УДК 621.372

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IKKITA DETERMINANT SIGNALNI FARQLASH

Annotatsiya: *Qabul qiluvchi qurilma kirishidagi tebranish* $s_1(t), s_2(t), \ldots s_m(t)$ *signallardan biri hamda xalaqit yig'indisidan iborat bo'lsin. Qabul qilingan* $u(t)$ *realizatsiyalar bo'yicha uzatish tomonidan qaysi signal uzatilganligini aniqlash masalasini yechish talab etilgan bo'lsin. Bunday masala asosan aloqa tizimlari uchun xosdir.Ma'lumki, aloqa tizimlarida turli signallarni qabul qilishdagi xatoliklar keraksiz (ortiqcha) bo'lib, ushbu tizimlarda nisbatan keng tarqalgan signallarni optimal qabul qilish mezonlaridan biri maksimum aposterior ehtimollik mezoni hisoblanadi.*

Kalit so'zlar: *Tebranish, realizatsiyalar, aposterior ehtimollik mezoni, determinant signa, korrelyatsiya.*

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DIFFERENTIATION OF TWO DETERMINANT SIGNALS

Abstract: Let the fluctuation at the input of the receiver consist of one of the signals s_1 (t), s_2 (t),...s_m (t) and the sum of interference. Let it be required to solve the problem of determining which signal was transmitted by the transmission according to the received u(t) realizations. Such a problem is mainly typical for communication systems. It is known that errors in the reception of various signals in communication systems are unnecessary (redundant), and one of the criteria for optimal reception of signals that is relatively common in these systems is the maximum posterior probability criterion.

Key words: Oscillation, realizations, posterior probability criterion, determinant sign, correlation.

Ikkita determinant signalni farqlash.

Qabul qiluvchi qurilma kirishidagi signal quyidagi ko‘rinishga ega bo‘lsin

$$u(t)=\theta s_1(t)+(1-\theta)s_0(t)+n(t),$$

bunda, θ – tasodifiy miqdor bo‘lib, mos ravishda p_0 va p_1 ehtimolliklarga ega 0 yoki 1 qiymatini qabul qiladi; $s_0(t)$ va $s_1(t)$ – aniq parametrli foydali signal; $n(t)$ – matematik kutilmasi nolga va korrelyatsiya funksiyasi $R_n(\tau)=\frac{N_0}{2}\delta(\tau)$ ga teng bo‘lgan stasionar gauss oq shovqini [1].

U holda o‘xshashlik nisbati quyidagi ko‘rinishga ega bo‘ladi

$$l(u)=\exp\left(\frac{-E_1}{N_0}+\frac{2}{N_0}\int_0^T u(t)s_1(t)dt\right)/\exp\left(\frac{-E_0}{N_0}+\frac{2}{N_0}\int_0^T u(t)s_0(t)dt\right),$$

bunda, E_0 va E_1 – $s_0(t)$ va $s_1(t)$ signallarning energiyasi. Ushbu nisbatni logarifmlasak, quyidagi ifodaga ega bo‘lamiz [2]

$$\ln l(u)=\frac{-E_1-E_0}{N_0}+\frac{2}{N_0}\int_0^T u(t)(s_1(t)-s_0(t))dt.$$

Bundan $s_1(t)$ signal uzatilgan deb qaror qabul qilinadi, agar quyidagi shart bajarilsa

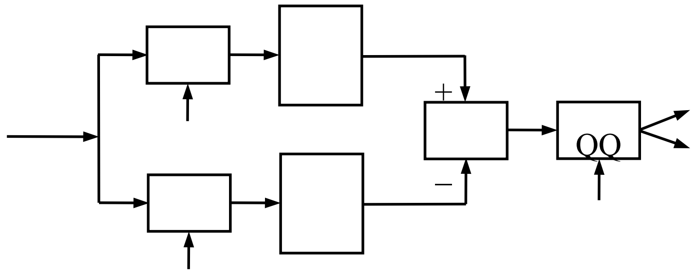
$$z=\frac{2}{N_0}\int_0^T u(t)(s_1(t)-s_0(t))dt \geq \ln\frac{p_0}{p_1}+\frac{E_1-E_0}{N_0}=C_1. \quad (1.1)$$

Simmetrik kanal uchun, ya’ni $p_0=p_1=0{,}5$ va $E_0=E_1=E$ holat uchun, C_1 sath (chegara) nolga teng bo‘ladi va farqlash tenglamasi quyidagi ko‘rinishni oladi [3]

$$z \underset{s_0}{\overset{s_1}{\gtrless}} 0. \quad (1.2)$$

Ushbu (3.59) algoritm asosida ishlovchi optimal kogerent qabul qiluvchi qurilmaning strukturaviy sxemasi 1-rasmda keltirilgan, rasmda QQ – qaror qabullagich [4]. Sxemaning yuqori va past qismlaridagi korrelyatorlar impuls xarakteristikasi mos ravishda $h_1(t)=s_1(T-t)$ va $h_0(t)=s_0(T-t)$ ga teng bo‘lgan moslashgan filtrlar bilan almashtirilishi mumkin (2-rasm).

1-rasm. *Ikkita determinant signalni korrelyatsion farqlovchi qurilmaning strukturaviy sxemasi*

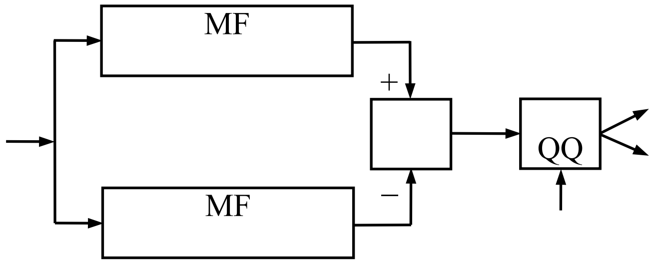


$P_x(s_0)$ va $P_x(s_1)$ shartli ehtimolliklar mos holda $s_0(t)$ va $s_1(t)$ signallar uchun z taqsimot orqali quyidagicha aniqlanadi [5]

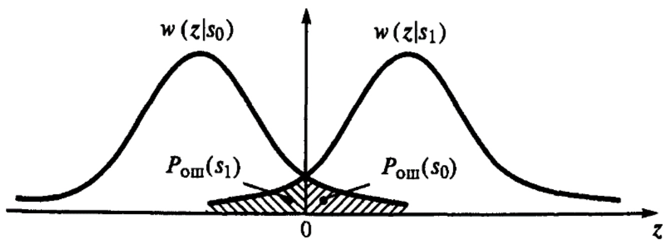
$$P_x(s_0)=\int_{z>C_1} w(z|s_0)\,dz,$$

$$P_x(s_1)=\int_{z<C_1} w(z|s_1)\,dz. \quad (1.3)$$

2-rasm. *Moslashgan filtrlar yordamida ikkita determinant signallarni farqlovchi qurilmaning strukturaviy sxemasi*



2-rasmda $w(z_1)=w(z|s_1)$ va $w(z_0)=w(z|s_0)$ taqsimotlarning grafiklari keltirilgan.



3.-rasm. *Determinant signallarni farqlashda ehtimollik zichliklari*

(1.1)–(1.3) ifodalar hamda $w(z_1)$ va $w(z_0)$ taqsimotlarni e’tiborga olib, quyidagiga ega bo‘lamiz

$$P_x=0{,}5\left(\int_0^{\infty} w(z|s_0)\,dz+\int_{-\infty}^{0} w(z|s_1)\,dz\right)=¿$$

$$¿1-\Phi\left(\sqrt{\frac{E}{N_0}(1-r_s)}\right)=1-\Phi\left(\sqrt{(1-r_s)}h\right),(1.4)$$

bunda, $\Phi(z)=\frac{1}{2\pi}\int_{-\infty}^{z}e^{-t^2/2}dt$ – ehtimollik integrali, $h^2=\frac{E}{N_0}$.

(1.4) formuladan ko‘rinadiki, xatolik o‘rtacha ehtimolligi nafaqat signalning energiyasi va shovqinning spektral quvvat zichligiga bog‘liq, balki signallar o‘rtasidagi o‘zaro korrelyatsiya koeffitsiyentiga, ya’ni qo‘llaniladigan signallar tizimiga ham bog‘liq ekan [6,7]. Ehtimollik integrali $\Phi(z)$ monoton o‘suvchi funksiya hisoblanadi. Demak, bir xil $\frac{E}{N_0}$ nisbatda o‘zaro korrelyatsiya koeffitsiyenti r_s qancha kichik bo‘lsa, tizim xalaqitbardoshligi shuncha yuqori bo‘ladi [8,9].

O‘zaro korrelyatsiya koeffitsiyenti $-1\le r_s\le 1$ oralig‘ida bo‘lishini e’tiborga olsak, u holda korrelyatsiya koeffitsiyenti $r_s=-1$ ga teng bo‘lgan signallar eng katta xalaqitbardoshlikka ega signallar hisoblanadi. Ushbu signallar bir xil shaklga ega bo‘lib, ishoralari qarama-qarshi bo‘ladi va shuning uchun ham qarama-qarshi signallar deb yuritiladi [10]. Ular uchun

$$P_x=1-\Phi\left(\sqrt{\frac{2E}{N_0}}\right)=1-\Phi\left(\sqrt{2}h\right).(1.5)$$

Qarama-qarshi signallarga misol sifatida fazasi π ga surilgan fazasi manipulyasiyalangan quyidagi signallarni keltirish mumkin

$$s_1(t)=U_0\cos\omega_0 t, s_0(t)=U_0\cos(\omega_0 t+\pi), 0\le t\le T.$$

Ortogonal signallar ($r_s=0$) nisbatan kichik xalaqitbardoshlikka ega, ular uchun

$$P_x=1-\Phi\left(\sqrt{\frac{E}{N_0}}\right)=1-\Phi(h).(1.6)$$

Agar $r_s=1$ bo‘lsa, bunday signallar aynan teng signallar bo‘ladi, ya’ni $s_1(t)=s_0(t)$, va ularni tabiiyki farqlash mumkin emas. Ular uchun $P_x=0{,}5$.

Ortogonal signallarga misol sifatida fazasi $\pi/2$ ga surilgan fazasi manipulyasiyalangan quyidagi signallarni keltirish mumkin [11].

$$s_1(t)=U_0\cos\omega_0 t,\ s_0(t)=U_0\cos(\omega_0 t+\pi/2),\ 0\le t\le T.$$

Ortogonal signallarni chastota manipulyasisini qo'llagan holda ham hosil qilish mumkin. Ushbu holda

$$s_1(t)=U_0\cos(\omega_1 t-\varphi_1),\ s_0(t)=U_0\cos(\omega_0 t-\varphi_0).$$

Bunda $\varphi_1=\varphi_0=\varphi$ bo'lganda ushbu signallar orasidagi o'zaro korrelyatsiya koeffitsiyenti quyidagi ko'rinishni oladi

$$r_s=\frac{\sin((\omega_1-\omega_0)T)}{(\omega_1-\omega_0)T}+\frac{\sin((\omega_1+\omega_0)T-2\varphi)+\sin 2\varphi}{(\omega_1+\omega_0)T}.$$

Agar $(\omega_1-\omega_0)T=2\pi k,\ k=1,2,\ldots,$ sharti bajarilsa, korrelyatsiya koeffitsiyenti r_s nolga teng bo'ladi va ushbu signallar ortogonal hisoblanadi. Amaliyotda $\omega_1,\omega_0\, va\, T$ parametrlar $(\omega_1-\omega_0)T\gg 1$ shartni qanoatlantiradigan qilib tanlanadi, bunda $r_s\approx 0$ bo'ladi [12].

Shuni payqash qiyin emaski, chastotasi manipulyasiyalangan signallar o'rtasidagi o'zaro korrelyatsiya koeffitsiyenti r_s minimal bo'lishi uchun chastotalar orasidagi farq $1{,}5\pi$ ga teng bo'lishi kerak, ya'ni $(\omega_1-\omega_0)T=1{,}5\pi$. Bunda xatolik ehtimolligi quyidagicha aniqlanadi [13].

$$P_x=1-\Phi\left(\sqrt{\frac{1{,}21E}{N_0}}\right)=1-\Phi(\sqrt{1{,}21}h).$$

Endi amplitudasi manipulyasiyalangan signallarning xalaqitbardoshligini ko'rib chiqamiz, bunda

$$s_1(t)=U_0\cos(\omega_0 t+\varphi),\ s_0(t)=0,\ 0\le t\le T.$$

Ushbu holatda signallarni farqlash algoritmi quyidagi ko'rinishga ega bo'ladi [14]

$$z=\frac{2}{N_0}\int_0^T u(t)s_1(t)dt \underset{s_0}{\overset{s_1}{\gtrless}} \frac{E}{N_0}+\ln\frac{p_0}{p_1}=C_1.$$

Ehtimollik zichliklari $w(z/s_1)$ va $w(z/s_0)$ gauss taqsimot qonuniga bo'ysunadi va matematik kutilmasi va dispersiyasi mos ravishda quyidagi qiymatlarga ega bo'ladi $M\{z\}=\frac{2E}{N_0},\sigma_z^2=\frac{2E}{N_0}$ va $M\{z\}=0,\ \sigma_z^2=2E/N_0$.

Agar $p_1 = p_0 = 0{,}5$ bo‘lsa, o‘rtacha xatolik ehtimolligi

$$P_x = 0{,}5\left(\int_{-\infty}^{C_1} w(z|s_1)\,dz + \int_{C_1}^{\infty} w(z|s_0)\,dz\right).$$

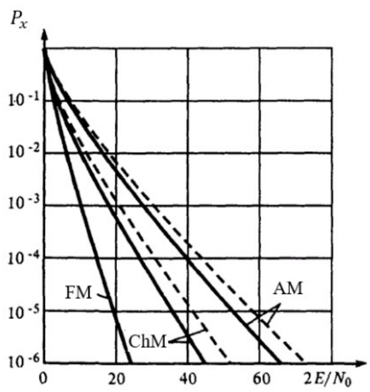
$C_1 = E/N_0$ ekanligini e’tiborga olib, va birinchi integral ahamiyatga ega emas deb hisoblasak [15]

$$P_x = 1 - \Phi\left(0{,}5\sqrt{\frac{2E}{N_0}}\right) = 1 - \Phi\left(\frac{h}{\sqrt{2}}\right). (1.7)$$

4-rasmda fazasi (FM), chastotasi (ChM) va amplitudasi (AM) manipulyasiyalangan signallar uchun (uzluksiz chiziq) formulalar bo‘yicha hisoblangan xatolik ehtimolligining $2E/N_0$ nisbatiga bog‘liqligi grafigi keltirilgan.

Shunday qilib, eng katta xalaqitbardoshlikka fazasi manipulyasiyalangan signallar ega bo‘lar ekan. Ushbu FM signallar ChM signallarga qaraganda 2 marotaba, AM signallarga nisbatan esa 4 marotaba energetik yutuq (samaradorlik) qa ega. ChM signallar AM signallarga nisbatan 2 marotaba energetik yutuqqa ega [16].

Ma’lumki, $\sqrt{2E(1-r_s)}$ kattalik signallar orasidagi masofani ifodalaydi, ya’ni $d = \left(\int_0^T [s_1(t) - s_0(t)]^2 dt\right)^{1/2}$.



4-rasm. *AM, ChM va FM determinant signallarni farqlash xatolik ehtimolligi (uzluksiz chiziq) va tasodifiy boshlang‘ich fazali AM va ChM signallarni farqlash xatolik ehtimolligi (shtrix chiziq)*

Bundan foydlanib, (1.4) ifodani quyidagicha yozish mumkin

$$P_x = 1 - \Phi\left(\frac{d}{\sqrt{2N_0}}\right). (1.8)$$

Ushbu ifodadan quyidagi xulosaga kelish mumkin: gauss oq shovqini ta'siridagi kanalda xatolik ehtimolligi faqat signallar orasidagi masofaga va shovqinning quvvat spektral zichligiga bog'liq bo'ladi. Ushbu xulosa m $(m>2)$ ta signallarni farqlashda o'rinlidir [17].

Foydalanilgan adabiyotlar

1. Mustofoqulov, J. A., & Bobonov, D. T. L. (2021). "MAPLE" DA SO'NUVCHI ELEKTROMAGNIT TEBRANISHLARNING MATEMATIK TAHLILI. *Academic research in educational sciences*, *2*(10), 374-379.

2. Mustofoqulov, J. A., Hamzaev, A. I., & Suyarova, M. X. (2021). RLC ZANJIRINING MATEMATIK MODELI VA UNI "MULTISIM" DA HISOBLASH. *Academic research in educational sciences*, *2*(11), 1615-1621.

3. Иняминов, Ю. А., Хамзаев, А. И. У., & Абдиев, Х. Э. У. (2021). Передающее устройство асинхронно-циклической системы. *Scientific progress*, *2*(6), 204-207.

4. Каршибоев, Ш. А., Муртазин, Э. Р., & Файзуллаев, М. (2023). ИСПОЛЬЗОВАНИЕ СОЛНЕЧНОЙ ЭНЕРГИИ. *Экономика и социум*, (4-1 (107)), 678-681.

5. Мулданов, Ф. Р., Умаров, Б. К. У., & Бобонов, Д. Т. (2022). РАЗРАБОТКА КРИТЕРИЙ, АЛГОРИТМА И ЕГО ПРОГРАММНОГО ОБЕСПЕЧЕНИЯ ДЛЯ СИСТЕМЫ ИДЕНТИФИКАЦИИ ЛИЦА ЧЕЛОВЕКА. *Universum: технические науки*, (11-3 (104)), 13-16.

6. Мулданов, Ф. Р., & Иняминов, Й. О. (2023). МАТЕМАТИЧЕСКОЕ, АЛГОРИТМИЧЕСКОЕ И ПРОГРАММНОЕ ОБЕСПЕЧЕНИЕ СОЗДАНИЯ СИСТЕМЫ РОБОТА-АНАЛИЗАТОРА В ВИДЕОТЕХНОЛОГИЯХ. *Экономика и социум*, (3-2 (106)), 793-798.

7. Ирисбоев, Ф. Б., Эшонкулов, А. А. У., & Исломов, М. Х. У. (2022). ПОКАЗАТЕЛИ МНОГОКАСКАДНЫХ УСИЛИТЕЛЕЙ. *Universum: технические науки*, (11-3 (104)), 5-8.

8. Zhabbor, M., Matluba, S., & Farrukh, Y. (2022). STAGES OF DESIGNING A TWO-CASCADE AMPLIFIER CIRCUIT IN THE “MULTISIM” PROGRAMM. *Universum: технические науки*, (11-8 (104)), 43-47.

9. Каршибоев, Ш., & Муртазин, Э. Р. (2022). ТИПЫ РАДИО АНТЕНН. *Universum: технические науки*, (11-3 (104)), 9-12.

10. Омонов С.Р., & Ирисбоев Ф.М. (2023). АВТОМАТИЗИРОВАННЫЕ СИСТЕМЫ ДЛЯ ИСПЫТАНИЙ НА ЭМС НА ОСНОВЕ ПРОГРАММНОЙ ПЛАТФОРМЫ R&S ELEKTRA. Экономика и социум, (5-1 (108)), 670-677.

11. Саттаров Сергей Абудиевич, & Омонов Сардор Рахмонкул Угли (2022). ИЗМЕРЕНИЯ ШУМОПОДОБНЫХ СИГНАЛОВ С ПОМОЩЬЮ АНАЛИЗАТОРА СПЕКТРА FPC1500. Universum: технические науки, (11-3 (104)), 17-20.

12. Якименко, И. В., Каршибоев, Ш. А., & Муртазин, Э. Р. (2023). Джизакский политехнический институт СПЕЦИАЛИЗИРОВАННОЕ МАШИННОЕ ОБУЧЕНИЕ ДЛЯ РАДИОЧАСТОТ. Экономика и социум, 1196.

13. Абдиев, Х., Умаров, Б., & Тоштемиров, Д. (2021). Структура и принципы солнечных коллекторов. In *НАУКА И СОВРЕМЕННОЕ ОБЩЕСТВО: АКТУАЛЬНЫЕ ВОПРОСЫ, ДОСТИЖЕНИЯ И ИННОВАЦИИ* (pp. 9-13).

14. Раббимов, Э. А., & Иняминов, Ю. О. (2022). ВЛИЯНИЕ ОКИСНОЙ ПЛЕНКИ НА КОЭФФИЦИЕНТЫ РАСПЫЛЕНИЯ КРЕМНИЯ. *Universum: технические науки*, (11-6 (104)), 25-27.

15. Mustafaqulov, A. A., Sattarov, S. A., & Adilov, N. H. (2002). Structure and properties of crystals of the quartz which has been growth up on neutron irradiated seeds. In *Abstracts of 2. Eurasian Conference on Nuclear Science and its Application*.

16. Раббимов, Э. А., Жўраева, Н. М., & Ахмаджонова, У. Т. (2020). Влияние окисной пленки на коэффициенты распыления кремния. *Экономика и социум*, (6-2 (73)), 187-189.

17. Yuldashev, F. (2023). HARORATI MOBIL ELEKTRON QURILMALAR ASOSIDA NAZORAT QILINADIGAN QUYOSh QOZONI. *Interpretation and researches*, *1*(1).