} r_2^{c_2-1} e^{-\frac{r_2}{\Omega_2}} \int_0^{r_T} \frac{\rho_2^{-\frac{c_2-1}{2}}}{\Gamma(c_1)(1-\rho_2)\Omega_1^{c_1+1}} (r_{12}r_1)^{\frac{c_1-1}{2}} e^{-\frac{r_{12}+r_1}{(1-\rho_2)\Omega_1}} I_{c_1-1} \left( \frac{2\sqrt{\rho_2 r_{12} r_1}}{(1-\rho_2)\Omega_1} \right) dr_{12} + \\ & + P_1 \gamma \left( c_1, \frac{r_T}{\Omega_1} \right) \frac{\rho_2^{-\frac{c_2-1}{2}}}{\Gamma(c_2)(1-\rho_2)\Omega_2^{c_2+1}} (r_1 r_2)^{\frac{c_2-1}{2}} e^{-\frac{r_1+r_2}{(1-\rho_2)\Omega_2}} I_{c_2-1} \left( \frac{2\sqrt{\rho_2 r_1 r_2}}{(1-\rho_2)\Omega_2} \right) + \\ & + P_1 \int_0^{r_T} \frac{\rho_1^{-\frac{c_1-1}{2}}}{\Gamma(c_1)(1-\rho_1)\Omega_1^{c_1+1}} (r_{11}r_2)^{\frac{c_1-1}{2}} e^{-\frac{r_{11}+r_2}{(1-\rho_1)\Omega_1}} I_{c_1-1} \left( \frac{2\sqrt{\rho_1 r_{11} r_2}}{(1-\rho_1)\Omega_1} \right) dr_{11} \cdot \\ & \cdot \int_0^{r_T} \frac{\rho_2^{-\frac{c_2-1}{2}}}{\Gamma(c_2)(1-\rho_2)\Omega_2^{c_2+1}} (r_{22}r_1)^{\frac{c_2-1}{2}} e^{-\frac{r_{22}+r_1}{(1-\rho_2)\Omega_2}} I_{c_2-1} \left( \frac{2\sqrt{\rho_2 r_{22} r_1}}{(1-\rho_2)\Omega_2} \right) dr_{22} + \\ & + P_2 \frac{\rho_2^{-\frac{c_2-1}{2}}}{\Gamma(c_2)(1-\rho_2)\Omega_2^{c_2+1}} (r_1 r_2)^{\frac{c_2-1}{2}} e^{-\frac{r_1+r_2}{(1-\rho_2)\Omega_2}} I_{c_2-1} \left( \frac{2\sqrt{\rho_2 r_1 r_2}}{(1-\rho_2)\Omega_2} \right) + \end{aligned}$$

$$\begin{aligned}
 & + P_2 \frac{1}{\Gamma(c_1)} \Omega_1^{-c_1} r_2^{c_1-1} e^{-\frac{r_2}{\Omega_1}} \int_0^{r_T} \frac{\rho_1^{-\frac{c_2-1}{2}}}{\Gamma(c_2)(1-\rho_1)\Omega_2^{c_2+1}} (r_{22}r_1)^{\frac{c_2-1}{2}} e^{-\frac{r_{22}+r_1}{(1-\rho_1)\Omega_2}} I_{c_2-1} \left( \frac{2\sqrt{\rho_1 r_{22} r_1}}{(1-\rho_1)\Omega_2} \right) dr_{22} + \\
 & + P_2 \gamma \left( c_2, \frac{r_T}{\Omega_2} \right) \frac{\rho_1^{-\frac{c_1-1}{2}}}{\Gamma(c_1)(1-\rho_1)\Omega_1^{c_1+1}} (r_1 r_2)^{\frac{c_1-1}{2}} e^{-\frac{r_1+r_2}{(1-\rho_1)\Omega_1}} I_{c_1-1} \left( \frac{2\sqrt{\rho_1 r_1 r_2}}{(1-\rho_1)\Omega_1} \right) + \\
 & + P_2 \int_0^{r_T} \frac{\rho_2^{-\frac{c_2-1}{2}}}{\Gamma(c_2)(1-\rho_2)\Omega_2^{c_2+1}} (r_{21}r_2)^{\frac{c_2-1}{2}} e^{-\frac{r_{21}+r_2}{(1-\rho_2)\Omega_2}} I_{c_2-1} \left( \frac{2\sqrt{\rho_2 r_{21} r_2}}{(1-\rho_2)\Omega_2} \right) dr_{21} \cdot \\
 & \cdot \int_0^{r_T} \frac{\rho_1^{-\frac{c_1-1}{2}}}{\Gamma(c_1)(1-\rho_1)\Omega_1^{c_1+1}} (r_{12}r_1)^{\frac{c_1-1}{2}} e^{-\frac{r_{12}+r_1}{(1-\rho_1)\Omega_1}} I_{c_1-1} \left( \frac{2\sqrt{\rho_1 r_{12} r_1}}{(1-\rho_1)\Omega_1} \right) dr_{12} \quad (3.8.9)
 \end{aligned}$$

Izrazi (3.3.98-101) su u obliku jednostrukog integrala sa konačnim granicama.

Združena gustina raspodele verovatnoće se može dobiti u zatvorenom obliku korišćenjem generalizovane Marcum-ove  $Q$ -funkcije  $m$ -tog reda, gde je  $m$  pozitivan ceo broj, što nije ozbiljno ograničenje, jer ako  $m$  nije ceo broj, ova formula se može upotrebiti za  $\lfloor m \rfloor$  i  $\lfloor m + 1 \rfloor$  za dobijanje donje i gornje granice, kao i u slučaju Nakagami  $m$  fedinga.

Za predstavljanje združene PDF u zatvorenom obliku potrebno je rešiti integral  $\int_{r_T}^{\infty} p_{x_1 x_2}(x_1, x_2) dx_1$ , gde je  $p_{x_1 x_2}(x_1, x_2)$  dato u (3.3.97). Transformacijom  $p_{x_1 x_2}(x_1, x_2)$ , ona se može predstaviti u obliku koji u podintegralnom delu predstavlja podintegralni deo generalizovane Marcum-ove  $Q$ -funkcije  $m$ -tog reda.

$$x_1 = \frac{x^2 \Omega (1-\rho)}{2} \quad x = \frac{\sqrt{2x_1}}{\sqrt{\Omega(1-\rho)}} \quad dx_1 = x \Omega (1-\rho) dx \quad (3.8.10)$$

$$x_2 = \frac{a^2 \Omega (1-\rho)}{2\rho} \quad a = \frac{\sqrt{2\rho x_2}}{\sqrt{\Omega(1-\rho)}} \quad (3.8.11)$$

$$\begin{aligned}
 \int_{r_T}^{\infty} p_{x_1 x_2}(x_1, x_2) dx_1 &= \frac{\rho^{-\frac{c-1}{2}}}{\Gamma(c)(1-\rho)\Omega^{c+1}} \int_{r_T}^{\infty} (x_1 x_2)^{\frac{c-1}{2}} e^{-\frac{x_1+x_2}{(1-\rho)\Omega}} I_{c-1} \left( \frac{2\sqrt{\rho x_1 x_2}}{\Omega(1-\rho)} \right) dx_1 = \\
 &= \frac{1}{\Gamma(c)} \Omega^{-c} x_2^{c-1} e^{-\frac{x_2}{\Omega}} \frac{1}{a^{c-1}} \int_{\frac{\sqrt{2r_T}}{\sqrt{\Omega(1-\rho)}}}^{\infty} x^c e^{-\left(\frac{x^2}{2} + \frac{a^2}{2}\right)} I_{c-1}(xa) dx = \\
 &= \frac{1}{\Gamma(c)} \Omega^{-c} x_2^{c-1} e^{-\frac{x_2}{\Omega}} Q_c \left( \frac{\sqrt{2\rho x_2}}{\sqrt{\Omega(1-\rho)}}, \frac{\sqrt{2r_T}}{\sqrt{\Omega(1-\rho)}} \right) \quad (3.8.12)
 \end{aligned}$$

Na osnovu (3.8.13) se dobija:

$$\int_0^{r_1} p_{x_1, x_2}(x_1, x_2) dx_1 = \frac{1}{\Gamma(c)} \Omega^{-c} x_2^{c-1} e^{-\frac{x_2}{\Omega}} \left[ 1 - Q_c \left( \frac{\sqrt{2\rho x_2}}{\sqrt{\Omega(1-\rho)}}, \frac{\sqrt{2r_1}}{\sqrt{\Omega(1-\rho)}} \right) \right] \quad (3.8.13)$$

Zamenom (3.8.13) u izrazima (3.8.6-9) dobija se konačni oblik za združenu gustinu raspodele verovatnoće na izlazu iz SSC kombinera.

Za  $r_1 < r_T, r_2 < r_T$

$$\begin{aligned} p_{r_1 r_2}(r_1, r_2) = & P_1 \frac{1}{\Gamma(c_2)} \Omega_2^{-c_2} r_1^{c_2-1} e^{-\frac{r_1}{\Omega_2}} \left[ 1 - Q_{c_2} \left( \frac{\sqrt{2\rho_2 r_1}}{\sqrt{\Omega_2(1-\rho_2)}}, \frac{\sqrt{2r_T}}{\sqrt{\Omega_2(1-\rho_2)}} \right) \right] \cdot \\ & \cdot \frac{1}{\Gamma(c_1)} \Omega_1^{-c_1} r_2^{c_1-1} e^{-\frac{r_2}{\Omega_1}} \left[ 1 - Q_{c_1} \left( \frac{\sqrt{2\rho_1 r_2}}{\sqrt{\Omega_1(1-\rho_1)}}, \frac{\sqrt{2r_T}}{\sqrt{\Omega_1(1-\rho_1)}} \right) \right] + \\ & + P_2 \frac{1}{\Gamma(c_1)} \Omega_1^{-c_1} r_1^{c_1-1} e^{-\frac{r_1}{\Omega_1}} \left[ 1 - Q_{c_1} \left( \frac{\sqrt{2\rho_1 r_1}}{\sqrt{\Omega_1(1-\rho_1)}}, \frac{\sqrt{2r_T}}{\sqrt{\Omega_1(1-\rho_1)}} \right) \right] \cdot \\ & \cdot \frac{1}{\Gamma(c_2)} \Omega_2^{-c_2} r_2^{c_2-1} e^{-\frac{r_2}{\Omega_2}} \left[ 1 - Q_{c_2} \left( \frac{\sqrt{2\rho_2 r_2}}{\sqrt{\Omega_2(1-\rho_2)}}, \frac{\sqrt{2r_T}}{\sqrt{\Omega_2(1-\rho_2)}} \right) \right] \end{aligned} \quad (3.8.14)$$

Za  $r_1 \geq r_T, r_2 < r_T$

$$\begin{aligned} p_{r_1 r_2}(r_1, r_2) = & P_1 \frac{1}{\Gamma(c_1)} \Omega_1^{-c_1} r_1^{c_1-1} e^{-\frac{r_1}{\Omega_1}} \frac{1}{\Gamma(c_2)} \Omega_2^{-c_2} r_2^{c_2-1} e^{-\frac{r_2}{\Omega_2}} \left[ 1 - Q_{c_1} \left( \frac{\sqrt{2\rho_1 r_1}}{\sqrt{\Omega_1(1-\rho_1)}}, \frac{\sqrt{2r_T}}{\sqrt{\Omega_1(1-\rho_1)}} \right) \right] + \\ & + P_1 \frac{1}{\Gamma(c_2)} \Omega_2^{-c_2} r_1^{c_2-1} e^{-\frac{r_1}{\Omega_2}} \left[ 1 - Q_{c_2} \left( \frac{\sqrt{2\rho_2 r_1}}{\sqrt{\Omega_2(1-\rho_2)}}, \frac{\sqrt{2r_T}}{\sqrt{\Omega_2(1-\rho_2)}} \right) \right] \cdot \\ & \cdot \frac{1}{\Gamma(c_1)} \Omega_1^{-c_1} r_2^{c_1-1} e^{-\frac{r_2}{\Omega_1}} \left[ 1 - Q_{c_1} \left( \frac{\sqrt{2\rho_1 r_2}}{\sqrt{\Omega_1(1-\rho_1)}}, \frac{\sqrt{2r_T}}{\sqrt{\Omega_1(1-\rho_1)}} \right) \right] + \\ & + P_2 \frac{1}{\Gamma(c_2)} \Omega_2^{-c_2} r_1^{c_2-1} e^{-\frac{r_1}{\Omega_2}} \frac{1}{\Gamma(c_1)} \Omega_1^{-c_1} r_2^{c_1-1} e^{-\frac{r_2}{\Omega_1}} \left[ 1 - Q_{c_2} \left( \frac{\sqrt{2\rho_2 r_1}}{\sqrt{\Omega_2(1-\rho_2)}}, \frac{\sqrt{2r_T}}{\sqrt{\Omega_2(1-\rho_2)}} \right) \right] \cdot \\ & + P_2 \frac{1}{\Gamma(c_1)} \Omega_1^{-c_1} r_1^{c_1-1} e^{-\frac{r_1}{\Omega_1}} \left[ 1 - Q_{c_1} \left( \frac{\sqrt{2\rho_1 r_1}}{\sqrt{\Omega_1(1-\rho_1)}}, \frac{\sqrt{2r_T}}{\sqrt{\Omega_1(1-\rho_1)}} \right) \right] \cdot \\ & \cdot \frac{1}{\Gamma(c_2)} \Omega_2^{-c_2} r_2^{c_2-1} e^{-\frac{r_2}{\Omega_2}} \left[ 1 - Q_{c_2} \left( \frac{\sqrt{2\rho_2 r_2}}{\sqrt{\Omega_2(1-\rho_2)}}, \frac{\sqrt{2r_T}}{\sqrt{\Omega_2(1-\rho_2)}} \right) \right] \end{aligned} \quad (3.8.15)$$

Za  $r_1 < r_T, r_2 \geq r_T$

$$\begin{aligned}
p_{r_1 r_2}(r_1, r_2) = & P_1 \gamma \left( c_1, \frac{r_T}{\Omega_1} \right) \frac{\rho_2^{-\frac{c_2-1}{2}}}{\Gamma(c_2)(1-\rho_2)\Omega_2^{c_2+1}} (r_1 r_2)^{\frac{c_2-1}{2}} e^{-\frac{r_1+r_2}{(1-\rho_2)\Omega_2}} I_{c_2-1} \left( \frac{2\sqrt{\rho_2 r_1 r_2}}{(1-\rho_2)\Omega_2} \right) + \\
& + P_1 \frac{1}{\Gamma(c_2)} \Omega_2^{-c_2} r_1^{c_2-1} e^{-\frac{r_1}{\Omega_2}} \left[ 1 - Q_{c_2} \left( \frac{\sqrt{2\rho_2 r_1}}{\sqrt{\Omega_2(1-\rho_2)}}, \frac{\sqrt{2r_T}}{\sqrt{\Omega_2(1-\rho_2)}} \right) \right] \cdot \\
& \cdot \frac{1}{\Gamma(c_1)} \Omega_1^{-c_1} r_2^{c_1-1} e^{-\frac{r_2}{\Omega_1}} \left[ 1 - Q_{c_1} \left( \frac{\sqrt{2\rho_1 r_2}}{\sqrt{\Omega_1(1-\rho_1)}}, \frac{\sqrt{2r_T}}{\sqrt{\Omega_1(1-\rho_1)}} \right) \right] + \\
& + P_2 \gamma \left( c_2, \frac{r_T}{\Omega_2} \right) \frac{\rho_1^{-\frac{c_1-1}{2}}}{\Gamma(c_1)(1-\rho_1)\Omega_1^{c_1+1}} (r_1 r_2)^{\frac{c_1-1}{2}} e^{-\frac{r_1+r_2}{(1-\rho_1)\Omega_1}} I_{c_1-1} \left( \frac{2\sqrt{\rho_1 r_1 r_2}}{(1-\rho_1)\Omega_1} \right) + \\
& + P_2 \frac{1}{\Gamma(c_1)} \Omega_1^{-c_1} r_1^{c_1-1} e^{-\frac{r_1}{\Omega_1}} \left[ 1 - Q_{c_1} \left( \frac{\sqrt{2\rho_1 r_1}}{\sqrt{\Omega_1(1-\rho_1)}}, \frac{\sqrt{2r_T}}{\sqrt{\Omega_1(1-\rho_1)}} \right) \right] \cdot \\
& \cdot \frac{1}{\Gamma(c_2)} \Omega_2^{-c_2} r_2^{c_2-1} e^{-\frac{r_2}{\Omega_2}} \left[ 1 - Q_{c_2} \left( \frac{\sqrt{2\rho_2 r_2}}{\sqrt{\Omega_2(1-\rho_2)}}, \frac{\sqrt{2r_T}}{\sqrt{\Omega_2(1-\rho_2)}} \right) \right] \quad (3.8.16)
\end{aligned}$$

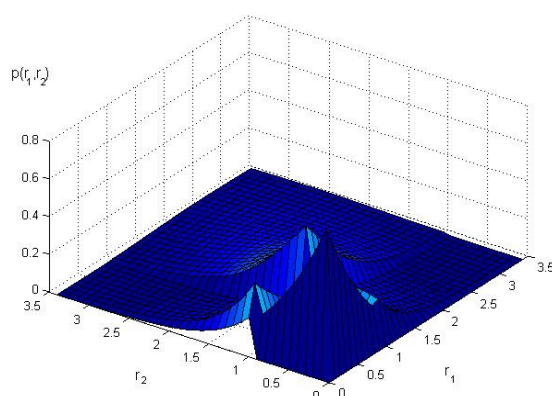
Za  $r_1 \geq r_T, r_2 \geq r_T$

$$\begin{aligned}
p_{r_1 r_2}(r_1, r_2) = & P_1 \frac{\rho^{-\frac{c_1-1}{2}}}{\Gamma(c_1)(1-\rho_1)\Omega_1^{c_1+1}} (r_1 r_2)^{\frac{c_1-1}{2}} e^{-\frac{r_1+r_2}{(1-\rho_1)\Omega_1}} I_{c_1-1} \left( \frac{2\sqrt{\rho_1 r_1 r_2}}{(1-\rho_1)\Omega_1} \right) + \\
& + P_1 \frac{1}{\Gamma(c_1)} \Omega_1^{-c_1} r_1^{c_1-1} e^{-\frac{r_1}{\Omega_1}} \frac{1}{\Gamma(c_2)} \Omega_2^{-c_2} r_2^{c_2-1} e^{-\frac{r_2}{\Omega_2}} \left[ 1 - Q_{c_1} \left( \frac{\sqrt{2\rho_1 r_1}}{\sqrt{\Omega_1(1-\rho_1)}}, \frac{\sqrt{2r_T}}{\sqrt{\Omega_1(1-\rho_1)}} \right) \right] + \\
& + P_1 \gamma \left( c_1, \frac{r_T}{\Omega_1} \right) \frac{\rho_2^{-\frac{c_2-1}{2}}}{\Gamma(c_2)(1-\rho_2)\Omega_2^{c_2+1}} (r_1 r_2)^{\frac{c_2-1}{2}} e^{-\frac{r_1+r_2}{(1-\rho_2)\Omega_2}} I_{c_2-1} \left( \frac{2\sqrt{\rho_2 r_1 r_2}}{(1-\rho_2)\Omega_2} \right) + \\
& + P_1 \frac{1}{\Gamma(c_2)} \Omega_2^{-c_2} r_1^{c_2-1} e^{-\frac{r_1}{\Omega_2}} \left[ 1 - Q_{c_2} \left( \frac{\sqrt{2\rho_2 r_1}}{\sqrt{\Omega_2(1-\rho_2)}}, \frac{\sqrt{2r_T}}{\sqrt{\Omega_2(1-\rho_2)}} \right) \right] \cdot \\
& \cdot \frac{1}{\Gamma(c_1)} \Omega_1^{-c_1} r_2^{c_1-1} e^{-\frac{r_2}{\Omega_1}} \left[ 1 - Q_{c_1} \left( \frac{\sqrt{2\rho_1 r_2}}{\sqrt{\Omega_1(1-\rho_1)}}, \frac{\sqrt{2r_T}}{\sqrt{\Omega_1(1-\rho_1)}} \right) \right] + \\
& + P_2 \frac{\rho_2^{-\frac{c_2-1}{2}}}{\Gamma(c_2)(1-\rho_2)\Omega_2^{c_2+1}} (r_1 r_2)^{\frac{c_2-1}{2}} e^{-\frac{r_1+r_2}{(1-\rho_2)\Omega_2}} I_{c_2-1} \left( \frac{2\sqrt{\rho_2 r_1 r_2}}{(1-\rho_2)\Omega_2} \right) + \\
& + P_2 \frac{1}{\Gamma(c_2)} \Omega_2^{-c_2} r_1^{c_2-1} e^{-\frac{r_1}{\Omega_2}} \frac{1}{\Gamma(c_1)} \Omega_1^{-c_1} r_2^{c_1-1} e^{-\frac{r_2}{\Omega_1}} \left[ 1 - Q_{c_2} \left( \frac{\sqrt{2\rho_2 r_1}}{\sqrt{\Omega_2(1-\rho_2)}}, \frac{\sqrt{2r_T}}{\sqrt{\Omega_2(1-\rho_2)}} \right) \right] +
\end{aligned}$$

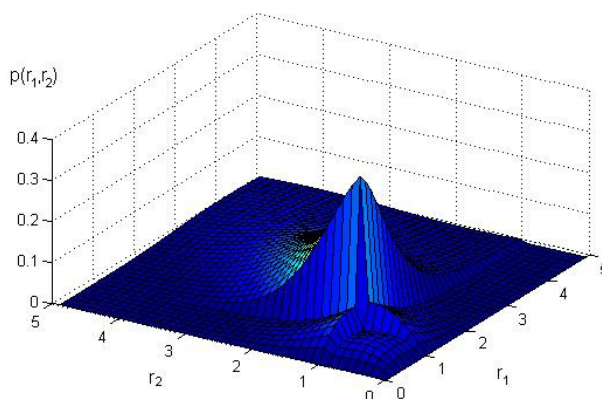
$$\begin{aligned}
 & P_2 \gamma \left( c_2, \frac{r_T}{\Omega_2} \right) \frac{\rho_1^{-\frac{c_1-1}{2}}}{\Gamma(c_1)(1-\rho_1)\Omega_1^{c_1+1}} (r_1 r_2)^{\frac{c_1-1}{2}} e^{-\frac{r_1+r_2}{(1-\rho_1)\Omega_1}} I_{c_1-1} \left( \frac{2\sqrt{\rho_1 r_1 r_2}}{(1-\rho_1)\Omega_1} \right) + \\
 & + P_2 \frac{1}{\Gamma(c_1)} \Omega_1^{-c_1} r_1^{c_1-1} e^{-\frac{r_1}{\Omega_1}} \left[ 1 - Q_{c_1} \left( \frac{\sqrt{2\rho_1 r_1}}{\sqrt{\Omega_1(1-\rho_1)}}, \frac{\sqrt{2r_T}}{\sqrt{\Omega_1(1-\rho_1)}} \right) \right] \cdot \\
 & \cdot \frac{1}{\Gamma(c_2)} \Omega_2^{-c_2} r_2^{c_2-1} e^{-\frac{r_2}{\Omega_2}} \left[ 1 - Q_{c_2} \left( \frac{\sqrt{2\rho_2 r_2}}{\sqrt{\Omega_2(1-\rho_2)}}, \frac{\sqrt{2r_T}}{\sqrt{\Omega_2(1-\rho_2)}} \right) \right] \quad (3.8.17)
 \end{aligned}$$

Radi uprošćavanja, a ne gubeći uopštenost, pretpostavljeno je da su parametri raspodele isti za obe grane kombinera.

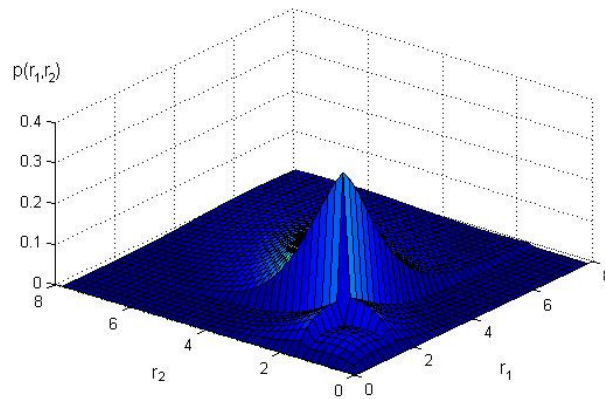
Na slikama 3.8.1.-9. predstavljena je zavisnost PDF od vrednosti signala za različite vrednosti parametara raspodele, korelacije i praga odlučivanja, gde je zbog lakšeg proračuna usvojeno da su parametri raspodele isti za obe grane kombinera.



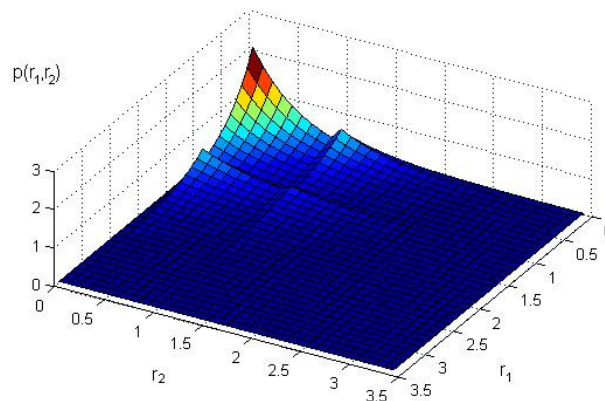
Slika 3.8.1. Združena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu gamma fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 1$ ,  $\Omega = 1$ ,  $c = 1$



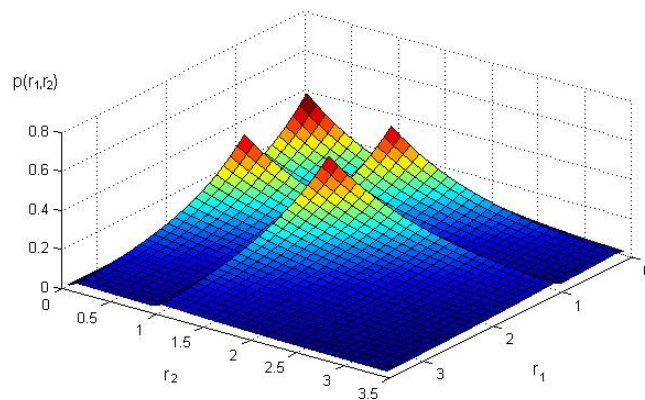
Slika 3.8.2. Združena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu gamma fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 1$ ,  $\Omega = 1$ ,  $c = 2$



Slika 3.8.3. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu gamma fedinga za parametre:  $\rho = 0.8$ ,  $r_T = 1$ ,  $\Omega = 1$ ,  $c = 3$

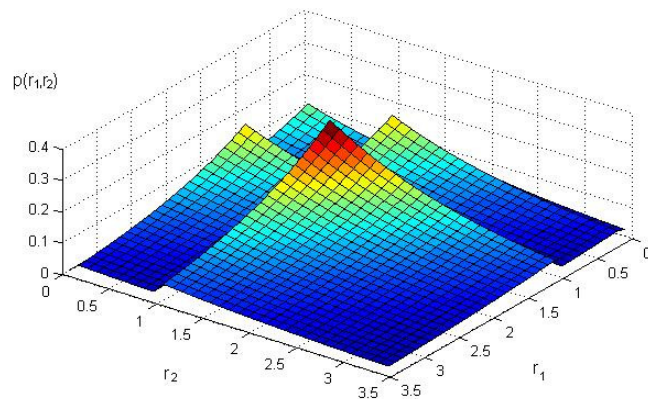


Slika 3.8.4. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu gamma fedinga za parametre:  $\rho = 0.2$ ,  $r_T = 1$ ,  $c = 1$ ,  $\Omega = 0.5$

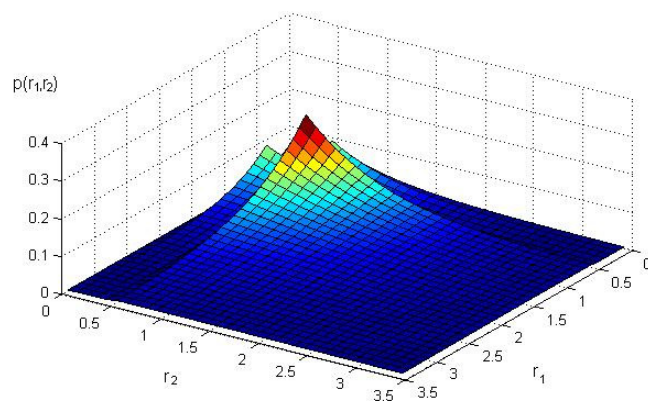


Slika 3.8.5. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu gamma fedinga za parametre:  $\rho = 0.2$ ,  $r_T = 1$ ,  $c = 1$ ,  $\Omega = 1$

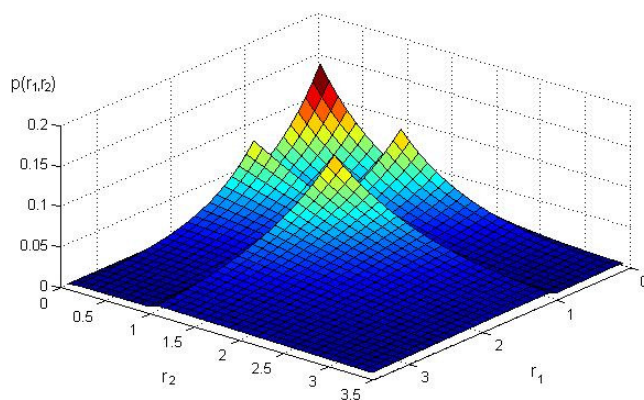




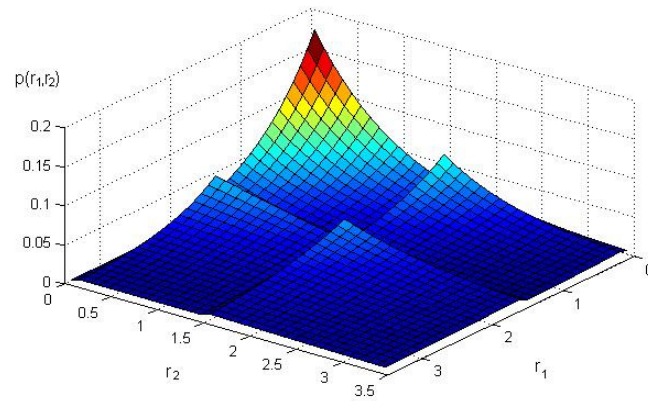
Slika 3.8.6. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu gamma fedinga za parametre:  $\rho = 0.2$ ,  $r_T = 1$ ,  $c = 1$ ,  $\Omega = 1.5$



Slika 3.8.7. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu gamma fedinga za parametre:  $\rho = 0.5$ ,  $c = 1$ ,  $\Omega = 1$ ,  $r_T = 1$



Slika 3.8.8. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu gamma fedinga za parametre:  $\rho = 0.5$ ,  $c = 1$ ,  $\Omega = 1$ ,  $r_T = 2$



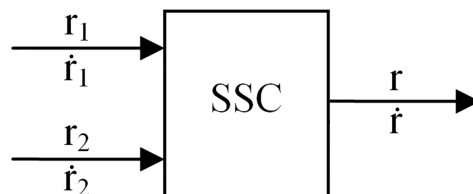
Slika 3.8.9. Zdužena gustina raspodele verovatnoće na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu gamma fedinga za parametre:  $\rho = 0.5$ ,  $c = 1$ ,  $\Omega = 1$ ,  $r_T = 3$

## 4 Karakteristike drugog reda SSC kombinera

Glavni akcenat u ovoj glavi je dat na razmatranju karakteristika drugog reda SSC kombinera u 2 trenutka vremena, a na osnovu prethodno dobijenih karakteristika prvog reda, kao što je združena gustina raspodele verovatnoće signala na izlazu u dva trenutka vremena. Ovakav slučaj dosad nije razmatran u dostupnoj literaturi, osim u radovima grupe autora među kojima je i autor disertacije [41], [42], [58]-[60]. Rezultati su dobijeni za slučaj da ne postoji korelacija između signala u jednoj grani u dva vremenska trenutka, a da su kao u prethodnom poglavlju međusobno nezavisni signali između grana prijemnika. Za dobijanje karakteristika drugog reda je neophodno uzeti u obzir osim gustina raspodele verovatnoće signala na ulazima u kombiner i gustine raspodele njihovih izvoda.

### 4.1 Model sistema u jednom trenutku vremena

Razmatra se SSC kombiner sa dva ulaza, kao u modelu predstavljenom na slici 4.1.1. Signali na ulazima su  $r_1$  i  $r_2$ , dok su njihovi izvodi  $\dot{r}_1$  i  $\dot{r}_2$ . Signal na izlazu iz kombinera je  $r$ , sa izvodom signala  $\dot{r}$ . Verovatnoća da kombiner prvo razmatra signal na prvoj grani je  $P_1$ , a na drugoj je  $P_2$ .



Slika 4.1.1. Model SSC kombinera sa dva ulaza u jednom trenutku vremena sa izvodima signala

slučaj  $r < r_T$

vrednosti ulaznih signala	vrednosti izvoda izlaznih signala	verovatnoća događaja
$r_1 < r_T, \quad r_2 < r_T$	$\dot{r} = \dot{r}_2$	$P_1$
$r_2 < r_T, \quad r_1 < r_T$	$\dot{r} = \dot{r}_1$	$P_2$

slučaj  $r \geq r_T$

vrednosti ulaznih signala	vrednosti izvoda izlaznih signala	verovatnoća događaja
$r_1 \geq r_T$	$\dot{r} = \dot{r}_1$	$P_1$
$r_1 < r_T, \quad r_2 \geq r_T$	$\dot{r} = \dot{r}_2$	$P_1$
$r_2 \geq r_T$	$\dot{r} = \dot{r}_2$	$P_2$
$r_2 < r_T, \quad r_1 \geq r_T$	$\dot{r} = \dot{r}_1$	$P_2$

Izraz za združenu gustinu raspodele verovatnoće signala i izvoda signala na izlazu iz kombinera će prvo biti dat za slučaj  $r < r_T$ . Na osnovu algoritma rada SSC kombinera u ovom slučaju, gustina raspodele verovatnoće je [15]:

$$p_{r\dot{r}}(r, \dot{r}) = P_1 F_{r_1}(r_T) p_{r_2 \dot{r}_2}(r, \dot{r}) + P_2 F_{r_2}(r_T) p_{r_1 \dot{r}_1}(r, \dot{r}) \quad (4.1.1)$$

Za slučaj  $r \geq r_T$ , združena gustinu raspodele verovatnoće signala i izvoda signala na izlazu iz kombinera je:

$$p_{r\dot{r}}(r, \dot{r}) = P_1 p_{r_1 \dot{r}_1}(r, \dot{r}) + P_1 F_{r_1}(r_T) p_{r_2 \dot{r}_2}(r, \dot{r}) + P_2 p_{r_2 \dot{r}_2}(r, \dot{r}) + P_2 F_{r_2}(r_T) p_{r_1 \dot{r}_1}(r, \dot{r}) \quad (4.1.2)$$

gde je  $r_T$  prag odluke, a kumulativne raspodele verovatnoće su date u trećoj glavi.

U slučaju kada su signal i njegov izvod nekorelisani, njihova združena gustinu raspodele verovatnoće na izlazu je:

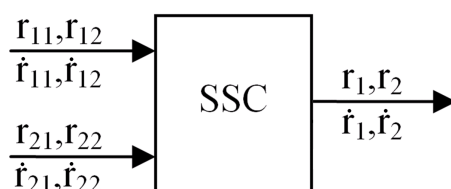
$$p_{r\dot{r}}(r, \dot{r}) = P_1 F_{r_1}(r_T) p_{r_2}(r) p_{\dot{r}_2}(\dot{r}) + P_2 F_{r_2}(r_T) p_{r_1}(r) p_{\dot{r}_1}(\dot{r}) \quad (4.1.3)$$

Za slučaj  $r \geq r_T$ , združena gustinu raspodele verovatnoće signala i izvoda signala na izlazu iz kombinera je:

$$p_{r\dot{r}}(r, \dot{r}) = P_1 p_{r_1}(r) p_{\dot{r}_1}(\dot{r}) + P_1 F_{r_1}(r_T) p_{r_2}(r) p_{\dot{r}_2}(\dot{r}) + P_2 p_{r_2}(r) p_{\dot{r}_2}(\dot{r}) + P_2 F_{r_2}(r_T) p_{r_1}(r) p_{\dot{r}_1}(\dot{r}) \quad (4.1.4)$$

## 4.2 Model sistema u dva trenutka vremena

U ovom poglavlju se razmatra SSC kombiner sa dve grane u dva trenutka vremena. Model sistema je prikazan na slici 4.2.1. Signali na ulazima su  $r_{11}$  i  $r_{21}$  u prvom trenutku vremena, a  $r_{12}$  i  $r_{22}$  u drugom trenutku vremena. Signali na izlazu su  $r_1$  i  $r_2$ . Izvodi signala na ulazima su  $\dot{r}_{11}$  i  $\dot{r}_{21}$  u prvom trenutku vremena, a  $\dot{r}_{12}$  i  $\dot{r}_{22}$  u drugom trenutku vremena. Izvodi signala na izlazu su  $\dot{r}_1$  i  $\dot{r}_2$ . Indeksi za ulazne signale i izvode su: prvi indeks je broj grane, a drugi razmatran vremenski trenutak. Za izlazni signal, indeks predstavlja razmatrani vremenski trenutak. Verovatnoća da kombiner prvo razmatra signal na prvoj grani je  $P_1$ , a na drugoj je  $P_2$ .



Slika 4.2.1. Model SSC kombinera sa dva ulaza u dva trenutka vremena sa izvodima signala

Za  $r_1 < r_T, r_2 < r_T$

U ovom slučaju svi signali su manji od praga  $r_T$ , odnosno:  $r_{11} < r_T, r_{12} < r_T, r_{21} < r_T, r_{22} < r_T$ . Neka kombiner prvo razmatra signal  $r_{11}$ . Pošto je  $r_{11} < r_T$ , onda je  $\dot{r}_1 = \dot{r}_{21}$ , a kako je  $r_{22} < r_T$ , onda je  $\dot{r}_2 = \dot{r}_{12}$ . Verovatnoća ovog događaja je  $P_1$ . Kada kombiner prvo razmatra signal  $r_{21}$ , onda važi da je  $r_{21} < r_T, \dot{r}_1 = \dot{r}_{11}$ , kao i  $r_{12} < r_T, \dot{r}_2 = \dot{r}_{22}$ . Verovatnoća ovog događaja je  $P_2$ .

vrednosti ulaznih signala	vrednosti izvoda ulaznih signala	vrednosti izvoda izlaznih signala	verovatnoća događaja
$r_{11} < r_T, r_{21} < r_T$	$r_{12} < r_T, r_{22} < r_T$	$\dot{r}_1 = \dot{r}_{21} \quad \dot{r}_2 = \dot{r}_{12}$	$P_1$
$r_{21} < r_T, r_{11} < r_T$	$r_{12} < r_T, r_{22} < r_T$	$\dot{r}_1 = \dot{r}_{11} \quad \dot{r}_2 = \dot{r}_{22}$	$P_2$

Za  $r_1 \geq r_T, r_2 < r_T$

vrednosti ulaznih signala	vrednosti izvoda ulaznih signala	vrednosti izvoda izlaznih signala	verovatnoća događaja
$r_{11} \geq r_T$	$r_{12} < r_T, r_{22} < r_T$	$\dot{r}_1 = \dot{r}_{11} \quad \dot{r}_2 = \dot{r}_{22}$	$P_1$
$r_{11} < r_T, r_{21} \geq r_T$	$r_{12} < r_T, r_{22} < r_T$	$\dot{r}_1 = \dot{r}_{21} \quad \dot{r}_2 = \dot{r}_{12}$	$P_1$
$r_{21} \geq r_T$	$r_{12} < r_T, r_{22} < r_T$	$\dot{r}_1 = \dot{r}_{21} \quad \dot{r}_2 = \dot{r}_{12}$	$P_2$
$r_{21} < r_T, r_{11} \geq r_T$	$r_{12} < r_T, r_{22} < r_T$	$\dot{r}_1 = \dot{r}_{11} \quad \dot{r}_2 = \dot{r}_{22}$	$P_2$

Za  $r_1 < r_T, r_2 \geq r_T$

vrednosti ulaznih signala	vrednosti izvoda ulaznih signala	vrednosti izvoda izlaznih signala	verovatnoća događaja
---------------------------	----------------------------------	-----------------------------------	----------------------

$r_{11} < r_T, r_{21} < r_T \quad r_{22} \geq r_T$	$\dot{r}_1 = \dot{r}_{21} \quad \dot{r}_2 = \dot{r}_{22}$	$P_1$
$r_{11} < r_T, r_{21} < r_T \quad r_{22} < r_T, r_{12} \geq r_T$	$\dot{r}_1 = \dot{r}_{21} \quad \dot{r}_2 = \dot{r}_{12}$	$P_1$
$r_{21} < r_T, r_{11} < r_T \quad r_{12} \geq r_T$	$\dot{r}_1 = \dot{r}_{11} \quad \dot{r}_2 = \dot{r}_{12}$	$P_2$
$r_{21} < r_T, r_{11} < r_T \quad r_{12} < r_T, r_{22} \geq r_T$	$\dot{r}_1 = \dot{r}_{11} \quad \dot{r}_2 = \dot{r}_{22}$	$P_2$

Za  $r_1 \geq r_T, r_2 \geq r_T$

vrednosti ulaznih signala	vrednosti izvoda izlaznih signala	verovatnoća događaja
$r_{11} \geq r_T, r_{12} \geq r_T$	$\dot{r}_1 = \dot{r}_{11} \quad \dot{r}_2 = \dot{r}_{12}$	$P_1$
$r_{11} \geq r_T \quad r_{12} < r_T, r_{22} \geq r_T$	$\dot{r}_1 = \dot{r}_{11} \quad \dot{r}_2 = \dot{r}_{22}$	$P_1$
$r_{11} < r_T, r_{21} \geq r_T \quad r_{22} \geq r_T$	$\dot{r}_1 = \dot{r}_{21} \quad \dot{r}_2 = \dot{r}_{22}$	$P_1$
$r_{11} < r_T, r_{21} \geq r_T \quad r_{22} < r_T, r_{12} < r_T$	$\dot{r}_1 = \dot{r}_{21} \quad \dot{r}_2 = \dot{r}_{12}$	$P_1$
$r_{21} \geq r_T \quad r_{22} \geq r_T$	$\dot{r}_1 = \dot{r}_{21} \quad \dot{r}_2 = \dot{r}_{22}$	$P_2$
$r_{21} \geq r_T \quad r_{22} < r_T, r_{12} \geq r_T$	$\dot{r}_1 = \dot{r}_{21} \quad \dot{r}_2 = \dot{r}_{12}$	$P_2$
$r_{21} < r_T, r_{11} \geq r_T \quad r_{12} \geq r_T$	$\dot{r}_1 = \dot{r}_{11} \quad \dot{r}_2 = \dot{r}_{12}$	$P_2$
$r_{21} < r_T, r_{11} \geq r_T \quad r_{12} < r_T, r_{22} \geq r_T$	$\dot{r}_1 = \dot{r}_{11} \quad \dot{r}_2 = \dot{r}_{22}$	$P_2$

Združena gustina raspodele verovatnoće signala i izvoda signala  $p_{r_1 r_2 \dot{r}_1 \dot{r}_2}(r_1, r_2, \dot{r}_1, \dot{r}_2)$  na izlazu iz SSC kombinera u 2 trenutka vremena se može na osnovu (3.2.1-4) predstaviti u obliku:

Za  $r_1 < r_T, r_2 < r_T$

$$\begin{aligned}
 p_{r_1 r_2 \dot{r}_1 \dot{r}_2}(r_1, r_2, \dot{r}_1, \dot{r}_2) = & P_1 \int_0^{r_T} dr_{11} \int_0^{r_T} dr_{22} p_{r_{11} r_{22} r_{21} r_{12} \dot{r}_{21} \dot{r}_{12}}(r_{11}, r_{22}, r_1, r_2, \dot{r}_1, \dot{r}_2) + \\
 & + P_2 \int_0^{r_T} dr_{21} \int_0^{r_T} dr_{12} p_{r_{21} r_{12} r_{11} r_{22} \dot{r}_{11} \dot{r}_{22}}(r_{21}, r_{12}, r_1, r_2, \dot{r}_1, \dot{r}_2)
 \end{aligned} \tag{4.2.1}$$

Za  $r_1 \geq r_T, r_2 < r_T$

$$\begin{aligned}
 p_{r_1 r_2 \dot{r}_1 \dot{r}_2}(r_1, r_2, \dot{r}_1, \dot{r}_2) = & P_1 \int_0^{r_T} dr_{12} p_{r_{12} r_{11} r_{22} \dot{r}_{11} \dot{r}_{22}}(r_{12}, r_1, r_2, \dot{r}_1, \dot{r}_2) + \\
 & + P_1 \int_0^{r_T} dr_{11} \int_0^{r_T} dr_{22} p_{r_{11} r_{22} r_{21} r_{12} \dot{r}_{21} \dot{r}_{12}}(r_{11}, r_{22}, r_1, r_2, \dot{r}_1, \dot{r}_2) + \\
 & + P_2 \int_0^{r_T} dr_{22} p_{r_{22} r_{21} r_{12} \dot{r}_{21} \dot{r}_{12}}(r_{22}, r_1, r_2, \dot{r}_1, \dot{r}_2) + P_2 \int_0^{r_T} dr_{21} \int_0^{r_T} dr_{12} p_{r_{21} r_{12} r_{11} r_{22} \dot{r}_{11} \dot{r}_{22}}(r_{21}, r_{12}, r_1, r_2, \dot{r}_1, \dot{r}_2)
 \end{aligned} \tag{4.2.2}$$

Za  $r_1 < r_T, r_2 \geq r_T$

$$\begin{aligned}
p_{r_1 r_2 \dot{r}_1 \dot{r}_2}(r_1, r_2, \dot{r}_1, \dot{r}_2) &= P_1 \int_0^{r_T} dr_{11} p_{r_{11} r_{21} r_{22} \dot{r}_{21} \dot{r}_{22}}(r_{11}, r_1, r_2, \dot{r}_1, \dot{r}_2) + \\
&+ P_1 \int_0^{r_T} dr_{11} \int_0^{r_T} dr_{22} p_{r_{11} r_{22} r_{21} r_{12} \dot{r}_{21} \dot{r}_{12}}(r_{11}, r_{22}, r_1, r_2, \dot{r}_1, \dot{r}_2) + \\
&+ P_2 \int_0^{r_T} dr_{21} p_{r_{21} r_{11} r_{12} \dot{r}_{11} \dot{r}_{12}}(r_{21}, r_1, r_2, \dot{r}_1, \dot{r}_2) + P_2 \int_0^{r_T} dr_{21} \int_0^{r_T} dr_{12} p_{r_{21} r_{12} r_{11} r_{22} \dot{r}_{11} \dot{r}_{22}}(r_{21}, r_{12}, r_1, r_2, \dot{r}_1, \dot{r}_2) \quad (4.2.3)
\end{aligned}$$

Za  $r_1 \geq r_T, r_2 \geq r_T$

$$\begin{aligned}
p_{r_1 r_2 \dot{r}_1 \dot{r}_2}(r_1, r_2, \dot{r}_1, \dot{r}_2) &= P_1 p_{r_{11} r_{12} \dot{r}_{11} \dot{r}_{12}}(r_1, r_2, \dot{r}_1, \dot{r}_2) + P_1 \int_0^{r_T} dr_{12} p_{r_{12} r_{11} r_{22} \dot{r}_{11} \dot{r}_{22}}(r_{12}, r_1, r_2, \dot{r}_1, \dot{r}_2) + \\
&+ P_1 \int_0^{r_T} dr_{11} p_{r_{11} r_{21} r_{22} \dot{r}_{21} \dot{r}_{22}}(r_{11}, r_1, r_2, \dot{r}_1, \dot{r}_2) + P_1 \int_0^{r_T} dr_{11} \int_0^{r_T} dr_{22} p_{r_{11} r_{22} r_{21} r_{12} \dot{r}_{21} \dot{r}_{12}}(r_{11}, r_{22}, r_1, r_2, \dot{r}_1, \dot{r}_2) + \\
&+ P_2 p_{r_{21} r_{22} \dot{r}_{21} \dot{r}_{22}}(r_1, r_2, \dot{r}_1, \dot{r}_2) + P_2 \int_0^{r_T} dr_{22} p_{r_{22} r_{21} r_{12} \dot{r}_{21} \dot{r}_{12}}(r_{22}, r_1, r_2, \dot{r}_1, \dot{r}_2) + \\
&+ P_2 \int_0^{r_T} dr_{21} p_{r_{21} r_{11} r_{12} \dot{r}_{11} \dot{r}_{12}}(r_{21}, r_1, r_2, \dot{r}_1, \dot{r}_2) + P_2 \int_0^{r_T} dr_{21} \int_0^{r_T} dr_{12} p_{r_{21} r_{12} r_{11} r_{22} \dot{r}_{11} \dot{r}_{22}}(r_{21}, r_{12}, r_1, r_2, \dot{r}_1, \dot{r}_2) \quad (4.2.4)
\end{aligned}$$

Za slučaj kada su signali u granama prijemnika u jednom vremenskom trenutku, kao i signali u jednoj grani u dva vremenska trenutka međusobno nekorelisani, marginalna združena gustina raspodele verovatnoće signala i njegovog izvoda  $p_{r_i \dot{r}_i}(r_i, \dot{r}_i)$  se može dobiti upotrebom združene gustine raspodele verovatnoće signala i izvoda  $p_{r_1 r_2 \dot{r}_1 \dot{r}_2}(r_1, r_2, \dot{r}_1, \dot{r}_2)$  [4], [61]:

$$p_{r_i \dot{r}_i}(r_i, \dot{r}_i) = \int_{-\infty}^{\infty} dr_j \int_0^{\infty} d\dot{r}_j p_{r_1 r_2 \dot{r}_1 \dot{r}_2}(r_i, r_j, \dot{r}_i, \dot{r}_j), \quad i, j=1, 2, \quad i \neq j \quad (4.2.5)$$

$$p_{r_i \dot{r}_i}(r_i, \dot{r}_i) = \int_0^{r_T} dr_j \int_{-\infty}^{\infty} d\dot{r}_j p_{r_1 r_2 \dot{r}_1 \dot{r}_2}(r_i, r_j, \dot{r}_i, \dot{r}_j) + \int_{r_T}^{\infty} dr_j \int_{-\infty}^{\infty} d\dot{r}_j p_{r_1 r_2 \dot{r}_1 \dot{r}_2}(r_i, r_j, \dot{r}_i, \dot{r}_j), \quad i, j=1, 2, \quad i \neq j \quad (4.2.6)$$

Na osnovu (4.2.6), i primenom izraza (3.2.5-3.2.8) za različite oblasti vrednosti signala na ulazima kombinera, dobijaju se združene gustine raspodele verovatnoće signala i izvoda  $p_{r_1 \dot{r}_1}(r_1, \dot{r}_1)$  i  $p_{r_2 \dot{r}_2}(r_2, \dot{r}_2)$ .

Za  $r_1 < r_T$ ,  $p_{r_1 \dot{r}_1}(r_1, \dot{r}_1)$  je:

$$\begin{aligned}
p_{\dot{r}_1 \dot{r}_1}(r_1, \dot{r}_1) &= P_1 p_{r_{21} \dot{r}_{21}}(r_1, \dot{r}_1) \int_0^{r_T} dr_{11} p_{r_{11}}(r_{11}) \int_0^{r_T} dr_{22} p_{r_{22}}(r_{22}) \int_0^{r_T} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_{r_{12} \dot{r}_{12}}(r_2, \dot{r}_2) + \\
&+ P_2 p_{r_{11} \dot{r}_{11}}(r_1, \dot{r}_1) \int_0^{r_T} dr_{21} p_{r_{21}}(r_{21}) \int_0^{r_T} dr_{12} p_{r_{12}}(r_{12}) \int_0^{r_T} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_{r_{22} \dot{r}_{22}}(r_2, \dot{r}_2) + \\
&+ P_1 p_{r_{21} \dot{r}_{21}}(r_1, \dot{r}_1) \int_0^{r_T} dr_{11} p_{r_{11}}(r_{11}) \int_{r_T}^{\infty} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_{r_{22} \dot{r}_{22}}(r_2, \dot{r}_2) + \\
&+ P_1 p_{r_{21} \dot{r}_{21}}(r_1, \dot{r}_1) \int_0^{r_T} dr_{11} p_{r_{11}}(r_{11}) \int_0^{r_T} dr_{22} p_{r_{22}}(r_{22}) \int_{r_T}^{\infty} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_{r_{12} \dot{r}_{12}}(r_2, \dot{r}_2) + \\
&+ P_2 p_{r_{11} \dot{r}_{11}}(r_1, \dot{r}_1) \int_0^{r_T} dr_{21} p_{r_{21}}(r_{21}) \int_{r_T}^{\infty} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_{r_{12} \dot{r}_{12}}(r_2, \dot{r}_2) + \\
&+ P_2 p_{r_{11} \dot{r}_{11}}(r_1, \dot{r}_1) \int_0^{r_T} dr_{21} p_{r_{21}}(r_{21}) \int_0^{r_T} dr_{12} p_{r_{12}}(r_{12}) \int_{r_T}^{\infty} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_{r_{22} \dot{r}_{22}}(r_2, \dot{r}_2) \tag{4.2.7}
\end{aligned}$$

Za  $r_1 \geq r_T$ ,  $p_{\dot{r}_1 \dot{r}_1}(r_1, \dot{r}_1)$  je:

$$\begin{aligned}
p_{\dot{r}_1 \dot{r}_1}(r_1, \dot{r}_1) &= P_1 p_{r_{11} \dot{r}_{11}}(r_1, \dot{r}_1) \int_0^{r_T} dr_{12} p_{r_{12}}(r_{12}) \int_0^{r_T} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_{r_{22} \dot{r}_{22}}(r_2, \dot{r}_2) + \\
&+ P_1 p_{r_{21} \dot{r}_{21}}(r_1, \dot{r}_1) \int_0^{r_T} dr_{11} p_{r_{11}}(r_{11}) \int_0^{r_T} dr_{22} p_{r_{22}}(r_{22}) \int_0^{r_T} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_{r_{12} \dot{r}_{12}}(r_2, \dot{r}_2) + \\
&+ P_2 p_{r_{21} \dot{r}_{21}}(r_1, \dot{r}_1) \int_0^{r_T} dr_{22} p_{r_{22}}(r_{22}) \int_0^{r_T} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_{r_{12} \dot{r}_{12}}(r_2, \dot{r}_2) + \\
&+ P_2 p_{r_{11} \dot{r}_{11}}(r_1, \dot{r}_1) \int_0^{r_T} dr_{21} p_{r_{21}}(r_{21}) \int_0^{r_T} dr_{12} p_{r_{12}}(r_{12}) \int_0^{r_T} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_{r_{22} \dot{r}_{22}}(r_2, \dot{r}_2) + \\
&+ P_1 p_{r_{11} \dot{r}_{11}}(r_1, \dot{r}_1) \int_{r_T}^{\infty} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_{r_{12} \dot{r}_{12}}(r_2, \dot{r}_2) + \\
&+ P_1 p_{r_{11} \dot{r}_{11}}(r_1, \dot{r}_1) \int_0^{r_T} dr_{12} p_{r_{12}}(r_{12}) \int_{r_T}^{\infty} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_{r_{22} \dot{r}_{22}}(r_2, \dot{r}_2) + \\
&+ P_1 p_{r_{21} \dot{r}_{21}}(r_1, \dot{r}_1) \int_0^{r_T} dr_{11} p_{r_{11}}(r_{11}) \int_{r_T}^{\infty} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_{r_{22} \dot{r}_{22}}(r_2, \dot{r}_2) + \\
&+ P_1 p_{r_{21} \dot{r}_{21}}(r_1, \dot{r}_1) \int_0^{r_T} dr_{11} p_{r_{11}}(r_{11}) \int_0^{r_T} dr_{22} p_{r_{22}}(r_{22}) \int_{r_T}^{\infty} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_{r_{12} \dot{r}_{12}}(r_2, \dot{r}_2) +
\end{aligned}$$



$$\begin{aligned}
& + P_2 p_{r_{21}\dot{r}_{21}}(r_1, \dot{r}_1) \int_{r_T}^{\infty} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_{r_{22}\dot{r}_{22}}(r_2, \dot{r}_2) + \\
& + P_2 p_{r_{21}\dot{r}_{21}}(r_1, \dot{r}_1) \int_0^{r_T} dr_{22} p_{r_{22}}(r_{22}) \int_{r_T}^{\infty} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_{r_{12}\dot{r}_{12}}(r_2, \dot{r}_2) + \\
& + P_2 p_{r_{11}\dot{r}_{11}}(r_1, \dot{r}_1) \int_0^{r_T} dr_{21} p_{r_{21}}(r_{21}) \int_{r_T}^{\infty} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_{r_{12}\dot{r}_{12}}(r_2, \dot{r}_2) + \\
& + P_2 p_{r_{11}\dot{r}_{11}}(r_1, \dot{r}_1) \int_0^{r_T} dr_{21} p_{r_{21}}(r_{21}) \int_0^{r_T} dr_{12} p_{r_{12}}(r_{12}) \int_{r_T}^{\infty} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_{r_{22}\dot{r}_{22}}(r_2, \dot{r}_2) \quad (4.2.8)
\end{aligned}$$

Za  $r_2 < r_T$ ,  $p_{r_2\dot{r}_2}(r_2, \dot{r}_2)$  je:

$$\begin{aligned}
p_{r_2\dot{r}_2}(r_2, \dot{r}_2) & = P_1 p_{r_{12}\dot{r}_{12}}(r_2, \dot{r}_2) \int_0^{r_T} dr_{11} p_{r_{11}}(r_{11}) \int_0^{r_T} dr_{22} p_{r_{22}}(r_{22}) \int_0^{r_T} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 p_{r_{21}\dot{r}_{21}}(r_1, \dot{r}_1) + \\
& + P_2 p_{r_{22}\dot{r}_{22}}(r_2, \dot{r}_2) \int_0^{r_T} dr_{21} p_{r_{21}}(r_{21}) \int_0^{r_T} dr_{12} p_{r_{12}}(r_{12}) \int_0^{r_T} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 p_{r_{11}\dot{r}_{11}}(r_1, \dot{r}_1) + \\
& + P_1 p_{r_{22}\dot{r}_{22}}(r_2, \dot{r}_2) \int_0^{r_T} dr_{12} p_{r_{12}}(r_{12}) \int_{r_T}^{\infty} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 p_{r_{11}\dot{r}_{11}}(r_1, \dot{r}_1) + \\
& + P_1 p_{r_{12}\dot{r}_{12}}(r_2, \dot{r}_2) \int_0^{r_T} dr_{11} p_{r_{11}}(r_{11}) \int_0^{r_T} dr_{22} p_{r_{22}}(r_{22}) \int_{r_T}^{\infty} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 p_{r_{21}\dot{r}_{21}}(r_1, \dot{r}_1) + \\
& + P_2 p_{r_{12}\dot{r}_{12}}(r_2, \dot{r}_2) \int_0^{r_T} dr_{22} p_{r_{22}}(r_{22}) \int_{r_T}^{\infty} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 p_{r_{21}\dot{r}_{21}}(r_1, \dot{r}_1) + \\
& + P_2 p_{r_{22}\dot{r}_{22}}(r_2, \dot{r}_2) \int_0^{r_T} dr_{21} p_{r_{21}}(r_{21}) \int_0^{r_T} dr_{12} p_{r_{12}}(r_{12}) \int_{r_T}^{\infty} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 p_{r_{11}\dot{r}_{11}}(r_1, \dot{r}_1) \quad (4.2.9)
\end{aligned}$$

Za  $r_2 \geq r_T$ ,  $p_{r_2\dot{r}_2}(r_2, \dot{r}_2)$  je:

$$\begin{aligned}
p_{r_2\dot{r}_2}(r_2, \dot{r}_2) & = P_1 p_{r_{22}\dot{r}_{22}}(r_2, \dot{r}_2) \int_0^{r_T} dr_{11} p_{r_{11}}(r_{11}) \int_0^{r_T} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 p_{r_{21}\dot{r}_{21}}(r_1, \dot{r}_1) + \\
& + P_1 p_{r_{12}\dot{r}_{12}}(r_2, \dot{r}_2) \int_0^{r_T} dr_{11} p_{r_{11}}(r_{11}) \int_0^{r_T} dr_{22} p_{r_{22}}(r_{22}) \int_0^{r_T} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 p_{r_{21}\dot{r}_{21}}(r_1, \dot{r}_1) + \\
& + P_2 p_{r_{12}\dot{r}_{12}}(r_2, \dot{r}_2) \int_0^{r_T} dr_{21} p_{r_{21}}(r_{21}) \int_0^{r_T} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 p_{r_{11}\dot{r}_{11}}(r_1, \dot{r}_1) + \\
& + P_2 p_{r_{22}\dot{r}_{22}}(r_2, \dot{r}_2) \int_0^{r_T} dr_{21} p_{r_{21}}(r_{21}) \int_0^{r_T} dr_{12} p_{r_{12}}(r_{12}) \int_0^{r_T} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 p_{r_{11}\dot{r}_{11}}(r_1, \dot{r}_1) +
\end{aligned}$$

$$\begin{aligned}
& + P_1 p_{r_{12}\dot{r}_{12}}(r_2, \dot{r}_2) \int_{r_T}^{\infty} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 p_{r_{11}\dot{r}_{11}}(r_1, \dot{r}_1) + \\
& + P_1 p_{r_{22}\dot{r}_{22}}(r_2, \dot{r}_2) \int_0^{r_T} dr_{12} p_{r_{12}}(r_{12}) \int_{r_T}^{\infty} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 p_{r_{11}\dot{r}_{11}}(r_1, \dot{r}_1) + \\
& + P_1 p_{r_{22}\dot{r}_{22}}(r_2, \dot{r}_2) \int_0^{r_T} dr_{11} p_{r_{11}}(r_{11}) \int_{r_T}^{\infty} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 p_{r_{21}\dot{r}_{21}}(r_1, \dot{r}_1) + \\
& + P_1 p_{r_{12}\dot{r}_{12}}(r_2, \dot{r}_2) \int_0^{r_T} dr_{11} p_{r_{11}}(r_{11}) \int_0^{r_T} dr_{22} p_{r_{22}}(r_{22}) \int_{r_T}^{\infty} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 p_{r_{21}\dot{r}_{21}}(r_1, \dot{r}_1) + \\
& + P_2 p_{r_{22}\dot{r}_{22}}(r_2, \dot{r}_2) \int_{r_T}^{\infty} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 p_{r_{21}\dot{r}_{21}}(r_1, \dot{r}_1) + \\
& + P_2 p_{r_{12}\dot{r}_{12}}(r_2, \dot{r}_2) \int_0^{r_T} dr_{22} p_{r_{22}}(r_{22}) \int_{r_T}^{\infty} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 p_{r_{21}\dot{r}_{21}}(r_1, \dot{r}_1) + \\
& + P_2 p_{r_{12}\dot{r}_{12}}(r_2, \dot{r}_2) \int_0^{r_T} dr_{21} p_{r_{21}}(r_{21}) \int_{r_T}^{\infty} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 p_{r_{11}\dot{r}_{11}}(r_1, \dot{r}_1) + \\
& + P_2 p_{r_{22}\dot{r}_{22}}(r_2, \dot{r}_2) \int_0^{r_T} dr_{21} p_{r_{21}}(r_{21}) \int_0^{r_T} dr_{12} p_{r_{12}}(r_{12}) \int_{r_T}^{\infty} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 p_{r_{11}\dot{r}_{11}}(r_1, \dot{r}_1) \tag{4.2.10}
\end{aligned}$$

Nakon određenih matematičkih transformacija, dobijaju se konačni izrazi za združene gustine raspodele verovatnoće signala i izvoda na izlazu iz SSC kombinera u 2 trenutka vremena.  $F_i(\cdot)$ ,  $p_i(\cdot, \cdot)$  i  $p_i(\cdot)$  označavaju statističke parametre signala i izvoda sa  $i$ -te ulazne grane kombinera, pri čemu važi da su raspodele u jednoj grani kombinera iste u oba trenutka vremena.

Za  $r_1 < r_T$ ,  $p_{r_1\dot{r}_1}(r_1, \dot{r}_1)$  je:

$$\begin{aligned}
p_{r_1\dot{r}_1}(r_1, \dot{r}_1) & = P_1 p_2(r_1, \dot{r}_1) F_1(r_T) F_2(r_T) + P_2 p_1(r_1, \dot{r}_1) F_1(r_T) F_2(r_T) + \\
& + P_1 p_2(r_1, \dot{r}_1) F_1(r_T) \int_{r_T}^{\infty} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_2(r_2, \dot{r}_2) + \\
& + P_2 p_1(r_1, \dot{r}_1) F_2(r_T) \int_{r_T}^{\infty} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_1(r_2, \dot{r}_2) \tag{4.2.11}
\end{aligned}$$

Za  $r_1 \geq r_T$ ,  $p_{r_1\dot{r}_1}(r_1, \dot{r}_1)$  je:

$$\begin{aligned}
p_{r_1\dot{r}_1}(r_1, \dot{r}_1) & = P_1 p_1(r_1, \dot{r}_1) F_1(r_T) + P_1 p_2(r_1, \dot{r}_1) F_1(r_T) F_2(r_T) + \\
& + P_2 p_2(r_1, \dot{r}_1) F_2(r_T) + P_2 p_1(r_1, \dot{r}_1) F_1(r_T) F_2(r_T) +
\end{aligned}$$

$$\begin{aligned}
& + P_1 p_1(r_1, \dot{r}_1) \int_{r_T}^{\infty} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_1(r_2, \dot{r}_2) + P_1 p_2(r_1, \dot{r}_1) F_1(r_T) \int_{r_T}^{\infty} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_2(r_2, \dot{r}_2) + \\
& + P_2 p_2(r_1, \dot{r}_1) \int_{r_T}^{\infty} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_2(r_2, \dot{r}_2) + P_2 p_1(r_1, \dot{r}_1) F_2(r_T) \int_{r_T}^{\infty} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_1(r_2, \dot{r}_2) \quad (4.2.12)
\end{aligned}$$

Za  $r_2 < r_T$ ,  $p_{r_2 \dot{r}_2}(r_2, \dot{r}_2)$  je:

$$\begin{aligned}
p_{r_2 \dot{r}_2}(r_2, \dot{r}_2) & = P_1 p_1(r_2, \dot{r}_2) F_1(r_T) F_2(r_T) + P_2 p_2(r_2, \dot{r}_2) F_1(r_T) F_2(r_T) + \\
& + P_1 p_2(r_2, \dot{r}_2) F_1(r_T) \int_{r_T}^{\infty} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 p_1(r_1, \dot{r}_1) + P_2 p_1(r_2, \dot{r}_2) F_2(r_T) \int_{r_T}^{\infty} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 p_2(r_1, \dot{r}_1) \quad (4.2.13)
\end{aligned}$$

Za  $r_2 \geq r_T$ ,  $p_{r_2 \dot{r}_2}(r_2, \dot{r}_2)$  je:

$$\begin{aligned}
p_{r_2 \dot{r}_2}(r_2, \dot{r}_2) & = P_1 p_1(r_2, \dot{r}_2) F_1(r_T) F_2(r_T) + P_1 p_2(r_2, \dot{r}_2) F_1(r_T) + \\
& + P_2 p_1(r_2, \dot{r}_2) F_2(r_T) + P_2 p_2(r_2, \dot{r}_2) F_1(r_T) F_2(r_T) + \\
& + P_1 p_1(r_2, \dot{r}_2) \int_{r_T}^{\infty} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 p_1(r_1, \dot{r}_1) + P_1 p_2(r_2, \dot{r}_2) F_1(r_T) \int_{r_T}^{\infty} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 p_1(r_1, \dot{r}_1) + \\
& + P_2 p_1(r_2, \dot{r}_2) F_2(r_T) \int_{r_T}^{\infty} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 p_2(r_1, \dot{r}_1) + P_2 p_2(r_2, \dot{r}_2) \int_{r_T}^{\infty} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 p_2(r_1, \dot{r}_1) \quad (4.2.14)
\end{aligned}$$

Za slučaj da su signal i njegov izvod međusobno nezavisni procesi, gustine raspodele verovatnoće izvoda se mogu dobiti integraljenjem po celom opsegu raspodele signala:

$$p_{\dot{r}_i}(\dot{r}_i) = \int_0^{\infty} d\dot{r}_i p_{r_i \dot{r}_i}(r_i, \dot{r}_i) = \int_0^{r_T} d\dot{r}_i p_{r_i \dot{r}_i}(r_i, \dot{r}_i) + \int_{r_T}^{\infty} d\dot{r}_i p_{r_i \dot{r}_i}(r_i, \dot{r}_i), \quad i=1,2 \quad (4.2.15)$$

Zamenom (4.2.11-14) u 4.2.15, dobijaju se izrazi za  $p_{\dot{r}_1}(\dot{r}_1)$  i  $p_{\dot{r}_2}(\dot{r}_2)$ :

$$\begin{aligned}
p_{\dot{r}_1}(\dot{r}_1) & = P_1(1 - F_1(r_T))p_1(\dot{r}_1) + P_2 F_2(r_T)p_1(\dot{r}_1) + \\
& + P_1 F_1(r_T)p_2(\dot{r}_1) + P_2(1 - F_2(r_T))p_2(\dot{r}_1) \quad (4.2.16)
\end{aligned}$$

$$\begin{aligned}
p_{\dot{r}_2}(\dot{r}_2) & = P_1 F_1(r_T) F_2(r_T) p_1(\dot{r}_2) + P_1(1 - F_1(r_T))(1 - F_1(r_T))p_1(\dot{r}_2) + \\
& + P_2 F_2(r_T)(1 - F_2(r_T))p_1(\dot{r}_2) + P_2(1 - F_1(r_T))F_2(r_T)p_1(\dot{r}_2) + \\
& + P_1 F_1(r_T)(1 - F_1(r_T))p_2(\dot{r}_2) + P_1 F_1(r_T)(1 - F_2(r_T))p_2(\dot{r}_2) + \\
& P_2 F_1(r_T) F_2(r_T) p_2(\dot{r}_2) + P_2(1 - F_2(r_T))(1 - F_2(r_T))p_2^2(\dot{r}_2) \quad (4.2.17)
\end{aligned}$$

### 4.3 Gustina raspodele verovatnoće izvoda signala na izlazu SSC kombinera u dva trenutka vremena u prisustvu Rayleigh-jevog fedinga

Gustine raspodele verovatnoće izvoda signala na ulazu u kombiner  $\dot{r}_{i,j}$  u prisustvu Rayleigh-jevog fedinga imaju normalnu raspodelu sa nultom srednjom vrednošću [16], [19]:

$$p_{\dot{r}_i}(\dot{r}_{i,j}) = \frac{1}{\sqrt{2\pi\dot{\sigma}_i}} e^{-\frac{\dot{r}_{i,j}^2}{2\dot{\sigma}_i^2}} \quad , -\infty < \dot{r}_{i,j} < \infty \quad (4.3.1)$$

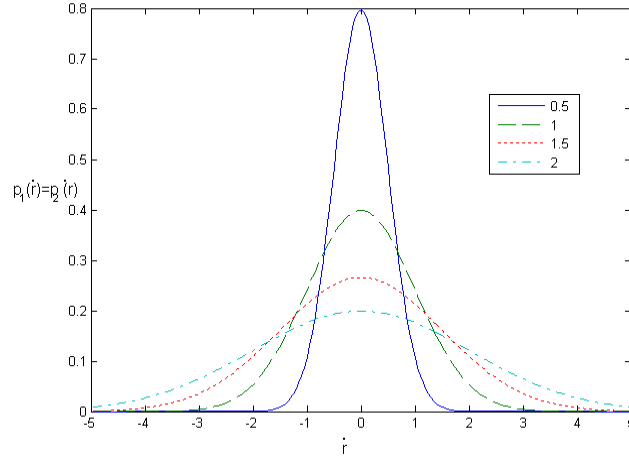
gde su  $i=1,2$   $j=1,2$  i  $\dot{\sigma}_i^2 = 2\sigma^2\pi^2 f_m^2$  je varijansa, dok je  $f_m$  maksimalni Doppler-ov frekventni pomeraj.

Gustine raspodele verovatnoće izvoda signala  $\dot{r}_1$  i  $\dot{r}_2$  na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Rayleigh-jevog fedinga se dobija kada se u prethodno dobijene opšte izraze CDF signala i PDF njegovog izvoda zamene u (3.3.2) i (4.3.1)

$$\begin{aligned} p_{\dot{r}_1}(\dot{r}_1) = & P_1 e^{-\frac{r_T}{2\sigma_1^2}} \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_1^2}{2\dot{\sigma}_1^2}} + P_2 \left(1 - e^{-\frac{r_T}{2\sigma_2^2}}\right) \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_1^2}{2\dot{\sigma}_1^2}} + \\ & + P_1 \left(1 - e^{-\frac{r_T}{2\sigma_1^2}}\right) \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{r}_1^2}{2\dot{\sigma}_2^2}} + P_2 e^{-\frac{r_T}{2\sigma_2^2}} \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{r}_1^2}{2\dot{\sigma}_2^2}} \end{aligned} \quad (4.3.2)$$

$$\begin{aligned} p_{\dot{r}_2}(\dot{r}_2) = & P_1 \left(1 - e^{-\frac{r_T}{2\sigma_1^2}}\right) \left(1 - e^{-\frac{r_T}{2\sigma_2^2}}\right) \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_1^2}} + P_1 e^{-\frac{r_T}{2\sigma_1^2}} e^{-\frac{r_T}{2\sigma_1^2}} \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_1^2}} + \\ & + P_2 \left(1 - e^{-\frac{r_T}{2\sigma_2^2}}\right) e^{-\frac{r_T}{2\sigma_2^2}} \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_1^2}} + P_2 e^{-\frac{r_T}{2\sigma_1^2}} \left(1 - e^{-\frac{r_T}{2\sigma_2^2}}\right) \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_1^2}} + \\ & + P_1 \left(1 - e^{-\frac{r_T}{2\sigma_1^2}}\right) e^{-\frac{r_T}{2\sigma_1^2}} \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_2^2}} + P_1 \left(1 - e^{-\frac{r_T}{2\sigma_1^2}}\right) e^{-\frac{r_T}{2\sigma_2^2}} \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_2^2}} + \\ & P_2 \left(1 - e^{-\frac{r_T}{2\sigma_1^2}}\right) \left(1 - e^{-\frac{r_T}{2\sigma_2^2}}\right) \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_2^2}} + P_2 e^{-\frac{r_T}{2\sigma_2^2}} e^{-\frac{r_T}{2\sigma_2^2}} \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_2^2}} \end{aligned} \quad (4.3.3)$$

Na slici 4.3.1. su prikazane gustine raspodele verovatnoće izvoda signala na izlazu SSC kombinera u dva trenutka vremena i može se videti da su za kanale sa identičnim raspodelama i ove krive identične i prate normalnu raspodelu.



Slika 4.3.1. Gustine raspodele verovatnoće izvoda signala za SSC kombiner u dva trenutka vremena za različite vrednosti  $\dot{\sigma}$  u prisustvu Rayleigh-jevog fedinga za parametre  $r_T = 1$ ,  $\sigma = 0.1$

#### 4.4 Gustina raspodele verovatnoće izvoda signala na izlazu SSC kombinera u dva trenutka vremena u prisustvu Nakagami-m fedinga

Gustine raspodele verovatnoće izvoda signala na ulazu u kombiner  $\dot{r}_{i,j}$  u prisustvu Nakagami-m fedinga imaju normalnu raspodelu sa nultom srednjom vrednošću [16], [19]:

$$p_{\dot{r}_i}(\dot{r}_{i,j}) = \frac{1}{\sqrt{2\pi\dot{\sigma}_i}} e^{-\frac{\dot{r}_{i,j}^2}{2\dot{\sigma}_i^2}} \quad , -\infty < \dot{r}_{i,j} < \infty \quad (4.4.1)$$

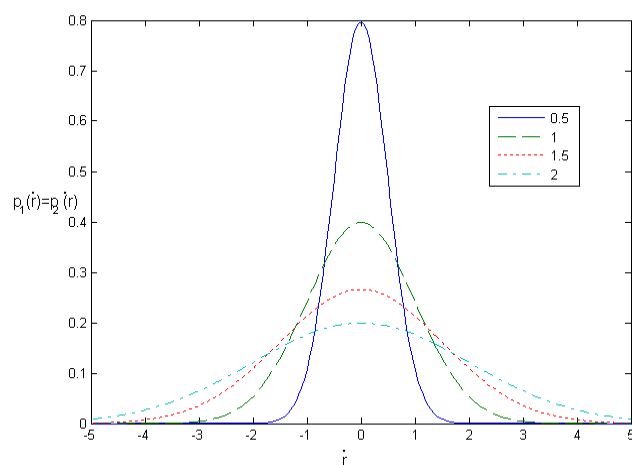
gde su  $i=1,2$   $j=1,2$  i  $\dot{\sigma}_i^2 = 2\sigma^2\pi^2 f_m^2$  je varijansa, dok je  $f_m$  maksimalni Doppler-ov frekventni pomeraj.

CDF signala u prisustvu Nakagami-m fedinga je dat u (3.4.2) i na osnovu njega i (4.2.16-17) dobijaju se gustine raspodele verovatnoće izvoda signala  $\dot{r}_1$  i  $\dot{r}_2$ :

$$\begin{aligned} p_{\dot{r}_1}(\dot{r}_1) &= P_1 \left( 1 - \gamma \left( \frac{m_1}{\Omega_1} r_T^2, m_1 \right) \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_1^2}{2\dot{\sigma}_1^2}} + P_2 \gamma \left( \frac{m_2}{\Omega_2} r_T^2, m_2 \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_1^2}{2\dot{\sigma}_1^2}} + \\ &+ P_1 \gamma \left( \frac{m_1}{\Omega_1} r_T^2, m_1 \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{r}_1^2}{2\dot{\sigma}_2^2}} + P_2 e^{-\frac{r_T}{2\sigma^2}} \left( 1 - \gamma \left( \frac{m_2}{\Omega_2} r_T^2, m_2 \right) \right) e^{-\frac{\dot{r}_1^2}{2\dot{\sigma}_2^2}} \quad (4.4.2) \\ p_{\dot{r}_2}(\dot{r}_2) &= P_1 \gamma \left( \frac{m_1}{\Omega_1} r_T^2, m_1 \right) \gamma \left( \frac{m_2}{\Omega_2} r_T^2, m_2 \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_1^2}} + \end{aligned}$$

$$\begin{aligned}
& P_1 \left( 1 - \gamma \left( \frac{m_1}{\Omega_1} r_T^2, m_1 \right) \right) \left( 1 - \gamma \left( \frac{m_1}{\Omega_1} r_T^2, m_1 \right) \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{i}_2^2}{2\dot{\sigma}_1^2}} + \\
& + P_2 \gamma \left( \frac{m_2}{\Omega_2} r_T^2, m_2 \right) \left( 1 - \gamma \left( \frac{m_2}{\Omega_2} r_T^2, m_2 \right) \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{i}_2^2}{2\dot{\sigma}_1^2}} + \\
& P_2 \left( 1 - \gamma \left( \frac{m_1}{\Omega_1} r_T^2, m_1 \right) \right) \gamma \left( \frac{m_2}{\Omega_2} r_T^2, m_2 \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{i}_2^2}{2\dot{\sigma}_1^2}} + \\
& + P_1 \gamma \left( \frac{m_1}{\Omega_1} r_T^2, m_1 \right) \left( 1 - \gamma \left( \frac{m_1}{\Omega_1} r_T^2, m_1 \right) \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{i}_2^2}{2\dot{\sigma}_2^2}} + \\
& P_1 \gamma \left( \frac{m_1}{\Omega_1} r_T^2, m_1 \right) \left( 1 - \gamma \left( \frac{m_2}{\Omega_2} r_T^2, m_2 \right) \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{i}_2^2}{2\dot{\sigma}_2^2}} + \\
& P_2 \gamma \left( \frac{m_1}{\Omega_1} r_T^2, m_1 \right) \gamma \left( \frac{m_2}{\Omega_2} r_T^2, m_2 \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{i}_2^2}{2\dot{\sigma}_2^2}} + \\
& P_2 \left( 1 - \gamma \left( \frac{m_2}{\Omega_2} r_T^2, m_2 \right) \right) \left( 1 - \gamma \left( \frac{m_2}{\Omega_2} r_T^2, m_2 \right) \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{i}_2^2}{2\dot{\sigma}_2^2}} \tag{4.4.3}
\end{aligned}$$

PDF izvoda signala na izlazu SSC kombinera u dva trenutka vremena su date na slici 4.4.1. za kanale sa identičnim fading kanalima.



Slika 4.3.1. Gustina raspodele verovatnoće izvoda signala za SSC kombiner u dva trenutka vremena za različite vrednosti  $\dot{\sigma}$  u prisustvu Nakagami- $m$  fadinga za parametre:  $r_T = 1$ ,  $\Omega = 1.5$ ,  $m = 1$

#### 4.5 Gustina raspodele verovatnoće izvoda signala na izlazu SSC kombinera u dva trenutka vremena u prisustvu Rice-ovog fedinga

Gustine raspodele verovatnoće izvoda signala na ulazu u kombiner  $\dot{r}_{i,j}$  u prisustvu Rice-ovog fedinga imaju normalnu raspodelu sa nultom srednjom vrednošću [318,319]:

$$p_{\dot{r}_i}(\dot{r}_{i,j}) = \frac{1}{\sqrt{2\pi\dot{\sigma}_i}} e^{-\frac{\dot{r}_{i,j}^2}{2\dot{\sigma}_i^2}} \quad , -\infty < \dot{r}_{i,j} < \infty \quad (4.5.1)$$

gde su  $i=1,2$   $j=1,2$  i  $\dot{\sigma}_i^2 = 2\sigma^2\pi^2 f_m^2$  je varijansa, dok je  $f_m$  maksimalni Doppler-ov frekventni pomeraj.

Gustine raspodele verovatnoće izvoda signala  $\dot{r}_1$  i  $\dot{r}_2$  na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Rice-ovog fedinga se dobijaju na isti način kao za Rayleigh-jev i Nakagami-m fading, gde je CDF signala dat u (3.5.2).

$$p_{\dot{r}_1}(\dot{r}_1) = P_1 Q_1\left(\frac{A_1}{\sigma_1}, \frac{r_T}{\sigma_1}\right) \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_1^2}{2\dot{\sigma}_1^2}} + P_2 \left(1 - Q_1\left(\frac{A_2}{\sigma_2}, \frac{r_T}{\sigma_2}\right)\right) \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_1^2}{2\dot{\sigma}_1^2}} +$$

$$+ P_1 \left(1 - Q_1\left(\frac{A_1}{\sigma_1}, \frac{r_T}{\sigma_1}\right)\right) \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{r}_1^2}{2\dot{\sigma}_2^2}} + P_2 Q_1\left(\frac{A_2}{\sigma_2}, \frac{r_T}{\sigma_2}\right) \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{r}_1^2}{2\dot{\sigma}_2^2}} \quad (4.5.2)$$

$$p_{\dot{r}_2}(\dot{r}_2) = P_1 \left(1 - Q_1\left(\frac{A_1}{\sigma_1}, \frac{r_T}{\sigma_1}\right)\right) \left(1 - Q_1\left(\frac{A_2}{\sigma_2}, \frac{r_T}{\sigma_2}\right)\right) \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_1^2}} +$$

$$P_1 Q_1\left(\frac{A_1}{\sigma_1}, \frac{r_T}{\sigma_1}\right) Q_1\left(\frac{A_1}{\sigma_1}, \frac{r_T}{\sigma_1}\right) \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_1^2}} +$$

$$+ P_2 \left(1 - Q_1\left(\frac{A_2}{\sigma_2}, \frac{r_T}{\sigma_2}\right)\right) Q_1\left(\frac{A_2}{\sigma_2}, \frac{r_T}{\sigma_2}\right) \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_1^2}} +$$

$$P_2 Q_1\left(\frac{A_1}{\sigma_1}, \frac{r_T}{\sigma_1}\right) \left(1 - Q_1\left(\frac{A_2}{\sigma_2}, \frac{r_T}{\sigma_2}\right)\right) \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_1^2}} +$$

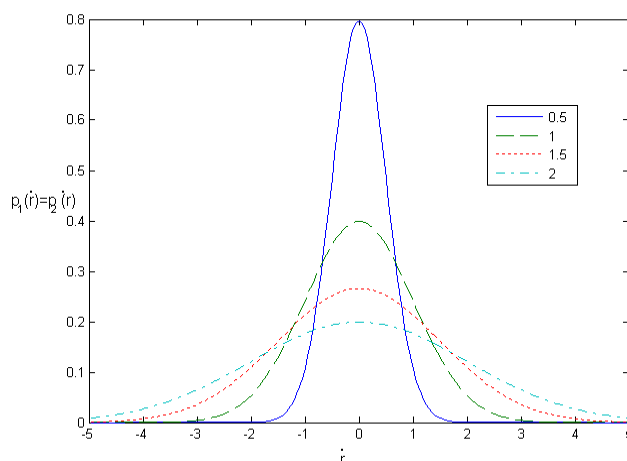
$$+ P_1 \left(1 - Q_1\left(\frac{A_1}{\sigma_1}, \frac{r_T}{\sigma_1}\right)\right) Q_1\left(\frac{A_1}{\sigma_1}, \frac{r_T}{\sigma_1}\right) \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_2^2}} +$$

$$P_1 \left(1 - Q_1\left(\frac{A_1}{\sigma_1}, \frac{r_T}{\sigma_1}\right)\right) Q_1\left(\frac{A_2}{\sigma_2}, \frac{r_T}{\sigma_2}\right) \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_2^2}} +$$

$$P_2 \left( 1 - Q_1 \left( \frac{A_1}{\sigma_1}, \frac{r_T}{\sigma_1} \right) \right) \left( 1 - Q_1 \left( \frac{A_2}{\sigma_2}, \frac{r_T}{\sigma_2} \right) \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_2^2}} +$$

$$P_2 Q_1 \left( \frac{A_2}{\sigma_2}, \frac{r_T}{\sigma_2} \right) Q_1 \left( \frac{A_2}{\sigma_2}, \frac{r_T}{\sigma_2} \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_2^2}} \quad (4.5.3)$$

Na slici 4.5.1. su prikazane gustine raspodele verovatnoće izvoda signala na izlazu SSC kombinera u prisustvu Rice-ovog fedinga



Slika 4.5.1. Gustine raspodele verovatnoće izvoda signala za SSC kombinera u dva trenutka vremena za različite vrednosti  $\dot{\sigma}$  u prisustvu Rice-ovog fedinga za parametre  $A = 1$ ,  $\sigma = 0.5$ ,  $r_T = 1$

### 4.6 Združena gustina raspodele verovatnoće signala i izvoda signala na izlazu SSC kombinera u dva trenutka vremena u prisustvu Weibull-ovog fedinga

Združene gustine raspodele verovatnoće signala  $r_{i,j}$  i izvoda signala na ulazu u kombinera  $\dot{r}_{i,j}$  su [17]:

$$p_{r_{i,j}, \dot{r}_{i,j}}(r_{i,j}, \dot{r}_{i,j}) = \frac{\beta_i^2 r_{i,j}^{(3\beta_i/2)-2}}{f_m (2\pi\Omega_i)^{3/2}} e^{-\frac{\beta_i^2 r_{i,j}^{\beta_i-2} \dot{r}_{i,j}^2}{8\pi^2 f_m^2 \Omega_i} - \frac{r_{i,j}^{\beta_i}}{\Omega_i}} \quad , -\infty < \dot{r}_{i,j} < \infty \quad (4.6.1)$$

gde su  $i=1,2$   $j=1,2$ ,  $\beta_i$  predstavlja Weibull-ov feding parametar i pozitivna je realna konstanta i  $\Omega_i = E(r_{i,j}^{\beta_i})$ .

Združene gustine raspodele verovatnoće signala i izvoda na izlazu iz SSC kombinera u dva trenutka vremena u prisustvu Weibull-ovog fedinga se dobijaju na osnovu (4.2.11-14). Za  $r_l < r_T$ ,  $p_{r_{i,j}, \dot{r}_{i,j}}(r_{i,j}, \dot{r}_{i,j})$  je:



$$\begin{aligned}
p_{r_1 \dot{r}_1}(r_1, \dot{r}_1) = & P_1 \frac{\beta_2^2 r_1^{(3\beta_2/2)-2}}{f_m(2\pi\Omega_2)^{3/2}} e^{-\frac{\beta_2^2 r_1^{\beta_2-2} \dot{r}_1^2}{8\pi^2 f_m^2 \Omega_2} - \frac{r_1^{\beta_2}}{\Omega_2}} F_1(r_T) F_2(r_T) + P_2 \frac{\beta_1^2 r_1^{(3\beta_1/2)-2}}{f_m(2\pi\Omega_1)^{3/2}} e^{-\frac{\beta_1^2 r_1^{\beta_1-2} \dot{r}_1^2}{8\pi^2 f_m^2 \Omega_1} - \frac{r_1^{\beta_1}}{\Omega_1}} F_1(r_T) F_2(r_T) + \\
& + P_1 \frac{\beta_2^2 r_1^{(3\beta_2/2)-2}}{f_m(2\pi\Omega_2)^{3/2}} e^{-\frac{\beta_2^2 r_1^{\beta_2-2} \dot{r}_1^2}{8\pi^2 f_m^2 \Omega_2} - \frac{r_1^{\beta_2}}{\Omega_2}} F_1(r_T) \int_{r_T}^{\infty} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 \frac{\beta_2^2 r_2^{(3\beta_2/2)-2}}{f_m(2\pi\Omega_2)^{3/2}} e^{-\frac{\beta_2^2 r_2^{\beta_2-2} \dot{r}_2^2}{8\pi^2 f_m^2 \Omega_2} - \frac{r_2^{\beta_2}}{\Omega_2}} + \\
& + P_2 \frac{\beta_1^2 r_1^{(3\beta_1/2)-2}}{f_m(2\pi\Omega_1)^{3/2}} e^{-\frac{\beta_1^2 r_1^{\beta_1-2} \dot{r}_1^2}{8\pi^2 f_m^2 \Omega_1} - \frac{r_1^{\beta_1}}{\Omega_1}} F_2(r_T) \int_{r_T}^{\infty} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_1(r_2, \dot{r}_2) \quad (4.6.2)
\end{aligned}$$

Za  $r_1 \geq r_T$ ,  $p_{r_1 \dot{r}_1}(r_1, \dot{r}_1)$  je:

$$\begin{aligned}
p_{r_1 \dot{r}_1}(r_1, \dot{r}_1) = & P_1 \frac{\beta_1^2 r_1^{(3\beta_1/2)-2}}{f_m(2\pi\Omega_1)^{3/2}} e^{-\frac{\beta_1^2 r_1^{\beta_1-2} \dot{r}_1^2}{8\pi^2 f_m^2 \Omega_1} - \frac{r_1^{\beta_1}}{\Omega_1}} F_1(r_T) + P_1 \frac{\beta_2^2 r_1^{(3\beta_2/2)-2}}{f_m(2\pi\Omega_2)^{3/2}} e^{-\frac{\beta_2^2 r_1^{\beta_2-2} \dot{r}_1^2}{8\pi^2 f_m^2 \Omega_2} - \frac{r_1^{\beta_2}}{\Omega_2}} F_1(r_T) F_2(r_T) + \\
& + P_2 \frac{\beta_2^2 r_1^{(3\beta_2/2)-2}}{f_m(2\pi\Omega_2)^{3/2}} e^{-\frac{\beta_2^2 r_1^{\beta_2-2} \dot{r}_1^2}{8\pi^2 f_m^2 \Omega_2} - \frac{r_1^{\beta_2}}{\Omega_2}} F_2(r_T) + P_2 \frac{\beta_1^2 r_1^{(3\beta_1/2)-2}}{f_m(2\pi\Omega_1)^{3/2}} e^{-\frac{\beta_1^2 r_1^{\beta_1-2} \dot{r}_1^2}{8\pi^2 f_m^2 \Omega_1} - \frac{r_1^{\beta_1}}{\Omega_1}} F_1(r_T) F_2(r_T) + \\
& + P_1 \frac{\beta_1^2 r_1^{(3\beta_1/2)-2}}{f_m(2\pi\Omega_1)^{3/2}} e^{-\frac{\beta_1^2 r_1^{\beta_1-2} \dot{r}_1^2}{8\pi^2 f_m^2 \Omega_1} - \frac{r_1^{\beta_1}}{\Omega_1}} \int_{r_T}^{\infty} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_1(r_2, \dot{r}_2) + \\
& + P_1 \frac{\beta_2^2 r_1^{(3\beta_2/2)-2}}{f_m(2\pi\Omega_2)^{3/2}} e^{-\frac{\beta_2^2 r_1^{\beta_2-2} \dot{r}_1^2}{8\pi^2 f_m^2 \Omega_2} - \frac{r_1^{\beta_2}}{\Omega_2}} F_1(r_T) \int_{r_T}^{\infty} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 \frac{\beta_2^2 r_2^{(3\beta_2/2)-2}}{f_m(2\pi\Omega_2)^{3/2}} e^{-\frac{\beta_2^2 r_2^{\beta_2-2} \dot{r}_2^2}{8\pi^2 f_m^2 \Omega_2} - \frac{r_2^{\beta_2}}{\Omega_2}} + \\
& + P_2 \frac{\beta_2^2 r_1^{(3\beta_2/2)-2}}{f_m(2\pi\Omega_2)^{3/2}} e^{-\frac{\beta_2^2 r_1^{\beta_2-2} \dot{r}_1^2}{8\pi^2 f_m^2 \Omega_2} - \frac{r_1^{\beta_2}}{\Omega_2}} \int_{r_T}^{\infty} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 \frac{\beta_2^2 r_2^{(3\beta_2/2)-2}}{f_m(2\pi\Omega_2)^{3/2}} e^{-\frac{\beta_2^2 r_2^{\beta_2-2} \dot{r}_2^2}{8\pi^2 f_m^2 \Omega_2} - \frac{r_2^{\beta_2}}{\Omega_2}} + \\
& + P_2 \frac{\beta_1^2 r_1^{(3\beta_1/2)-2}}{f_m(2\pi\Omega_1)^{3/2}} e^{-\frac{\beta_1^2 r_1^{\beta_1-2} \dot{r}_1^2}{8\pi^2 f_m^2 \Omega_1} - \frac{r_1^{\beta_1}}{\Omega_1}} F_2(r_T) \int_{r_T}^{\infty} dr_2 \int_{-\infty}^{\infty} d\dot{r}_2 p_1(r_2, \dot{r}_2) \quad (4.6.3)
\end{aligned}$$

Za  $r_2 < r_T$ ,  $p_{r_2 \dot{r}_2}(r_2, \dot{r}_2)$  je:

$$\begin{aligned}
p_{r_2 \dot{r}_2}(r_2, \dot{r}_2) = & P_1 \frac{\beta_1^2 r_2^{(3\beta_1/2)-2}}{f_m(2\pi\Omega_1)^{3/2}} e^{-\frac{\beta_1^2 r_2^{\beta_1-2} \dot{r}_2^2}{8\pi^2 f_m^2 \Omega_1} - \frac{r_2^{\beta_1}}{\Omega_1}} F_1(r_T) F_2(r_T) + \\
& + P_2 \frac{\beta_2^2 r_2^{(3\beta_2/2)-2}}{f_m(2\pi\Omega_2)^{3/2}} e^{-\frac{\beta_2^2 r_2^{\beta_2-2} \dot{r}_2^2}{8\pi^2 f_m^2 \Omega_2} - \frac{r_2^{\beta_2}}{\Omega_2}} F_1(r_T) F_2(r_T) + \\
& + P_1 \frac{\beta_2^2 r_2^{(3\beta_2/2)-2}}{f_m(2\pi\Omega_2)^{3/2}} e^{-\frac{\beta_2^2 r_2^{\beta_2-2} \dot{r}_2^2}{8\pi^2 f_m^2 \Omega_2} - \frac{r_2^{\beta_2}}{\Omega_2}} F_1(r_T) \int_{r_T}^{\infty} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 \frac{\beta_1^2 r_1^{(3\beta_1/2)-2}}{f_m(2\pi\Omega_1)^{3/2}} e^{-\frac{\beta_1^2 r_1^{\beta_1-2} \dot{r}_1^2}{8\pi^2 f_m^2 \Omega_1} - \frac{r_1^{\beta_1}}{\Omega_1}} + \\
& + P_2 \frac{\beta_1^2 r_2^{(3\beta_1/2)-2}}{f_m(2\pi\Omega_1)^{3/2}} e^{-\frac{\beta_1^2 r_2^{\beta_1-2} \dot{r}_2^2}{8\pi^2 f_m^2 \Omega_1} - \frac{r_2^{\beta_1}}{\Omega_1}} F_2(r_T) \int_{r_T}^{\infty} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 \frac{\beta_2^2 r_1^{(3\beta_2/2)-2}}{f_m(2\pi\Omega_2)^{3/2}} e^{-\frac{\beta_2^2 r_1^{\beta_2-2} \dot{r}_1^2}{8\pi^2 f_m^2 \Omega_2} - \frac{r_1^{\beta_2}}{\Omega_2}} \quad (4.6.4)
\end{aligned}$$

Za  $r_2 \geq r_T$ ,  $p_{r_2 \dot{r}_2}(r_2, \dot{r}_2)$  je:

$$\begin{aligned}
p_{r_2 \dot{r}_2}(r_2, \dot{r}_2) = & P_1 \frac{\beta_1^2 r_2^{(3\beta_1/2)-2}}{f_m(2\pi\Omega_1)^{3/2}} e^{-\frac{\beta_1^2 r_2^{\beta_1-2} \dot{r}_2^2}{8\pi^2 f_m^2 \Omega_1} - \frac{r_2^{\beta_1}}{\Omega_1}} F_1(r_T) F_2(r_T) + P_1 \frac{\beta_2^2 r_2^{(3\beta_2/2)-2}}{f_m(2\pi\Omega_2)^{3/2}} e^{-\frac{\beta_2^2 r_2^{\beta_2-2} \dot{r}_2^2}{8\pi^2 f_m^2 \Omega_2} - \frac{r_2^{\beta_2}}{\Omega_2}} F_1(r_T) + \\
& + P_2 \frac{\beta_1^2 r_2^{(3\beta_1/2)-2}}{f_m(2\pi\Omega_1)^{3/2}} e^{-\frac{\beta_1^2 r_2^{\beta_1-2} \dot{r}_2^2}{8\pi^2 f_m^2 \Omega_1} - \frac{r_2^{\beta_1}}{\Omega_1}} F_2(r_T) + P_2 \frac{\beta_2^2 r_2^{(3\beta_2/2)-2}}{f_m(2\pi\Omega_2)^{3/2}} e^{-\frac{\beta_2^2 r_2^{\beta_2-2} \dot{r}_2^2}{8\pi^2 f_m^2 \Omega_2} - \frac{r_2^{\beta_2}}{\Omega_2}} F_1(r_T) F_2(r_T) + \\
& + P_1 \frac{\beta_1^2 r_2^{(3\beta_1/2)-2}}{f_m(2\pi\Omega_1)^{3/2}} e^{-\frac{\beta_1^2 r_2^{\beta_1-2} \dot{r}_2^2}{8\pi^2 f_m^2 \Omega_1} - \frac{r_2^{\beta_1}}{\Omega_1}} \int_{r_T}^{\infty} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 \frac{\beta_1^2 r_1^{(3\beta_1/2)-2}}{f_m(2\pi\Omega_1)^{3/2}} e^{-\frac{\beta_1^2 r_1^{\beta_1-2} \dot{r}_1^2}{8\pi^2 f_m^2 \Omega_1} - \frac{r_1^{\beta_1}}{\Omega_1}} + \\
& P_1 \frac{\beta_2^2 r_2^{(3\beta_2/2)-2}}{f_m(2\pi\Omega_2)^{3/2}} e^{-\frac{\beta_2^2 r_2^{\beta_2-2} \dot{r}_2^2}{8\pi^2 f_m^2 \Omega_2} - \frac{r_2^{\beta_2}}{\Omega_2}} F_1(r_T) \int_{r_T}^{\infty} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 \frac{\beta_1^2 r_1^{(3\beta_1/2)-2}}{f_m(2\pi\Omega_1)^{3/2}} e^{-\frac{\beta_1^2 r_1^{\beta_1-2} \dot{r}_1^2}{8\pi^2 f_m^2 \Omega_1} - \frac{r_1^{\beta_1}}{\Omega_1}} + \\
& + P_2 \frac{\beta_1^2 r_2^{(3\beta_1/2)-2}}{f_m(2\pi\Omega_1)^{3/2}} e^{-\frac{\beta_1^2 r_2^{\beta_1-2} \dot{r}_2^2}{8\pi^2 f_m^2 \Omega_1} - \frac{r_2^{\beta_1}}{\Omega_1}} F_2(r_T) \int_{r_T}^{\infty} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 \frac{\beta_2^2 r_1^{(3\beta_2/2)-2}}{f_m(2\pi\Omega_2)^{3/2}} e^{-\frac{\beta_2^2 r_1^{\beta_2-2} \dot{r}_1^2}{8\pi^2 f_m^2 \Omega_2} - \frac{r_1^{\beta_2}}{\Omega_2}} + \\
& P_2 \frac{\beta_2^2 r_2^{(3\beta_2/2)-2}}{f_m(2\pi\Omega_2)^{3/2}} e^{-\frac{\beta_2^2 r_2^{\beta_2-2} \dot{r}_2^2}{8\pi^2 f_m^2 \Omega_2} - \frac{r_2^{\beta_2}}{\Omega_2}} \int_{r_T}^{\infty} dr_1 \int_{-\infty}^{\infty} d\dot{r}_1 \frac{\beta_2^2 r_1^{(3\beta_2/2)-2}}{f_m(2\pi\Omega_2)^{3/2}} e^{-\frac{\beta_2^2 r_1^{\beta_2-2} \dot{r}_1^2}{8\pi^2 f_m^2 \Omega_2} - \frac{r_1^{\beta_2}}{\Omega_2}} \quad (4.6.5)
\end{aligned}$$

#### 4.7 Gustina raspodele verovatnoće izvoda signala na izlazu SSC kombinera u dva trenutka vremena u prisustvu log-normalnog fedinga

Gustine raspodele verovatnoće izvoda signala na ulazu u kombiner  $\dot{r}_{i,j}$  u prisustvu log-normalnog fedinga imaju normalnu raspodelu sa nultom srednjom vrednošću [60], [62]:

$$p_{\dot{r}_i}(\dot{r}_{i,j}) = \frac{1}{\sqrt{2\pi\dot{\sigma}_i}} e^{-\frac{\dot{r}_{i,j}^2}{2\dot{\sigma}_i^2}} \quad , -\infty < \dot{r}_{i,j} < \infty \quad (4.7.1)$$

gde su  $i=1,2$   $j=1,2$  i  $\dot{\sigma}_i^2 = 2\sigma^2 \pi^2 f_m^2$  je varijansa, dok je  $f_m$  maksimalni Doppler-ov frekventni pomeraj.

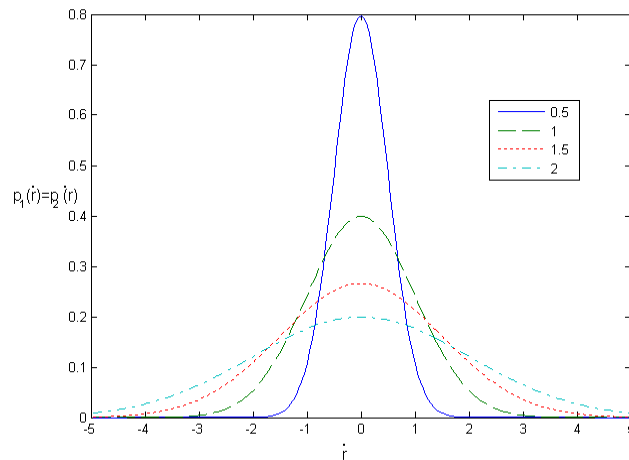
CDF signala u prisustvu log-normalnog fedinga je dat u (3.7.2) i na osnovu njega i (4.2.16-17) dobijaju se gustine raspodele verovatnoće izvoda signala  $\dot{r}_1$  i  $\dot{r}_2$ :

$$p_{\dot{r}_1}(\dot{r}_1) = P_1 Q\left(\frac{\ln r_T - \mu_1}{\sigma_1}\right) \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_1^2}{2\dot{\sigma}_1^2}} + P_2 \left(1 - Q\left(\frac{\ln r_T - \mu_2}{\sigma_2}\right)\right) \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_1^2}{2\dot{\sigma}_1^2}} +$$

$$+ P_1 \left( 1 - Q \left( \frac{\ln r_T - \mu_1}{\sigma_1} \right) \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{r}_1^2}{2\dot{\sigma}_2^2}} + P_2 Q \left( \frac{\ln r_T - \mu_2}{\sigma_2} \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{r}_1^2}{2\dot{\sigma}_2^2}} \quad (4.7.2)$$

$$\begin{aligned} p_{\dot{r}_2}(\dot{r}_2) = & P_1 \left( 1 - Q \left( \frac{\ln r_T - \mu_1}{\sigma_1} \right) \right) \left( 1 - Q \left( \frac{\ln r_T - \mu_2}{\sigma_2} \right) \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_1^2}} + \\ & P_1 Q \left( \frac{\ln r_T - \mu_1}{\sigma_1} \right) Q \left( \frac{\ln r_T - \mu_1}{\sigma_1} \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_1^2}} + \\ & + P_2 \left( 1 - Q \left( \frac{\ln r_T - \mu_2}{\sigma_2} \right) \right) Q \left( \frac{\ln r_T - \mu_2}{\sigma_2} \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_1^2}} + \\ & P_2 Q \left( \frac{\ln r_T - \mu_1}{\sigma_1} \right) \left( 1 - Q \left( \frac{\ln r_T - \mu_2}{\sigma_2} \right) \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_1^2}} + \\ & + P_1 \left( 1 - Q \left( \frac{\ln r_T - \mu_1}{\sigma_1} \right) \right) Q \left( \frac{\ln r_T - \mu_1}{\sigma_1} \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_2^2}} + \\ & P_1 \left( 1 - Q \left( \frac{\ln r_T - \mu_1}{\sigma_1} \right) \right) Q \left( \frac{\ln r_T - \mu_2}{\sigma_2} \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_2^2}} + \\ & P_2 \left( 1 - Q \left( \frac{\ln r_T - \mu_1}{\sigma_1} \right) \right) \left( 1 - Q \left( \frac{\ln r_T - \mu_2}{\sigma_2} \right) \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_2^2}} + \\ & P_2 Q \left( \frac{\ln r_T - \mu_2}{\sigma_2} \right) Q \left( \frac{\ln r_T - \mu_2}{\sigma_2} \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_2^2}} \end{aligned} \quad (4.7.3)$$

Na slici 4.7.1. su prikazane PDF izvoda signala na izlazu SSC kombinera u dva trenutka vremena. Sa kojih se vid da su za kanale sa identičnim raspodelama i ove krive identične.



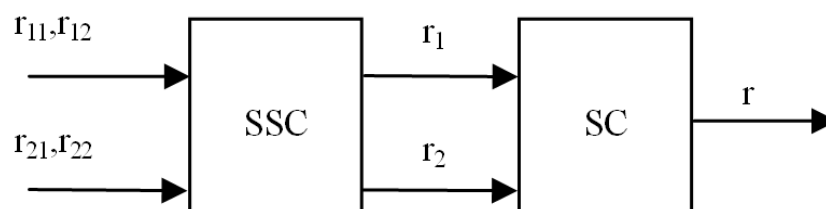
Slika 4.7.1. Gustine raspodele verovatnoće izvoda signala za SSC kombinera u dva trenutka vremena za različite vrednosti  $\dot{\sigma}$  u prisustvu log-normalnog fedinga za parametre  $r_T = 1$ ,  $\sigma = 1$ ,  $\mu = 0.5$

## 5 Karakteristike SSC/SC kombinera

U petoj glavi će biti dobijeni parametri složenog SSC/SC prijemnika u dva trenutka vremena, kada signali na izlazu iz SSC kombinera razmatranog u trećoj glavi predstavljaju ulaze u SC kombiner, tako da je izlazni signal iz složenog kombinera jednak najboljoj vrednosti signala na izlazu iz SSC kombinera.

### 5.1 Model sistema u dva trenutka vremena

U ovom poglavlju se razmatra SSC/SC kombiner sa dve grane u dva trenutka vremena. Model sistema je prikazan na slici 5.1.1. Signali na ulazima su  $r_{11}$  i  $r_{21}$  u prvom trenutku vremena, a  $r_{12}$  i  $r_{22}$  u drugom trenutku vremena. Indeksi za ulazne signale su: prvi indeks je broj grane, a drugi razmatran vremenski trenutak. Verovatnoća da kombiner prvo razmatra signal na prvoj grani je  $P_1$ , a na drugoj je  $P_2$ . Signali na izlazu iz SSC kombinera su  $r_1$  i  $r_2$ , gde indeks predstavlja razmatrani vremenski trenutak. Signal na izlazu iz složenog kombinera je  $r$ .



Slika 5.1.1. Model SSC/SC kombinera sa dva ulaza u dva trenutka vremena

Gustina raspodele verovatnoće signala na izlazu iz SSC/SC kombinera se dobija na oslovu združenih gustina raspodela verovatnoća signala na izlazima iz SSC kombinera u dva trenutka vremena, zavisno od oblasti u kojoj se signali nalaze:

Za slučaj  $r < r_T$  ( $r_1 < r_T, r_2 < r_T$ )

$$p_r(r) = \int_0^r p_{r_1, r_2}(r, r_2) dr_2 + \int_0^r p_{r_1, r_2}(r_1, r) dr_1 \quad (5.1.1)$$

Za slučaj  $r \geq r_T$  ( $r_1 < r_T, r_2 \geq r_T$ )

$$p_{r_1}(r) = \int_0^{r_T} p_{r_1, r_2}(r, r_2) dr_2 + \int_{r_T}^r p_{r_1, r_2}(r_1, r) dr_1 \quad (5.1.2)$$

Za slučaj  $r \geq r_T$  ( $r_1 \geq r_T, r_2 < r_T$ )

$$p_{r_2}(r) = \int_{r_T}^r p_{r_1, r_2}(r, r_2) dr_2 + \int_0^{r_T} p_{r_1, r_2}(r_1, r) dr_1 \quad (5.1.3)$$

Za slučaj  $r \geq r_T$  ( $r_1 < r_T, r_2 \geq r_T$ )

$$p_{r_3}(r) = \int_{r_T}^r p_{r_1, r_2}(r, r_2) dr_2 + \int_{r_T}^r p_{r_1, r_2}(r_1, r) dr_1 \quad (5.1.4)$$

Ukupna gustina raspodele verovatnoće signala na izlazu, za  $r \geq r_T$  je:

$$p_r(r) = p_{r_1}(r) + p_{r_2}(r) + p_{r_3}(r) \quad (5.1.5)$$

Verovatnoća otkaza  $P_{out}(r) = P(r_1 \leq r, r_2 \leq r)$  se dobija na osnovu PDF signala i može se predstaviti na sledeći način:

Za slučaj  $r < r_T$  ( $r_1 < r_T, r_2 < r_T$ )

$$P_{out}(r) = \int_0^r p_r(r) dr \quad (5.1.6)$$

Za slučaj  $r \geq r_T$  ( $r_1 \geq r_T, r_2 < r_T, r_1 \geq r_T, r_2 \geq r_T, r_1 \geq r_T, r_2 \geq r_T$ )

$$P_{out}(r) = \int_0^{r_i} p_r(r) dr + \int_{r_i}^r p_r(r) dr \quad (5.1.7)$$

## 5.2 Karakteristike SSC/SC kombinera u dva trenutka vremena u prisustvu Rayleigh-jevog fedinga

Gustina raspodele verovatnoće signala na izlazu iz SSC/SC kombinera u prisustvu Rayleigh-jevog fedinga se dobija na osnovu združenih gustina raspodela verovatnoća signala na izlazima iz SSC kombinera u dva trenutka vremena (3.3.16-19) i izraza (5.1.1-6).

Za slučaj  $r < r_T$  ( $r_1 < r_T, r_2 < r_T$ )

$$p_r(r) = 2 \frac{r}{\sigma^2} e^{-\frac{r^2}{2\sigma^2}} \left[ 1 - Q_1 \left( \frac{\rho r}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) \right] \cdot \left[ 1 - e^{-\frac{r^2}{2\sigma^2}} - e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r}{\sigma \sqrt{1-\rho^2}}, \frac{\rho r_i}{\sigma \sqrt{1-\rho^2}} \right) + e^{-\frac{r^2}{2\sigma^2}} Q_1 \left( \frac{r \rho}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) \right] \quad (5.2.1)$$

Za slučaj  $r \geq r_T$  ( $r_1 \geq r_T, r_2 < r_T, r_1 \geq r_T, r_2 \geq r_T, r_1 \geq r_T, r_2 \geq r_T$ )

$$p_r(r) = \frac{r}{\sigma^2} e^{-\frac{r^2}{2\sigma^2}} \left[ 1 - Q_1 \left( \frac{\rho r}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) \right] \cdot \left[ 4 - 2e^{-\frac{r^2}{2\sigma^2}} - 2e^{-\frac{r_i^2}{2\sigma^2}} - e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r_i}{\sigma \sqrt{1-\rho^2}}, \frac{\rho r_i}{\sigma \sqrt{1-\rho^2}} \right) + e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r_i \rho}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) - e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r}{\sigma \sqrt{1-\rho^2}}, \frac{\rho r_i}{\sigma \sqrt{1-\rho^2}} \right) + e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r \rho}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) \right] + \frac{r}{\sigma^2} e^{-\frac{r^2}{2\sigma^2}} \left[ 2 - Q_1 \left( \frac{\rho r}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) \right] \cdot \left[ e^{-\frac{r_i^2}{2\sigma^2}} - e^{-\frac{r}{2\sigma^2}} - e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r}{\sigma \sqrt{1-\rho^2}}, \frac{\rho r_i}{\sigma \sqrt{1-\rho^2}} \right) + e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r \rho}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) + e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r_i}{\sigma \sqrt{1-\rho^2}}, \frac{\rho r_i}{\sigma \sqrt{1-\rho^2}} \right) - e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r_i \rho}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) \right] \quad (5.2.2)$$

Izrazi za gustinu raspodele verovatnoće su dobijeni u zatvorenom obliku i povoljni su za proračun ostalih karakteristika sistema.

Verovatnoća otkaza se dobija na osnovu (5.1.6-7) i nakon određenih matematičkih transformacija je takođe dobijena u zatvorenom obliku:

Za slučaj  $r < r_T$  ( $r_1 < r_T, r_2 < r_T$ )

$$P_{out}(r) = \left[ 1 - e^{-\frac{r^2}{2\sigma^2}} - e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r}{\sigma} \sqrt{\frac{1}{1-\rho^2}}, \frac{\rho r_i}{\sigma \sqrt{1-\rho^2}} \right) + e^{-\frac{r^2}{2\sigma^2}} Q_1 \left( \frac{r\rho}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) \right]^2 \quad (5.2.3)$$

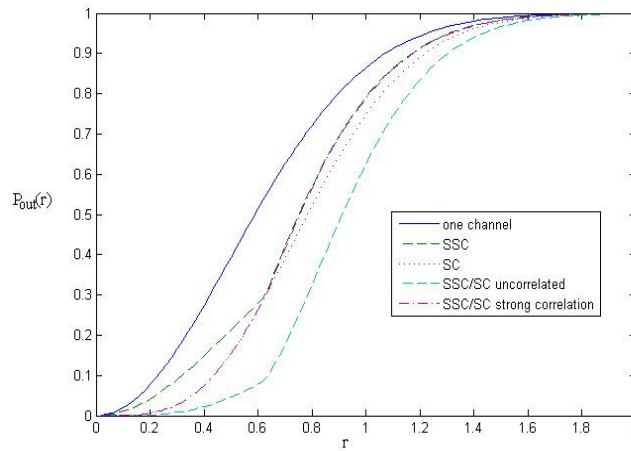
Za slučaj  $r \geq r_T$  ( $r_1 \geq r_T, r_2 < r_T, r_1 \geq r_T, r_2 \geq r_T, r_1 \geq r_T, r_2 \geq r_T$ )

$$\begin{aligned} P_{out}(r) = & \left[ 1 - e^{-\frac{r^2}{2\sigma^2}} - e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r}{\sigma} \sqrt{\frac{1}{1-\rho^2}}, \frac{\rho r_i}{\sigma \sqrt{1-\rho^2}} \right) + e^{-\frac{r^2}{2\sigma^2}} Q_1 \left( \frac{r_i\rho}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) \right]^2 + \\ & + \left\{ \left[ 1 - e^{-\frac{r^2}{2\sigma^2}} - e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r}{\sigma} \sqrt{\frac{1}{1-\rho^2}}, \frac{\rho r_i}{\sigma \sqrt{1-\rho^2}} \right) - e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r\rho}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) \right] - \right. \\ & \left. - \left[ 1 - e^{-\frac{r_i^2}{2\sigma^2}} - e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r_i}{\sigma} \sqrt{\frac{1}{1-\rho^2}}, \frac{\rho r_i}{\sigma \sqrt{1-\rho^2}} \right) + e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r_i\rho}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) \right] \right\} \cdot \\ & \cdot \left[ 2 - 2e^{-\frac{r^2}{2\sigma^2}} - e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r}{\sigma} \sqrt{\frac{1}{1-\rho^2}}, \frac{\rho r_i}{\sigma \sqrt{1-\rho^2}} \right) + e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r_i\rho}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) \right] + \\ & + \left( 1 - e^{-\frac{r^2}{2\sigma^2}} \right) \left\{ \left[ e^{-\frac{r^2}{2\sigma^2}} Q_1 \left( \frac{r}{\sigma} \sqrt{\frac{1}{1-\rho^2}}, \frac{\rho r_i}{\sigma \sqrt{1-\rho^2}} \right) - e^{-\frac{r^2}{2\sigma^2}} Q_1 \left( \frac{r\rho}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) \right] - \right. \\ & \left. - \left[ e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r_i}{\sigma} \sqrt{\frac{1}{1-\rho^2}}, \frac{\rho r_i}{\sigma \sqrt{1-\rho^2}} \right) - e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r_i\rho}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) \right] \right\} + \\ & + \left\{ \left[ 1 - e^{-\frac{r^2}{2\sigma^2}} - e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r}{\sigma} \sqrt{\frac{1}{1-\rho^2}}, \frac{\rho r_i}{\sigma \sqrt{1-\rho^2}} \right) + e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r\rho}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) \right] - \right. \\ & \left. - \left[ 1 - e^{-\frac{r_i^2}{2\sigma^2}} - e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r_i}{\sigma} \sqrt{\frac{1}{1-\rho^2}}, \frac{\rho r_i}{\sigma \sqrt{1-\rho^2}} \right) + e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r_i\rho}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) \right] \right\} \cdot \\ & \cdot \left[ 1 - e^{-\frac{r^2}{2\sigma^2}} - e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r_i}{\sigma} \sqrt{\frac{1}{1-\rho^2}}, \frac{\rho r_i}{\sigma \sqrt{1-\rho^2}} \right) + e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r_i\rho}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) \right] + \\ & + \left( 2 - e^{-\frac{r^2}{2\sigma^2}} \right) \left\{ \left[ e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r}{\sigma} \sqrt{\frac{1}{1-\rho^2}}, \frac{\rho r_i}{\sigma \sqrt{1-\rho^2}} \right) - e^{-\frac{r^2}{2\sigma^2}} Q_1 \left( \frac{r\rho}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) \right] - \right. \\ & \left. - \left[ e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r_i}{\sigma} \sqrt{\frac{1}{1-\rho^2}}, \frac{\rho r_i}{\sigma \sqrt{1-\rho^2}} \right) - e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r_i\rho}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) \right] \right\} - \\ & - \left[ e^{-\frac{r^2}{2\sigma^2}} Q_1 \left( \frac{r}{\sigma} \sqrt{\frac{1}{1-\rho^2}}, \frac{\rho r_i}{\sigma \sqrt{1-\rho^2}} \right) - e^{-\frac{r^2}{2\sigma^2}} Q_1 \left( \frac{r\rho}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) \right] + \\ & - \left[ e^{-\frac{r^2}{2\sigma^2}} Q_1 \left( \frac{r}{\sigma} \sqrt{\frac{1}{1-\rho^2}}, \frac{\rho r_i}{\sigma \sqrt{1-\rho^2}} \right) - e^{-\frac{r^2}{2\sigma^2}} Q_1 \left( \frac{r\rho}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) \right] + \end{aligned}$$

$$\begin{aligned}
 & + \left[ e^{-\frac{r^2}{2\sigma^2}} Q_1 \left( \frac{r_i}{\sigma} \sqrt{\frac{1}{1-\rho^2}}, \frac{\rho r}{\sigma \sqrt{1-\rho^2}} \right) - e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r_i \rho}{\sigma \sqrt{1-\rho^2}}, \frac{r}{\sigma \sqrt{1-\rho^2}} \right) \right] + \\
 & + \left\{ \left[ 1 - e^{-\frac{r}{2\sigma^2}} - e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r}{\sigma} \sqrt{\frac{1}{1-\rho^2}}, \frac{\rho r_i}{\sigma \sqrt{1-\rho^2}} \right) + e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r \rho}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) \right] - \right. \\
 & - \left. \left[ 1 - e^{-\frac{r_i^2}{2\sigma^2}} - e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r_i}{\sigma} \sqrt{\frac{1}{1-\rho^2}}, \frac{\rho r_i}{\sigma \sqrt{1-\rho^2}} \right) + e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r_i \rho}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) \right] \right\} \cdot \\
 & \cdot \left\{ \left[ 2 - 2e^{-\frac{r}{2\sigma^2}} - e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r}{\sigma} \sqrt{\frac{1}{1-\rho^2}}, \frac{\rho r_i}{\sigma \sqrt{1-\rho^2}} \right) + e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r \rho}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) \right] - \right. \\
 & - \left. \left[ 2 - 2e^{-\frac{r_i^2}{2\sigma^2}} - e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r_i}{\sigma} \sqrt{\frac{1}{1-\rho^2}}, \frac{\rho r_i}{\sigma \sqrt{1-\rho^2}} \right) + e^{-\frac{r_i^2}{2\sigma^2}} Q_1 \left( \frac{r_i \rho}{\sigma \sqrt{1-\rho^2}}, \frac{r_i}{\sigma \sqrt{1-\rho^2}} \right) \right] \right\} \quad (5.2.4)
 \end{aligned}$$

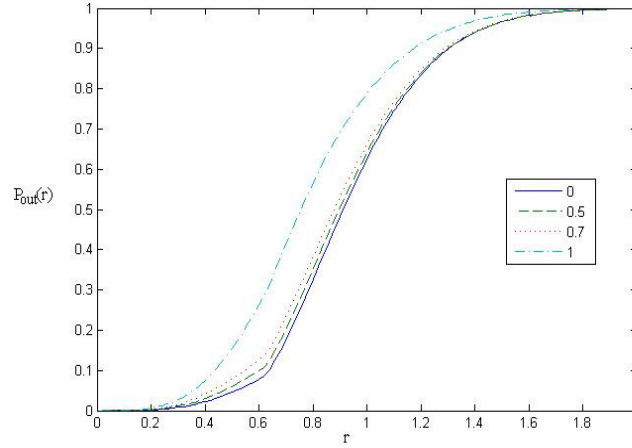
Na slici 5.2.1. su prikazane familije kriva za verovatnoće otkaza za različite tipove kombinera u prisustvu Rayleigh-jevog fedinga za jednokanalni prijemnik, SSC i SC prijemnike u jednom trenutku vremena i SSC/SC prijemnik u 2 trenutka vremena u slučajevima bez korelacije i sa veoma jakom korelacijom na ulazima u kombiner. Može se zaključiti da SSC/SC kombiner ima značajno bolje performanse za slučaj bez korelacije, a za slučaj sa jakom korelacijom,  $\rho=1$ , SSC/SC kombiner za  $r < r_T$  prati rezultate za SC kombiner u jednom trenutku vremena, a u ostalom delu za SSC kombiner u jednom trenutku vremena.

Kada se analiziraju verovatnoće otkaza za SSC/SC kombinere u 2 trenutka vremena koje su prikazane na slici 5.2.2. jasno se uočava da se benefiti upotrebe ove vrste kombinera povećavaju sa smanjenjem korelacije između ulaznih signala.



Slika 5.2.1. Verovatnoće otkaza za različite tipove kombinera u prisustvu Rayleigh-jevog fedinga za parametre:  $\sigma = 0.5$ ,  $\rho = 0;1$





Slika 5.2.2. Verovatnoće otkaza za SSC/SC kombinera u dva trenutka vremena za različite vrednosti korelacije u prisustvu Rayleigh-jevog fedinga za parametar  $\sigma = 0.5$

### 5.3 Karakteristike SSC/SC kombinera u dva trenutka vremena u prisustvu log-normalnog fedinga

Gustina raspodele verovatnoće signala na izlazu iz SSC/SC kombinera u prisustvu log-normalnog fedinga se dobija na oslovu združenih gustina raspodela verovatnoća signala na izlazima iz SSC kombinera u dva trenutka vremena (3.7.17-20) i izraza (5.1.1-6).

Za slučaj  $r < r_T$  ( $r_1 < r_T, r_2 < r_T$ )

$$p_r(r) = 2 \frac{1}{\sqrt{2\pi}\sigma r} e^{-\frac{(\ln r - \mu)^2}{2\sigma^2}} \left( \frac{1}{2} + \operatorname{erf} \left( \frac{\ln r_i - (\mu + \rho(\ln r - \mu))}{\sigma\sqrt{1-\rho^2}\sqrt{2}} \right) \right) \cdot \int_0^r \frac{1}{\sqrt{2\pi}\sigma r_1} e^{-\frac{(\ln r_1 - \mu)^2}{2\sigma^2}} \left( \frac{1}{2} + \operatorname{erf} \left( \frac{\ln r_i - (\mu + \rho(\ln r_1 - \mu))}{\sigma\sqrt{1-\rho^2}\sqrt{2}} \right) \right) dr_1 \quad (5.3.1)$$

Za slučaj  $r \geq r_T$  ( $r_1 \geq r_T, r_2 < r_T, r_1 \geq r_T, r_2 \geq r_T, r_1 \geq r_T, r_2 \geq r_T$ )

$$p_r(r) = \frac{1}{2\sqrt{2\pi}\sigma r} e^{-\frac{(\ln r - \mu)^2}{2\sigma^2}} \left( \frac{1}{2} + \frac{1}{2} \operatorname{erf} \left( \frac{\ln r - \mu}{\sigma\sqrt{2}} \right) \right) \cdot \left( \frac{1}{2} + \operatorname{erf} \left( \frac{\ln r_i - (\mu + \rho(\ln r - \mu))}{\sigma\sqrt{1-\rho^2}\sqrt{2}} \right) \right) + \frac{1}{2\sqrt{2\pi}\sigma r} e^{-\frac{(\ln r - \mu)^2}{2\sigma^2}} \cdot \int_0^r \frac{1}{\sqrt{2\pi}\sigma r_1} e^{-\frac{(\ln r_1 - \mu)^2}{2\sigma^2}} \left( \frac{1}{2} + \operatorname{erf} \left( \frac{\ln r_i - (\mu + \rho(\ln r_1 - \mu))}{\sigma\sqrt{1-\rho^2}\sqrt{2}} \right) \right) dr_1 +$$

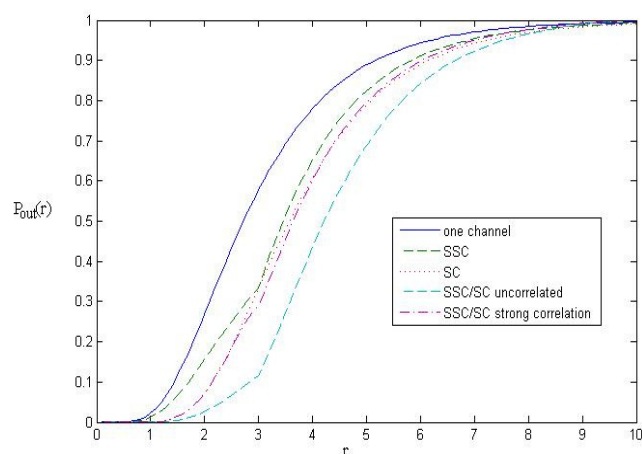
$$\begin{aligned}
& + \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{(\ln r - \mu)^2}{2\sigma^2}} \left( \frac{1}{2} + \operatorname{erf} \left( \frac{\ln r_i - (\mu + \rho(\ln r - \mu))}{\sigma\sqrt{1-\rho^2}\sqrt{2}} \right) \right) \\
& \cdot \int_0^r \frac{1}{\sqrt{2\pi\sigma r_1}} e^{-\frac{(\ln r_1 - \mu)^2}{2\sigma^2}} \left( \frac{1}{2} + \operatorname{erf} \left( \frac{\ln r_i - (\mu + \rho(\ln r_1 - \mu))}{\sigma\sqrt{1-\rho^2}\sqrt{2}} \right) \right) dr_1 + \\
& + \frac{1}{2\pi\sigma^2\sqrt{1-\rho^2}r} \left( \frac{1}{2} + \operatorname{erf} \left( \frac{\ln r_i - \mu}{\sigma\sqrt{2}} \right) \right) \\
& \cdot \int_0^r \frac{1}{r_1} e^{-\frac{1}{2(1-\rho^2)} \left[ \left( \frac{\ln r - \mu}{\sigma} \right)^2 + \left( \frac{\ln r_1 - \mu}{\sigma} \right)^2 - 2\rho \left( \frac{\ln r - \mu}{\sigma} \right) \left( \frac{\ln r_1 - \mu}{\sigma} \right) \right]} dr_1 + \\
& + \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{(\ln r - \mu)^2}{2\sigma^2}} \left( \frac{1}{2} + \operatorname{erf} \left( \frac{\ln r_i - (\mu + \rho(\ln r - \mu))}{\sigma\sqrt{1-\rho^2}\sqrt{2}} \right) \right) \\
& \cdot \int_0^r \frac{1}{\sqrt{2\pi\sigma r_1}} e^{-\frac{(\ln r_1 - \mu)^2}{2\sigma^2}} \left( \frac{1}{2} + \operatorname{erf} \left( \frac{\ln r_i - (\mu + \rho(\ln r_1 - \mu))}{\sigma\sqrt{1-\rho^2}\sqrt{2}} \right) \right) dr_1 + \\
& + \frac{2}{2\pi\sigma^2\sqrt{1-\rho^2}r} \cdot \int_{r_i}^r \frac{1}{r_1} e^{-\frac{1}{2(1-\rho^2)} \left[ \left( \frac{\ln r - \mu}{\sigma} \right)^2 + \left( \frac{\ln r_1 - \mu}{\sigma} \right)^2 - 2\rho \left( \frac{\ln r - \mu}{\sigma} \right) \left( \frac{\ln r_1 - \mu}{\sigma} \right) \right]} dr_1 + \\
& + 2 \frac{1}{2\pi\sigma^2\sqrt{1-\rho^2}r} \left( \frac{1}{2} + \operatorname{erf} \left( \frac{\ln r_i - \mu}{\sigma\sqrt{2}} \right) \right) \\
& \cdot \int_{r_i}^r \frac{1}{r_1} e^{-\frac{1}{2(1-\rho^2)} \left[ \left( \frac{\ln r - \mu}{\sigma} \right)^2 + \left( \frac{\ln r_1 - \mu}{\sigma} \right)^2 - 2\rho \left( \frac{\ln r - \mu}{\sigma} \right) \left( \frac{\ln r_1 - \mu}{\sigma} \right) \right]} dr_1 + \\
& + \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{(\ln r - \mu)^2}{2\sigma^2}} \left( \frac{1}{2} + \frac{1}{2} \operatorname{erf} \left( \frac{\ln r - \mu}{\sigma\sqrt{2}} \right) \right) \\
& \cdot \left( \frac{1}{2} + \operatorname{erf} \left( \frac{\ln r_i - (\mu + \rho(\ln r - \mu))}{\sigma\sqrt{1-\rho^2}\sqrt{2}} \right) \right) + \\
& + \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{(\ln r - \mu)^2}{2\sigma^2}} \cdot \int_{r_i}^r \frac{1}{\sqrt{2\pi\sigma r_1}} e^{-\frac{(\ln r_1 - \mu)^2}{2\sigma^2}} \left( \frac{1}{2} + \operatorname{erf} \left( \frac{\ln r_i - (\mu + \rho(\ln r_1 - \mu))}{\sigma\sqrt{1-\rho^2}\sqrt{2}} \right) \right) dr_1 + \\
& + 2 \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{(\ln r - \mu)^2}{2\sigma^2}} \left( \frac{1}{2} + \operatorname{erf} \left( \frac{\ln r_i - (\mu + \rho(\ln r - \mu))}{\sigma\sqrt{1-\rho^2}\sqrt{2}} \right) \right) \\
& \cdot \int_{r_i}^r \frac{1}{\sqrt{2\pi\sigma r_1}} e^{-\frac{(\ln r_1 - \mu)^2}{2\sigma^2}} \left( \frac{1}{2} + \operatorname{erf} \left( \frac{\ln r_i - (\mu + \rho(\ln r_1 - \mu))}{\sigma\sqrt{1-\rho^2}\sqrt{2}} \right) \right) dr_1
\end{aligned} \tag{5.3.2}$$

Izrazi za gustinu raspodele verovatnoće su dobijeni u obliku jednostrukog integrala i mogu biti upotrebljeni za proračun ostalih karakteristika sistema.

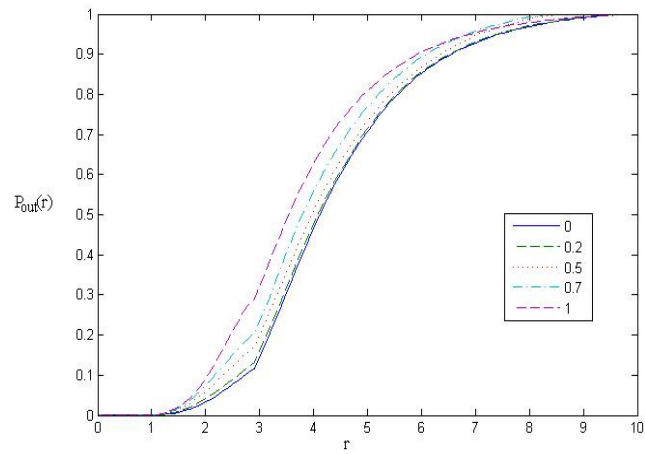
Verovatnoća otkaza se dobija na osnovu (5.1.6-7) i (5.3.1-2).

Verovatnoće otkaza za različite tipove kombinera u prisustvu log-normalnog fedinga za jednokanalni prijemnik, SSC i SC prijemnike u jednom trenutku vremena i SSC/SC prijemnik u 2 trenutka vremena u slučajevima bez korelacije i sa veoma jakom korelacijom na ulazima u kombiner su prikazane na slici 5.3.1. familije kriva za. Može se zaključiti da SSC/SC kombiner kao i u slučaju Rayleigh-jevog fedinga ima značajno bolje performanse za slučaj bez korelacije, a za slučaj sa jakom korelacijom,  $\rho=1$ , SSC/SC kombiner za  $r < r_T$  prati rezultate za SC kombiner u jednom trenutku vremena, a u ostalom delu za SSC kombiner u jednom trenutku vremena.

Kada se analiziraju verovatnoće otkaza za SSC/SC kombinere u 2 trenutka vremena koje su prikazane na slici 5.2.2. takođe se kao za slučaj Rayleigh-jevog fedinga jasno uočava da se benefiti upotrebe ove vrste kombinera povećavaju sa smanjenjem korelacije između ulaznih signala.



Slika 5.3.1. Verovatnoće otkaza za različite tipove kombinera u prisustvu log-normalnog fedinga za parametre:  $\mu = 1$ ,  $\sigma = 0.5$ ,  $\rho = 0$ ;1



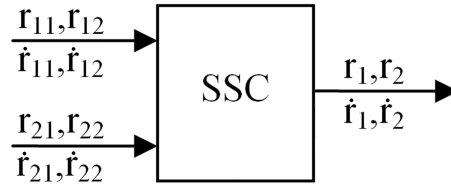
Slika 5.3.2. Verovatnoće otkaza za SSC/SC kombiner u dva trenutka vremena za različite vrednosti korelacije u prisustvu log-normalnog fedinga za parametre:  $\mu = 1$ ,  $\sigma = 0.5$ ,  $\rho = 0;1$

## 6 Karakteristike drugog reda SSC/SC kombinera

Karakteristike drugog reda SSC/SC kombinera u dva trenutka vremena su važne za analizu rada složenih kombinera. Na osnovu rezultata za združene gustine raspodele verovatnoće signala i izvoda signala na izlazima iz SSC kombinera u dva trenutka vremena i izraza za združenu gustinu raspodele verovatnoće signala na izlazu, dobijaju se vrednosti za srednju učestanost preseka nivoa, a upotrebom srednje učestanosti preseka nivoa i verovatnoće otkaza može se odrediti srednje vreme trajanja otkaza.

### 6.1 Model sistema u dva trenutka vremena

U ovom poglavlju se razmatraju karakteristike drugog reda SSC/SC kombinera sa dve grane u dva trenutka vremena. Model sistema je prikazan na slici 6.1.1. Signali na ulazima su  $r_{11}$  i  $r_{21}$  u prvom trenutku vremena, a  $r_{12}$  i  $r_{22}$  u drugom trenutku vremena. Signali na izlazu iz SSC kombinera su  $r_1$  i  $r_2$ . Izvodi signala na ulazima su  $\dot{r}_{11}$  i  $\dot{r}_{21}$  u prvom trenutku vremena, a  $\dot{r}_{12}$  i  $\dot{r}_{22}$  u drugom trenutku vremena. Izvodi signala na izlazu iz SSC kombinera su  $\dot{r}_1$  i  $\dot{r}_2$ . Signal na izlazu iz složenog kombinera je  $r$ , a njegov izvod  $\dot{r}$ . Verovatnoća da kombiner prvo razmatra signal na prvoj grani je  $P_1$ , a na drugoj je  $P_2$ .



Slika 6.1.1. Model SSC/SC kombinera sa dva ulaza u dva trenutka vremena sa izvodima signala

Združena gustina raspodele verovatnoće signala i izvoda signala na izlazu iz SC kombinera je:

$$p_{rr}(r, \dot{r}) = p_{r_1}(\dot{r}) \int_0^r p_{r_1 r_2}(r, r_2) dr_2 + p_{r_2}(\dot{r}) \int_0^r p_{r_1 r_2}(r_1, r) dr_1 \quad (6.1.1)$$

Združena gustina raspodele verovatnoće signala i izvoda signala na izlazu iz SSC/SC kombinera se dobija na osnovu združenih gustina raspodela verovatnoća signala na izlazima iz SSC kombinera u dva trenutka vremena i raspodela njihovih izvoda, zavisno od oblasti u kojoj se signali nalaze:

Za slučaj  $r < r_T$  ( $r_1 < r_T, r_2 < r_T$ )

$$p_{rr}(r, \dot{r}) = p_{r_1}(\dot{r}) \int_0^r p_{r_1 r_2}(r, r_2) dr_2 + p_{r_2}(\dot{r}) \int_0^r p_{r_1 r_2}(r_1, r) dr_1 \quad (6.1.2)$$

Za slučaj  $r \geq r_T$  ( $r_1 \geq r_T, r_2 < r_T$ )

$$p_{rr}^1(r, \dot{r}) = p_{r_1}(\dot{r}) \int_0^{r_T} p_{r_1 r_2}(r, r_2) dr_2 + p_{r_2}(\dot{r}) \int_{r_T}^r p_{r_1 r_2}(r_1, r) dr_1 \quad (6.1.3)$$

Za slučaj  $r \geq r_T$  ( $r_1 \geq r_T, r_2 < r_T$ )

$$p_{rr}^2(r, \dot{r}) = p_{r_1}(\dot{r}) \int_{r_T}^r p_{r_1 r_2}(r, r_2) dr_2 + p_{r_2}(\dot{r}) \int_0^{r_T} p_{r_1 r_2}(r_1, r) dr_1 \quad (6.1.4)$$

Za slučaj  $r \geq r_T$  ( $r_1 \geq r_T, r_2 \geq r_T$ )

$$p_{rr}^3(r, \dot{r}) = p_{r_1}(\dot{r}) \int_{r_T}^r p_{r_1 r_2}(r, r_2) dr_2 + p_{r_2}(\dot{r}) \int_{r_T}^r p_{r_1 r_2}(r_1, r) dr_1 \quad (6.1.5)$$

Ukupna združena gustina raspodele verovatnoće signala i izvoda signala na izlazu, za  $r \geq r_T$  je:

$$p_{rr}(r, \dot{r}) = p_{rr}^1(r, \dot{r}) + p_{rr}^2(r, \dot{r}) + p_{rr}^3(r, \dot{r}) \quad (6.1.6)$$

## 6.2 Karakteristike drugog reda SSC/SC kombinera u dva trenutka vremena u prisustvu Rice-ovog fedinga

Združena gustina raspodele verovatnoće signala i izvoda signala na izlazu iz SSC/SC kombinera u prisustvu Rice-ovog fedinga se dobija na oslovu gustina raspodela verovatnoća izvoda signala na izlazima iz SSC kombinera u dva trenutka vremena (4.5.2-3) i izraza (6.1.2-6).

Za slučaj  $r < r_T$  ( $r_1 < r_T, r_2 < r_T$ )

$$\begin{aligned}
 p_{rr}(r, \dot{r}) = & \left[ P_1 \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_1^2}{2\dot{\sigma}_1^2}} + P_2 \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_2^2}} + \right. \\
 & + \left( P_2 \left[ 1 - Q_1 \left( \frac{A_2}{\sigma_2}, \frac{r_T}{\sigma_2} \right) \right] - P_1 \left[ 1 - Q_1 \left( \frac{A_1}{\sigma_1}, \frac{r_T}{\sigma_1} \right) \right] \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_1^2}{2\dot{\sigma}_1^2}} + \\
 & + \left( P_1 \left[ 1 - Q_1 \left( \frac{A_1}{\sigma_1}, \frac{r_T}{\sigma_1} \right) \right] - P_2 \left[ 1 - Q_1 \left( \frac{A_2}{\sigma_2}, \frac{r_T}{\sigma_2} \right) \right] \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_2^2}} \left. \right] \cdot \\
 & \cdot \int_0^r [P_1 D_2(r) D_1(r_2) + P_2 D_1(r) D_2(r_2)] dr_2 + \\
 & + \left[ P_1 \left[ 1 - Q_1 \left( \frac{A_1}{\sigma_1}, \frac{r_T}{\sigma_1} \right) \right] \left[ 1 - Q_1 \left( \frac{A_2}{\sigma_2}, \frac{r_T}{\sigma_2} \right) \right] \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_1^2}} + \right. \\
 & + P_2 \left[ 1 - Q_1 \left( \frac{A_1}{\sigma_1}, \frac{r_T}{\sigma_1} \right) \right] \left[ 1 - Q_1 \left( \frac{A_2}{\sigma_2}, \frac{r_T}{\sigma_2} \right) \right] \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_2^2}} + \\
 & + P_1 B_1(r_T) \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_2^2}} + P_2 B_2(r_T) \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_1^2}} + \\
 & + P_1 \left[ 1 - Q_1 \left( \frac{A_1}{\sigma_1}, \frac{r_T}{\sigma_1} \right) \right] Q_1 \left( \frac{A_2}{\sigma_2}, \frac{r_T}{\sigma_2} \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_2^2}} + \\
 & + P_2 \left[ 1 - Q_1 \left( \frac{A_2}{\sigma_2}, \frac{r_T}{\sigma_2} \right) \right] Q_1 \left( \frac{A_1}{\sigma_1}, \frac{r_T}{\sigma_1} \right) \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_1^2}} + \\
 & + P_1 C_1(r_T) \frac{1}{\sqrt{2\pi\dot{\sigma}_1}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_1^2}} + P_2 C_2(r_T) \frac{1}{\sqrt{2\pi\dot{\sigma}_2}} e^{-\frac{\dot{r}_2^2}{2\dot{\sigma}_2^2}} \left. \right] \cdot \\
 & \cdot \int_0^r [P_1 D_2(r_1) D_1(r) + P_2 D_1(r_1) D_2(r)] dr_1
 \end{aligned} \tag{6.2.1}$$

Za slučaj  $r \geq r_T$  ( $r_1 \geq r_T, r_2 < r_T, r_1 \geq r_T, r_2 \geq r_T, r_1 \geq r_T, r_2 \geq r_T$ )

$$\begin{aligned}
 p_{rr}(r, r) = & \left[ P_1 \frac{1}{\sqrt{2\pi\hat{\sigma}_1}} e^{-\frac{r_1^2}{2\hat{\sigma}_1^2}} + P_2 \frac{1}{\sqrt{2\pi\hat{\sigma}_2}} e^{-\frac{r_1^2}{2\hat{\sigma}_2^2}} + \right. \\
 & + \left( P_2 \left[ 1 - Q_1 \left( \frac{A_2}{\sigma_2}, \frac{r_T}{\sigma_2} \right) \right] - P_1 \left[ 1 - Q_1 \left( \frac{A_1}{\sigma_1}, \frac{r_T}{\sigma_1} \right) \right] \right) \frac{1}{\sqrt{2\pi\hat{\sigma}_1}} e^{-\frac{r_1^2}{2\hat{\sigma}_1^2}} + \\
 & \left. + \left( P_1 \left[ 1 - Q_1 \left( \frac{A_1}{\sigma_1}, \frac{r_T}{\sigma_1} \right) \right] - P_2 \left[ 1 - Q_1 \left( \frac{A_2}{\sigma_2}, \frac{r_T}{\sigma_2} \right) \right] \right) \frac{1}{\sqrt{2\pi\hat{\sigma}_2}} e^{-\frac{r_1^2}{2\hat{\sigma}_2^2}} \right] \cdot \\
 & \left[ \int_0^{r_T} \left[ P_1 \frac{r_2}{\sigma_2^2} e^{-\frac{r_2^2 + A_2^2}{2\sigma_2^2}} I_0 \left( \frac{r_2 A_2}{\sigma_2^2} \right) D_1(r) + P_1 D_2(r) D_1(r_2) + P_2 \frac{r_2}{\sigma_1^2} e^{-\frac{r_2^2 + A_1^2}{2\sigma_1^2}} I_0 \left( \frac{r_2 A_1}{\sigma_1^2} \right) D_2(r) + P_2 D_1(r) D_2(r_2) \right] dr_2 + \right. \\
 & + \int_{r_T}^r \left[ P_1 (1 - Q_1(A/\sigma_1, r/\sigma_1)) \cdot \frac{rr_2}{\sigma_2^4 (1 - \rho^2)} e^{-\frac{r^2 + r_2^2 + 2A_2^2 (1 - \rho)}{2\sigma_2^2 (1 - \rho^2)}} \cdot \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho r r_2}{\sigma_2^2 (1 - \rho^2)} \right) I_i \left( \frac{A_2 r}{\sigma_2^2 (1 + \rho)} \right) I_i \left( \frac{A_2 r_2}{\sigma_2^2 (1 + \rho)} \right) + \right. \\
 & \quad + P_1 D_2(r_1) D_1(r_2) + P_2 (1 - Q_1(A/\sigma_2, r/\sigma_2)) \cdot \\
 & \quad \cdot \frac{r_1 r_2}{\sigma_1^4 (1 - \rho^2)} e^{-\frac{r_1^2 + r_2^2 + 2A_1^2 (1 - \rho)}{2\sigma_1^2 (1 - \rho^2)}} \cdot \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho r_1 r_2}{\sigma_1^2 (1 - \rho^2)} \right) I_i \left( \frac{A_1 r_1}{\sigma_1^2 (1 + \rho)} \right) I_i \left( \frac{A_1 r_2}{\sigma_1^2 (1 + \rho)} \right) + \\
 & \quad + P_2 D_1(r) D_2(r_2) \left. \right] dr_2 + \int_{r_T}^r \left[ P_1 \frac{r_1 r_2}{\sigma_1^4 (1 - \rho^2)} e^{-\frac{r_1^2 + r_2^2 + 2A_1^2 (1 - \rho)}{2\sigma_1^2 (1 - \rho^2)}} \cdot \right. \\
 & \quad \cdot \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho r_1 r_2}{\sigma_1^2 (1 - \rho^2)} \right) I_i \left( \frac{A_1 r_1}{\sigma_1^2 (1 + \rho)} \right) I_i \left( \frac{A_1 r_2}{\sigma_1^2 (1 + \rho)} \right) + \\
 & \quad + P_1 (1 - Q_1(A/\sigma_1, r/\sigma_1)) \cdot \frac{r_1 r_2}{\sigma_2^4 (1 - \rho^2)} e^{-\frac{r_1^2 + r_2^2 + 2A_2^2 (1 - \rho)}{2\sigma_2^2 (1 - \rho^2)}} \cdot \\
 & \quad \cdot \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho r_1 r_2}{\sigma_2^2 (1 - \rho^2)} \right) I_i \left( \frac{A_2 r_1}{\sigma_2^2 (1 + \rho)} \right) I_i \left( \frac{A_2 r_2}{\sigma_2^2 (1 + \rho)} \right) + \\
 & \quad + P_1 \frac{r_2}{\sigma_2^2} e^{-\frac{r_2^2 + A_2^2}{2\sigma_2^2}} I_0 \left( \frac{r_2 A_2}{\sigma_2^2} \right) D_1(r_1) + P_1 D_2(r_1) D_1(r_2) + \\
 & \quad + P_2 \frac{r_1 r_2}{\sigma_2^4 (1 - \rho^2)} e^{-\frac{r_1^2 + r_2^2 + 2A_2^2 (1 - \rho)}{2\sigma_2^2 (1 - \rho^2)}} \cdot \\
 & \quad \cdot \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho r_1 r_2}{\sigma_2^2 (1 - \rho^2)} \right) I_i \left( \frac{A_2 r_1}{\sigma_2^2 (1 + \rho)} \right) I_i \left( \frac{A_2 r_2}{\sigma_2^2 (1 + \rho)} \right) + \\
 & \quad + P_2 (1 - Q_1(A/\sigma_2, r/\sigma_2)) \cdot \frac{r_1 r_2}{\sigma_1^4 (1 - \rho^2)} e^{-\frac{r_1^2 + r_2^2 + 2A_1^2 (1 - \rho)}{2\sigma_1^2 (1 - \rho^2)}} \cdot \\
 & \quad \cdot \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho r_1 r_2}{\sigma_1^2 (1 - \rho^2)} \right) I_i \left( \frac{A_1 r_1}{\sigma_1^2 (1 + \rho)} \right) I_i \left( \frac{A_1 r_2}{\sigma_1^2 (1 + \rho)} \right) + \\
 & \quad \left. + P_2 \frac{r_2}{\sigma_1^2} e^{-\frac{r_2^2 + A_1^2}{2\sigma_1^2}} I_0 \left( \frac{r_2 A_1}{\sigma_1^2} \right) D_2(r_1) + P_2 D_1(r_1) D_2(r_2) \right] dr_2 \left. \right] +
 \end{aligned}$$

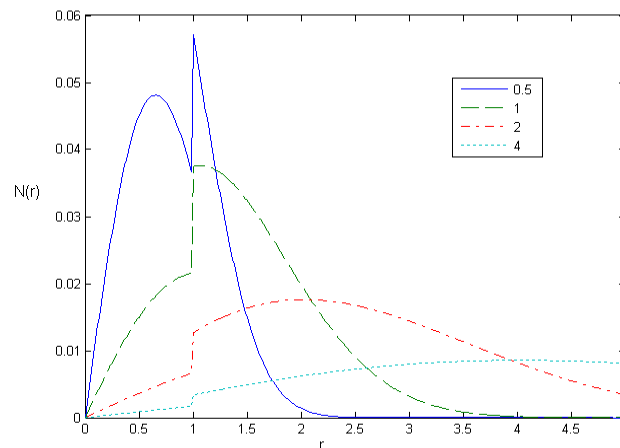


$$\begin{aligned}
 & + \left[ P_1 \left[ 1 - Q_1 \left( \frac{A_1}{\sigma_1}, \frac{r_T}{\sigma_1} \right) \right] \left[ 1 - Q_1 \left( \frac{A_2}{\sigma_2}, \frac{r_T}{\sigma_2} \right) \right] \frac{1}{\sqrt{2\pi\sigma_1}} e^{-\frac{r_2^2}{2\sigma_1^2}} + \right. \\
 & + P_2 \left[ 1 - Q_1 \left( \frac{A_1}{\sigma_1}, \frac{r_T}{\sigma_1} \right) \right] \left[ 1 - Q_1 \left( \frac{A_2}{\sigma_2}, \frac{r_T}{\sigma_2} \right) \right] \frac{1}{\sqrt{2\pi\sigma_2}} e^{-\frac{r_2^2}{2\sigma_2^2}} + \\
 & + P_1 B_1(r_T) \frac{1}{\sqrt{2\pi\sigma_2}} e^{-\frac{r_2^2}{2\sigma_2^2}} + P_2 B_2(r_T) \frac{1}{\sqrt{2\pi\sigma_1}} e^{-\frac{r_2^2}{2\sigma_1^2}} + \\
 & + P_1 \left[ 1 - Q_1 \left( \frac{A_1}{\sigma_1}, \frac{r_T}{\sigma_1} \right) \right] Q_1 \left( \frac{A_2}{\sigma_2}, \frac{r_T}{\sigma_2} \right) \frac{1}{\sqrt{2\pi\sigma_2}} e^{-\frac{r_2^2}{2\sigma_2^2}} + \\
 & + P_2 \left[ 1 - Q_1 \left( \frac{A_2}{\sigma_2}, \frac{r_T}{\sigma_2} \right) \right] Q_1 \left( \frac{A_1}{\sigma_1}, \frac{r_T}{\sigma_1} \right) \frac{1}{\sqrt{2\pi\sigma_1}} e^{-\frac{r_2^2}{2\sigma_1^2}} + \\
 & \left. + P_1 C_1(r_T) \frac{1}{\sqrt{2\pi\sigma_1}} e^{-\frac{r_2^2}{2\sigma_1^2}} + P_2 C_2(r_T) \frac{1}{\sqrt{2\pi\sigma_2}} e^{-\frac{r_2^2}{2\sigma_2^2}} \right] \cdot \\
 & \cdot \left[ \int_{r_T}^r \left[ P_1 \frac{r}{\sigma_2^2} e^{-\frac{r^2 + A_2^2}{2\sigma_2^2}} I_0 \left( \frac{rA_2}{\sigma_2} \right) D_1(r_1) + P_1 D_2(r_1) D_1(r) + \right. \right. \\
 & \left. \left. + P_2 \frac{r}{\sigma_1^2} e^{-\frac{r^2 + A_1^2}{2\sigma_1^2}} I_0 \left( \frac{rA_1}{\sigma_1} \right) D_2(r_1) + P_2 D_1(r_1) D_2(r) \right] dr_1 + \right. \\
 & + \int_0^{r_T} \left[ P_1 (1 - Q_1(A/\sigma_1, r_i/\sigma_1)) \cdot \frac{r_1 r}{\sigma_2^4 (1 - \rho^2)} e^{-\frac{r_1^2 + r^2 + 2A_2^2 (1 - \rho)}{2\sigma_2^2 (1 - \rho^2)}} \cdot \right. \\
 & \cdot \sum_{i=0}^{\infty} \mathcal{E}_i I_i \left( \frac{\rho r_1 r}{\sigma_2^2 (1 - \rho^2)} \right) I_i \left( \frac{A_2 r_1}{\sigma_2^2 (1 + \rho)} \right) I_i \left( \frac{A_2 r}{\sigma_2^2 (1 + \rho)} \right) + \\
 & \quad + P_1 D_2(r_1) D_1(r) + \\
 & \quad + P_2 (1 - Q_1(A/\sigma_2, r_i/\sigma_2)) \cdot \\
 & \quad \cdot \frac{r_1 r}{\sigma_1^4 (1 - \rho^2)} e^{-\frac{r_1^2 + r^2 + 2A_1^2 (1 - \rho)}{2\sigma_1^2 (1 - \rho^2)}} \cdot \\
 & \cdot \sum_{i=0}^{\infty} \mathcal{E}_i I_i \left( \frac{\rho r_1 r}{\sigma_1^2 (1 - \rho^2)} \right) I_i \left( \frac{A_1 r_1}{\sigma_1^2 (1 + \rho)} \right) I_i \left( \frac{A_1 r}{\sigma_1^2 (1 + \rho)} \right) + \\
 & \quad + P_2 D_1(r_1) D_2(r) \left. \right] dr_1 + \\
 & + \int_{r_T}^r \left[ P_1 \frac{r_1 r_2}{\sigma_1^4 (1 - \rho^2)} e^{-\frac{r_1^2 + r_2^2 + 2A_1^2 (1 - \rho)}{2\sigma_1^2 (1 - \rho^2)}} \cdot \right. \\
 & \cdot \sum_{i=0}^{\infty} \mathcal{E}_i I_i \left( \frac{\rho r_1 r_2}{\sigma_1^2 (1 - \rho^2)} \right) I_i \left( \frac{A_1 r_1}{\sigma_1^2 (1 + \rho)} \right) I_i \left( \frac{A_1 r_2}{\sigma_1^2 (1 + \rho)} \right) + \\
 & \quad \left. + P_1 (1 - Q_1(A/\sigma_1, r_i/\sigma_1)) \cdot \right.
 \end{aligned}$$

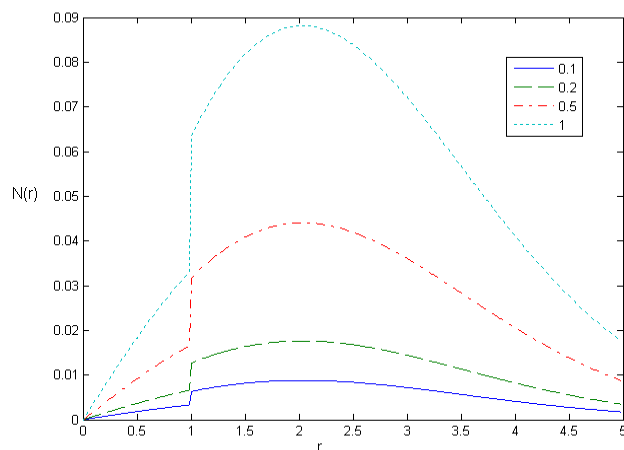
$$\begin{aligned}
 & \cdot \frac{r_1 r_2}{\sigma_2^4 (1 - \rho^2)} e^{-\frac{r_1^2 + r_2^2 + 2A_2^2 (1 - \rho)}{2\sigma_2^2 (1 - \rho^2)}} \cdot \\
 & \cdot \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho r_1 r_2}{\sigma_2^2 (1 - \rho^2)} \right) I_i \left( \frac{A_2 r_1}{\sigma_2^2 (1 + \rho)} \right) I_i \left( \frac{A_2 r_2}{\sigma_2^2 (1 + \rho)} \right) + \\
 & + P_1 \frac{r_2}{\sigma_2^2} e^{-\frac{r_2^2 + A_2^2}{2\sigma_2^2}} I_0 \left( \frac{r_2 A_2}{\sigma_2^2} \right) D_1(r_1) + P_1 D_2(r_1) D_1(r_2) + \\
 & + P_2 \frac{r_1 r_2}{\sigma_2^4 (1 - \rho^2)} e^{-\frac{r_1^2 + r_2^2 + 2A_2^2 (1 - \rho)}{2\sigma_2^2 (1 - \rho^2)}} \cdot \\
 & \cdot \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho r_1 r_2}{\sigma_2^2 (1 - \rho^2)} \right) I_i \left( \frac{A_2 r_1}{\sigma_2^2 (1 + \rho)} \right) I_i \left( \frac{A_2 r_2}{\sigma_2^2 (1 + \rho)} \right) + \\
 & + P_2 (1 - Q_1(A/\sigma_2, r_1/\sigma_2)) \cdot \\
 & \cdot \frac{r_1 r_2}{\sigma_1^4 (1 - \rho^2)} e^{-\frac{r_1^2 + r_2^2 + 2A_1^2 (1 - \rho)}{2\sigma_1^2 (1 - \rho^2)}} \cdot \\
 & \cdot \sum_{i=0}^{\infty} \varepsilon_i I_i \left( \frac{\rho r_1 r_2}{\sigma_1^2 (1 - \rho^2)} \right) I_i \left( \frac{A_1 r_1}{\sigma_1^2 (1 + \rho)} \right) I_i \left( \frac{A_1 r_2}{\sigma_1^2 (1 + \rho)} \right) + \\
 & + P_2 \frac{r_2}{\sigma_1^2} e^{-\frac{r_2^2 + A_1^2}{2\sigma_1^2}} I_0 \left( \frac{r_2 A_1}{\sigma_1^2} \right) D_2(r_1) + P_2 D_1(r_1) D_2(r_2) \Big] dr_1 \quad (6.2.2)
 \end{aligned}$$

Na osnovu izraza (6.2.1) i (6.2.2) se primenom u (2.2.5) i (2.2.6) dobijaju vrednosti za srednju učestanost preseka nivoa i srednje vreme trajanja otkaza.

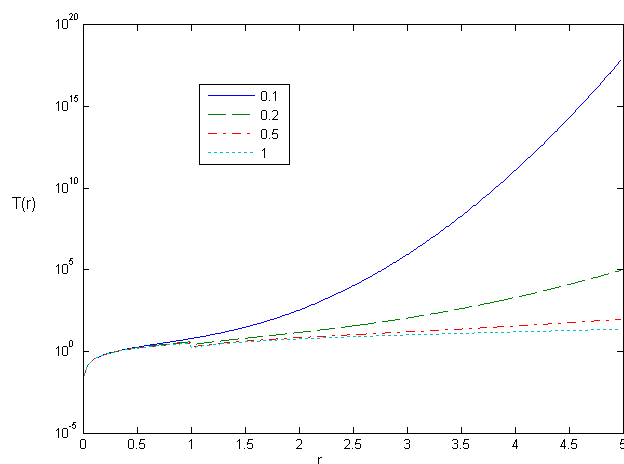
Na slikama 6.2.1 i 6.2.2 su prikazane vrednosti srednje učestanosti preseka nivoa za SSC/SC kombiner u dva trenutka vremena u prisustvu Rice-ovog fedinga za različite varijanse signala i njihovih izvoda, dok je srednje vreme trajanja otkaza predstavljeno na slikama 6.2.3 i 6.2.4.



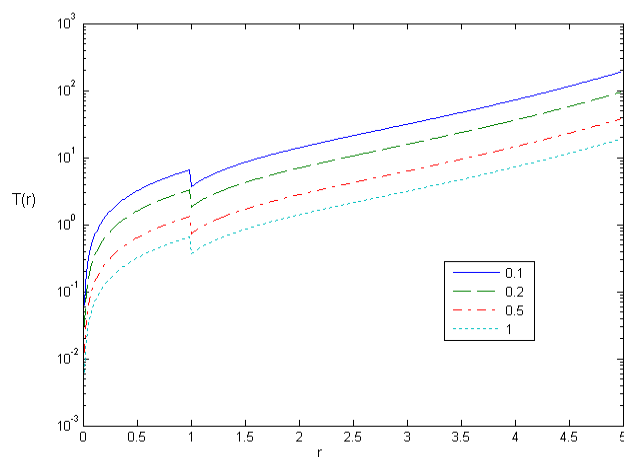
Slika 6.2.1. Srednja učestanost preseka nivoa za SSC/SC kombiner u dva trenutka vremena u prisustvu Rice-ovog fedinga za parametre:  $r_T = 1$ ,  $\sigma = 0.5; 1; 2; 4$ ,  $A = 0.5$ ,  $\dot{\sigma} = 0.2$



Slika 6.2.2. Srednja učestanost preseka nivoa za SSC/SC kombinera u dva trenutka vremena u prisustvu Rice-ovog fedinga za parametre:  $r_T = 1$ ,  $\sigma = 2$ ,  $A = 0.5$ ,  $\dot{\sigma} = 0.1; 0.2; 0.5; 1$



Slika 6.2.3. Srednje vreme trajanje otkaza za SSC/SC kombinera u dva trenutka vremena u prisustvu Rice-ovog fedinga za parametre:  $r_T = 1$ ,  $\sigma = 0.5; 1; 2; 4$ ,  $A = 0.5$ ,  $\dot{\sigma} = 0.2$



Slika 6.2.4. Srednje vreme trajanje otkaza za SSC/SC kombinera u dva trenutka vremena u prisustvu Rice-ovog fedinga za parametre:  $r_T = 1$ ,  $\sigma = 2$ ,  $A = 0.5$ ,  $\dot{\sigma} = 0.1; 0.2; 0.5; 1$

## 7 Zaključak

U disertaciji su predstavljene karakteristike složenih kombinera u dva trenutka vremena u prisustvu fedinga koji je glavni uzrok degradacije performansi bežičnih komunikacionih sistema. Dat je model sistema za SSC/SC kombiner u dva trenutka vremena sa dve grane na ulazu u prvi stepen koji predstavlja SSC kombiner, a čiji izlazi u dva trenutka vremena čine ulaze u SC kombiner kao drugi stepen.

Prikazani su opšti izrazi za združenu gustinu raspodele verovatnoće signala na izlazu SSC kombinera sa dva ulaza u dva trenutka vremena, a za slučajeve prenosnih kanala u prisustvu fedinga koji se karakterišu Rayleigh-jevom, Nakagami-m, Rice-ovom, log-normalnom, Weibull-ovom i gamma raspodelom, izvedeni su izrazi u zatvorenom obliku, pogodni za korišćenje u daljoj analizi za dobijanje statističkih veličina kojima se opisuju karakteristike složenog kombinera.

Gustine raspodele verovatnoće i verovatnoće otkaza su dobijene za složeni SSC/SC kombiner, a na osnovu njih se mogu dobiti i momenti, veličina fedinga i verovatnoća greške po bitu.

Osim karakteristika prvog reda, analizirane su i karakteristike drugog reda kao što su srednja učestanost preseka nivoa i srednje trajanje otkaza, a na osnovu razvijenog matematičkog modela u kome su osim gustina raspodela verovatnoća signala uzete u obzir i raspodele izvoda signala.

Na primerima je ilustrovano da su karakteristike složenih SSC/SC kombinera bolje u odnosu na karakteristike klasičnih SC i SSC kombinera u jednom trenutku vremena, tako da se ovakav sistem može praktično primeniti u prijemnicima bežičnih digitalnih signala.

Rezultati dobijeni u ovoj disertaciji za karakteristike složenih SSC/SC kombinera u dva trenutka vremena u prisustvu fedinga se mogu iskoristi za dalji rad na analizi drugih tipova složenih kombinera u dva trenutka vremena, kao što su SSC/MRC ili SSC/EGC, kao i za prenosne sisteme u prisustvu različitih tipova fedinga koji nisu razmatarni u ovoj disertaciji.

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## Kratka biografija kandidata

Kandidat mr Petar Nikolić rođen je 29.03.1974. godine u Pirotu. Osnovnu i srednju školu završio je u Pirotu sa odličnim uspehom i kao nosilac diplome „Vuk Karadžić“. Za vreme školovanja u osnovnoj i srednjoj školi, učestvovao je na republičkim i saveznim takmičenjima iz matematike.

Nakon završene srednje škole, 1.10.1993. godine, upisao je Elektronski fakultet u Nišu, profil Elektronika i telekomunikacije, koji je završio sa prosečnom ocenom 9.13. Diplomski rad “Širokopolasna CDMA tehnika”, koji je radio pri Katedri za Telekomunikacije, odbranio je 23.03.2001. sa ocenom 10.

Od aprila 2001. god. radi u kompaniji Tigar Tyres iz Pirota. Posle završenih studija upisao je magistarske studije na Elektronskom fakultetu u Nišu iz oblasti Telekomunikacija. Položilo je sve ispite predviđene nastavnim planom postdiplomskih studija sa prosečnom ocenom 10. Magistrirao je 13.11.2008. odbranivši magistarsku tezu pod naslovom “Uticaj fedinga i efekta senke na performanse digitalnih telekomunikacionih sistema”.

U saradnji sa drugim autorima, napisao je 62 naučno-istraživačka rada, od kojih kojih su 12 objavljena u međunarodnim časopisima (3 sa SCI liste), 1 u domaćem časopisu, 39 radova su referisana na međunarodnim simpozijumima i konferencijama i štampana u zbornicima radova tih konferencija, dok je 10 referisano na stručnim konferencijama u našoj zemlji i štampano u odgovarajućim zbornicima radova.

## Naučni radovi kandidata

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- a.2.** Dragana Krstić, **Petar Nikolić**, Fatih Destović, Mihajlo Stefanović, “The Joint Probability Density Function of the SSC Combiner Output Signal in the Presence of Log-Normal Fading”, *Electronics and Electrical Engineering, (Elektronika ir Elektrotehnika)*, No. 3 (109), pp. 11-16, 2011, ISSN 1392-1215,  
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