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Analysis of directional antennas for wireless data transmission systems

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Abstract: This research paper presents an analysis of the technical parameters of six types of antenna solutions for wireless data transmission systems operating in the frequency range of 1850–1990 MHz. Antennas used in consumer mobile systems have sufficient gain, good adaptability across the entire frequency range, simple design, and the ability to operate in all weather conditions.

Keywords: wireless transmission systems, antenna, gain, radiation pattern, radiation pattern factor, standing wave ratio, radiation level

Ma'lumotlarni simsiz uzatish tizimlari uchun yo'nalish antennalarining tahlili

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Annotatsiya: Ushbu ilmiy maqolada 1850 -1990 MGts chastota diapazonida ishlaydigan simsiz uzatish tizimlari uchun oltita turdagi antenna variantlarining texnik parametrlari tahlili keltirilgan. Foydalanuvchi mobil tizimlarida ishlatiladigan antennalar etarli kuchaytirish koeffitsientiga, butun chastota diapazoni bo'ylab yaxshi moslashuvi, oddiy dizayni va har qanday ob-havo sharoitida ishlash qobiliyatiga ega.

Kalit so'zlar: simsiz uzatish tizimlari, antenna, kuchaytirish koeffitsienti, yonalganlik diagrammasi, yo'nalish diagramma koeffitsienti, turg'un to'liq koeffitsienti, nurlanish darajasi

1. Kirish

Simsiz antennani tahlil qilish zamonaviy telekommunikatsiya texnologiyalarining muhim jihati hisoblanadi, chunki ma'lumotlarni uzatish samaradorligi bevosita antenna xususiyatlariga bog'liq [1, 2].

Ushbu ishning maqsadi har xil turdagi antennalarni o'rganishdan iborat bo'lib, yuqori tezlikda ma'lumot uzatishga bo'lgan talablar ortib borayotgan sharoitda tobora dolzarb bo'lib borayotgan MIMO antennalariga alohida e'tibor qaratishdir. Muammo dinamik o'zgaruvchan radiochastota muhitida maksimal ishonchlilik va aloqa sifatiga erishish uchun antennalarni optimallashtirishdir.

Hozirgi vaqtda har xil turdagi antennalar 1850-1990 MGts diapazonida ishlaydi. Eng ko'p ishlatiladigan chiziqli antennalar va muhrlangan (poloskali) elektron elementlarga asoslangan antenna massivlaridir. Antennaga qo'yiladigan asosiy talablar qayta ishlanayotgan (yoki olinadigan) ma'lumotlarning hajmi bilan belgilanadi va diapazoni, ruxsati, koordinatalarni aniqlashning aniqligi, tezligi, ishonchliligi, shovqinga chidamliligi va radiotexnika tizimining boshqa xususiyatlari bilan bog'liq.

2. Tadqiqot metodologiyasi

Keltirilgan adabiyotlardagi ishlardan farqli ravishda simsiz uzatish tizimi uchun zamonaviy antennalarni oltita turlari asosiy texnik ko'rsatkichlari bo'yicha qiyosiy tahlilini bajarish lozim.

Qiyosiy taqqoslash usulidan foydalangan holda ma'lumot uzatish tizimlari uchun olti turdagi antennalar o'rganib chiqildi va quyidagilarni ta'minlashi kerakligi belgilab olindi:

- chiziqli polarizatsiya (odatda vertikal). Polarizatsiya xarakteristikasi quyidagilarni aniqlaydi: chiqarilgan va qabul qilingan to'liqlarning qutblanishi, aylanuvchi polarizatsiyali to'liqlardan foydalanilganda polarizatsiya ellipsining ruxsat etilgan bir xillik koeffitsienti va radiatsiya maydonining chiziqli polarizatsiyasi bilan o'zaro qutblanish nurlanishining ruxsat etilgan darajasi;


- zarur kuchaytirish koeffitsienti. Antennaning yo'nalishiga qo'yiladigan talablar ikkita asosiy tekislik uchun fazoviy yo'nalish diagrammasi (YD) shakli va kengligini aniqlaydi, yon yaroqchalarining ruxsat etilgan darajasi, yo'nalish diagramma koeffitsienti (YDK) va antennaning polarizatsiya xarakteristikasi;

- chastota diapazoni (1850...1990) MGts. Antennalarning chastota xossalari chastotaga bog'liq bo'lgan asosiy antenna parametrlari qabul qilinadigan chegaralarda qoladigan chastota o'zgarishlari diapazoni bilan belgilanadi.

Chastota xususiyatlari mo'ljallangan antenna ishlatiladigan radio tizimiga qo'yiladigan talablarga bog'liq va harakat yo'nalishi yoki energiya xususiyatlarining o'zgarishi bilan belgilanadi;

- yon nurlanish darajasi (-15...-20) dB;

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- 1...3 dan kam bo'lgan doimiy to'liq nisbati bilan tavsiflangan mos keladigan daraja.

Antenna, har qanday radiotexnika qurilmasi singari, bir qator umumiy texnik va iqtisodiy talablarga ham javob beradi, masalan: belgilangan o'lchamlar, engil vazn, minimal xarajat, operatsion ishonchlilik, belgilangan sharoitlarga moslashish, nazorat qilish va ta'mirlash qulayligi talab etiladi.

1850–1990 MGts chastota diapazonida ishlaydigan antenna variantlari.

Picocell ANPC-173G-P-0-SF antenasi (1-rasm.) ichki va tashqi muhitda yuqori unumdorlikni ta'minlaydi. Ushbu antenna vertikal egilish, mahkamlash va aniq joylashishni aniqlash uchun noyob gorizontall o'rnatish tizimiga ega.

Antennaning afzalliklari uning kichik o'lchamlari va og'irligi, suvga chidamliligi, korroziyaga chidamliligi, o'rnatish qulayligi va polarizatsiya rejimini tanlashdan iborat.



1-rasm. Picocell ANPC-173G-P-0-SF turidagi antenna

1-jadval

Picocell ANPC-173G-P-0-SF turidagi antenna parametrlari

Chastota diapazoni, MGts	1850...1990
Kuchaytirishi, dB	7
TTK	1,5 dan katta emas
E	65°
H	70°
O'lchamlari, mm	140 × 115 × 38

ADFDP182-6565B-XDM tayanch stantsiya antenasi (2-rasm.) muhrlangan elektron antenadir, chastota diapazonida (1850...1990) MGts va E-tekisligida yo'nalganlik diagrammasi (YD) 6,5° kengligida va H-tekisligida 65° ni hosil qiladi. Antennaning kengligi 101 mm, balandligi 1389, 38 mm ni tashkil etadi.

Shuni ta'kidlash kerakki, ushbu antenna WCDMA aloqasi uchun tayanch stantsiyalarning apparat majmuasining bir qismi sifatida ishlatiladi.

MP19013PTFC muhrlangan elektron yo'nalishli antenna (3-rasm.) kichik o'lchamlar va oddiy qurilish bilan maksimal kuchaytirish koeffitsientini ta'minlash uchun mo'ljallangan.

Chastota (1850...1990) MGts diapazonida antenna 12,5 dB kuchaytirish koeffitsientiga ega va TTK darajasi 1,5 dan oshmaydi. Antenna, shuningdek, 35° E-tekislikda va 40° H-tekislikda namunasini ishlab chiqaradi. Antennaning kengligi 220,9 mm, uzunligi 180,3 mm, qalinligi 43,1 mm ni tashkil etadi.



2-rasm. ADFDP182-6565B-XDM turidagi antenna



3-rasm. MP19013PTFC turidagi antenna

Omni 151A turidagi antenna (4-rasm.) muhrlangan (bosilgan) elektron texnologiyasidan foydalangan holda qurilgan. Antenna vertikal polarizatsiya rejimida ishlaydi. Nurlantiruvchi elementlari bardoshli polikarbonat korpusida joylashgan. Ushbu antennani o'rnatish oson va har qanday yo'nalishda o'rnatilishi mumkin, chunki u ekrandan mustaqil.





4-rasm. Omni 151A turidagi antenna

2- jadval

Picocell ANPC-173G-P-0-SF turdagi antenasining texnik xususiyatlari

Chastota diapazoni, MGts	1850...1990
Kuchaytirishi, dB	4,2
TTK	2 dan katta emas
E	40°
H	70°
O'lchamlari, mm	295 × 19
Kuchaytirishi, dB	4,2



5-rasm. ANP-C-115 turidagi antenna

ANP-C-115 mikrostripli antenna (5-rasm.) yarim sharsimon radio to'lqinlarning tarqalishini ta'minlaydi. O'ng dumaloq polarizatsiya ko'p yo'nalishli muhitda zaiflashuvga qarshilikni yaxshilash uchun ishlatiladi.

(1850...1990) MGts chastota diapazonida antenaning kuchaytirish koeffitsienti 4 dB, TTK darajasi esa 2 dan oshmaydi. Azimut va balandlik tekisliklarida antenna yo'nalishli emas. Antennaning kengligi 50,8 mm va qalinligi 12,7 mm. U oddiy dizayni, ishonchliligi va foydalanuvchi ilovalariga moslashish qulayligi bilan ajralib turadi.

GRAD-9099PCS antenasi (6-rasm.) ko'p elementli antenna massivi bo'lib, unda YDni shakllantirish maxsus diagramma tashkil etuvchi sxemalari (DTES) tomonidan amalga oshiriladi, ular faza o'tkazgichlari, kechikish chiziqlari, kalitlar va raqamli signal protsessorini o'z ichiga oladi.

Antennalar kompyuterdan yoki tarmoq orqali boshqariladi. Barcha antennalar intermodulyatsiya buzilishi uchun qat'iy GSM standart talablariga javob beradi.

Ikki mustaqil nurlar bitta korpusda tizimli ravishda birlashtirilgan ikkita antenna pastki qatorlari tomonidan tashkil etilgan. Kerakli chastotali izolyatsiyani ta'minlash uchun antenna pastki qatorlari $\pm 45^\circ$ egilish bilan chiziqli, o'zaro ortogonal polarizatsiyaga ega bo'lib, ular ikki kirishli bosma sxemali radiatorlarga o'rnatilgan nurlanish tizimi tomonidan yaratilgan.



a)



b)

6-rasm. GRAD-9099PCS 3G uyali tarmoq antenasi

a) umumiy ko'rinish, b) massiv ichidagi elementlarning joylashishi

Har bir muhrlangan nurlatgich elektron boshqariladigan faza almashtirgichlardan tashkil topgan o'zining nur hosil qiluvchi sxemasi bilan hayajonlanadi (YDni shakllantirish uchun zarur bo'lgan antenna massividagi to'klarning fazaviy taqsimotini yaratadi) va yuqori chastotali signallarni moslashtirish va tarqatish qurilmalari (yuqori chastotali signallarni nurlatgichlar va fazani o'zgartiruvchi birliklar b o'ylab teng amplituda taqsimlanishini ta'minlaydi).

Yon yuproqchalar darajasini pasaytirish uchun antenna shunday tuzilganki, faza ichidagi taqsimot bi



ustunning faza o'zgartirgichlarida o'rnatilganda, YD Eyrga 4° ga egiladi.

Shuning uchun, masalan, balandlikda antenna YD nolga teng burilishiga erishish uchun nurni elektron ravishda 4° ga yuqoriga burish kerak.

3-jadval

GRAD-9099PCS antenasining texnik xususiyatlari

Chastota diapazoni, MGts	1830...1990
Kuchaytirishi, dB	16,5
TTK	1,5 dan katta emas
E	12°
H	65°
O'lchamlari, mm	1614 × 455 × 202

3. Xulosa

WCDMA1900 tarmoqlarida ma'lumotlarni uzatish uchun ko'plab antenna variantlari mavjud. Bu, birinchi navbatda, muhrlangan (bosilgan) elektron texnologiyasidan foydalangan holda ishlab chiqarilgan antennalardir. Foydalanuvchi mobil tizimlarida ishlatiladigan antennalar etarli kuchaytirish koeffitsientiga ega bo'lishi, butun chastota diapazoni bo'ylab yaxshi moslashuvi, oddiy dizayni va har qanday ob-havo sharoitida ishlash qobiliyatiga ega bo'lishi kerak. Yuqorida ko'rib chiqilgan antenna variantlari asosida chiziqli elementlarga asoslangan, bosqichma - bosqich antenna massivini tadqiq qilish va zamonaviy dasruriy ta'minotlardan foydalanib loyihalash maqsadga muvofiqdir.

Foydalangan adabiyotlar / References

[1] Микроэлектронные устройства СВЧ. Учебное пособие для радиотехнических специальностей вузов. / Г. И. Веселов, Е. Н. Егоров, Ю. Н. Алехин. – М.: Высшая школа. 1988. - 138 с.

[2] Сазонов, Д. М. Антенны и устройства СВЧ. Учебное пособие для радиотехнических специальностей вузов. / Д. М. Сазонов. – М.: Высшая школа. 1988. - 434 с.

[3] Устройства СВЧ и антенны. Под редакцией Д. И. Воскресенского. Издательство «Радиотехника». Москва-2006. -376с.

[4] Антенны: Учебное пособие. Коллектив авторов. - 2е изд., переработанное и доп. - СПб. Издательство «Лань», 2016 - 416 с.

[5] Холиков А.А., Умаров Ф.Ф. Радиотехник тизимлар назарияси асослари.

/ Дарслик. Тошкент-“Ўзбекистон”-2004. 152 б.

[6] Xalikov A.A., Davronbekov D.A., Kurbonov J.F. Raqamli mobil aloqa vositalari. Darslik.«O'zbekiston faylasuflari milliy jamiyati nashriyoti».Toshkent-2018. - 556b.

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