Commonwealth of Kentucky
Kentucky Public Service Commission

RECEIVED
FEB 27 2025
PUBLIC SERVICE COMMISSION

To: Case File: No 2024-00311
From: Nataliya Williams, Resident at the address: 107 Kenilworth Ct, ap.C
Radcliff, KY, 40160
email:

Request for Information for an Adjustment of Rates

On February 21, 2025 served Request for Information for an adjustment of Rates to Kentucky Public Service Commission Pursuant to 807 KAR 5:001(10)(b) Files a tariff or tarif sheet with the commission pursuant to KRS 278.180 and 807 KAR 5:011 that the commission has suspended and established a case to investigate or review.

Robert M. Conroy is a vice president of the both companies: Kentucky Utilities and Louisville Gas and Electric companies.

I request the copy of the adoption notice. Pursuant to 807 KAR 5:011. Section 11. a) a change of ownership or control of a utility occurs: b) a utility or a part of its business is transferred from the operating control of one (1) company to that of another; c) a utility's name is changed or d) a receiver or trustee assumes possession and operation of a utility. (2) Unless otherwis authorized by commission, the person operating the utility business going forward shall adopt, ratify and make as its own the predecessor's rates, classification, and requirements on file with the commission and effective at the time of the change of ownership or control. (3) an adoption notice may be filed and make effective without previous notice.

Robert M. Conroy and his employees of Kentucky Utilities are stealing my money without stopping. On my every electrical bills indicated the address of the Kentucky Utilities a PPL company P.O. Box 771670 St. Louis, MO 63177-1670 where I have to send my payments for electricity

Robert M. Conroy and his employees of Kentucky Utilities are stealing the money from Community Action Subsidy Winter (LIHEAP). On 2024-12-05 I was approved for KY Subsidy-Electric Benefit up to $167.00. I include the copies of approval from Community action.

Robert M. Conroy and his employees continue to indicate on my electric bills the address of KU a PPL company P.O. Box 771670 St. Louis, Mo 63177-1670.

I include the copies of the electrical bills. I do not know who stole my money. On the 3rd page of the electrical bill mailed 12/19/24 and mailed 1/21/25 wrot We had not received the pledge payment by the time this bill was prepared. Because Robert M. Conroy and his employees stole the money, I strongly believe.

I have filed my complaint with the Kentucky Public Service Commission on 9/19/2024. Since 9/19/2024 I have not received proof and evidences that my money has not been stolen as well as not stolen from the Community action; no knowle of the electricity from Robert M. Conroy and his employees.

I have received many proof and evidences non-compliance with the law and regulations of the USA and Kentucky.

Robert M. Conroy has to be fired forever and send to the death penalty where he belongs.

I have not received the detail explanations on the Kentucky Utilities Company third revision of original sheet No 5

What if the basic service charge per day? What is the "variable"? What is the "infrastracture"?

What is the single-phase secondary delivery?

Nataliya Williams

02/21/2025

Community Action PARTNERSHIP
Helping People. Changing Lives.

Subsidy Winter (LIHEAP)

Approved for a/an KY Subsidy-Electric Benefit up to $167.00

Vendor: Kentucky Utilities (LG&E - KU)- Grayson, Hardin, Larue, Marion, Nelson, & Washington #5458

Account Number: [redacted]
Name on Account: Nataliya Williams

This is not a Voucher
Voided after 60 days

Agency: CKCAC Central Office
PO Box 830,332 Hood
Ave
Lebanon 40033
UNITED STATES

Applicant:
Nataliya Williams
107 Kenilworth Ct, Apt C,
RADCLIFF, Kentucky 40160
Mobile [redacted]

Eligibility Criteria

Client Situation Past Due

Utility Bill Responsibility — Applicant Name and Address Match Utility Bill-Pay

Household Members	Date of Birth	Age	Identification	Income Type	Amount
Nataliya Williams	[redacted]	[redacted]	[redacted]	Employment Income	[redacted]

Household Size	Monthly Income	Annual Income
1	[redacted]	[redacted]

(89.43 % of the Federal Poverty Guidelines)

Is this household in a life threatening situation? ○ Yes ● No

By signing the Application, I certify and agree with each of the following statements:
- The Information provided for the Application is accurate.
- I understand that the receipt of assistance from this Program through misrepresentation is punishable by fine or imprisonment.
- I have received a copy of the Notice of Appeal. The Notice of Appeal includes a list of defined terms used in the LIHEAP Program Application.
- I agree that the receipt of assistance from this Program does not shift liability for any property damage to the CAA or any other Program administrators. I agree to release and hold harmless the CAA and any other Program administrator from any property damage in connection with the delivery of electric or heating fuel services.
- I am authorized to complete and submit this Application, and to release certain Confidential Information to Data Recipients, on behalf of all of the Data Subjects. I understand that the Data Recipients have a direct, tangible, legitimate interest in the Data Subjects and that the sharing of records and Confidential Information is necessary in the performance of a legitimate government function. I further authorize and am hereby requesting the disclosure of the Confidential Information among Data Recipients in connection with this Application. I am authorized to give this consent on behalf of all of the Data Subjects.
- I am authorized to release and hold harmless, and do hereby release and hold harmless, each Data Recipient from any claim, loss, demand, damage, and liability of any kind from each of the Data Subjects in connection with sharing of Confidential Information.
- I authorize the Data Recipient to provide notification of any breach or suspected breach involving Confidential Information by e-mail at the following email address:
I will notify the CAA if my email address changes. I understand this is one possible method of notification and other method(s) of notification may be used.
- I accept weatherization services as available to reduce my home heating costs.

Nataliya Williams — 2024-12-05
Applicant Signature — Date

Issued By: Breevel White — 2024-12-05
Worker Signature — Date

Community Action Kentucky 1-800-456-3452
Cabinet for Health and Family Services (CHFS) Ombudsman 1-800-372-2973

Application Date: 2024-12-05

Kentucky Community Action Partnerships

Home Energy Assistance Program (HEA)
Application Form

Section I – Household Information

Name: Natalya Williams **DOB:** [redacted] (mm/dd/yyyy)

Address: 107 Kenilworth Ct. Apt. C Radcliff, KY 42701
Street Address City State Zip

County of Residence: Hardin **Contact #:** [redacted]

Section II - HEA Program Certification:

I understand that this is an application to determine eligibility and does not guarantee that I will receive a benefit. Applications that meet the initial eligibility requirements may still be deemed not eligible for the program at a later point if additional criteria for the program are not met including but not limited to:

Select KU (Utility Provider)

HEA Program Criteria:

I understand that this is an application to determine eligibility and does not guarantee that I will receive a benefit. Applications that meet the initial eligibility requirements may still be deemed not eligible for the program at a later point if additional criteria for the program are not met including but not limited to:

- The account must be an active residential account for the Utility and cannot have their service disconnected
- The household must be responsible for home energy costs as defined by the Kentucky Public Service Commission
- The Utility must be granted access to the meter for monthly meter readings
- The customer's account is not for a multi-unit single meter building
- The account must not have another active payment plan in effect
- The Customer must not have more than one account per customer name
- The customer's account is not for a multi-unit single meter building
- **LG&E / KU** - The Benefit Type above is the primary heating fuel
- **LG&E / KU** - The account must not have an arrearage of more than $700 or a credit balance
- **LG&E / KU** - HEA funds cannot be used to pay down arrearages at the time of enrollment
- **KY Power HEART** - Household may not be receiving or have received funds through other HEA programs offered by KY Power for the Program Year (e.g. THAW or Donation HEART)
- **KY Power HEART** The account must not be 60 days or more in arrears
- **KY Power HEART** The applicant agrees to receive information on Kentucky Power's payment plans

☑ I understand that eligibility for this program depends on signing a separate authorization to release information and waiver of claims as well as agreeing this disclaimer.

☑ I also certify that the information on this enrollment form is correct, that I will notify the Community Action Agency if any of my information changes to ensure continued eligibility.

Nataliya Williams
Signature of Household Member

12-5-24
Date

Julie Arney
Worker Signature

12-5-24
Date

Agency: Hardin

Household placed on waitlist for HEA Program ☑ Yes ☐ No

Date Completed: 12-~~5~~6 24

Worker Initials: JA

AUTHORIZATION TO RELEASE INFORMATION AND WAIVER OF CLAIMS ("AUTHORIZATION")

Purpose of this Authorization: To be eligible for the HEA ("Program"), KU or its affiliates ("Utility"), the Commonwealth of Kentucky including the Kentucky Public Service Commission or its affiliates, Community Action Kentucky, Inc. ("CAK") and your Community Action Agency Hardin County CKCAC ("CAA") (collectively, the "Parties") must share, exchange and use certain Information (defined below) about applicants and participants. We refer to the process of sharing, exchanging, and using Information as a "release" of Information. This release of Information may take place on paper or electronically. The purpose of this Authorization is to: a) get your permission for the Parties to release Information about you in connection with the Program; b) get your promise not to make a claim against the Parties arising from the release of Information; and c) ensure you understand that giving permission for the release of your Information does not guarantee your selection for or continued enrollment in the Program.

Definition of Information: For purposes of this Authorization, the term "Information" means information that includes all records about you and your electric/natural gas service account, including but not limited to your payment records, usage data, natural gas consumption or usage (AMP) estimates, meter reading dates, service disconnection data, past due payments, billing due dates and amounts, pledges and partial payment agreements, Information about your application and eligibility for available weatherization programs, existing third-party notification information, other benefits or subsidies you receive to cover your home heating costs, amounts of other assistance provided, any intake and benefit information from the Program, social security number, driver's license number, age, date of birth, health Information and information relating to disabilities (except for mental health or chemical dependency information from a health care provider), employment information, education level, criminal history, Income and financial Information and any information collected or generated by the IRS with regard to your tax liability.

Authorization Time Periods: If you sign this Authorization, the Parties may release your Information covering the following time periods: a) sixty (60) months before the date of this Authorization; and b) up through the latter of: (i) sixty (60) months after the date of this Authorization; or (ii) six months after the effective date that your participation in the Program ends.

By initialing below, I accept and agree as follows:

A. I acknowledge that it is necessary for a release of my Information by and between the Parties so that the Parties can determine whether I would benefit from the Program, determine the level of benefits for which I may be eligible, administer the Program and study the overall effectiveness of the Program. I further understand that by authorizing the release my Information, I am not being assured of selection for, or continued enrollment in, the Program.

B. The Parties have my express permission to release the Information for the purposes described in this Authorization.

C. In consideration with processing my application and determining my eligibility in the Program, I release the Parties (including their directors, officers, affiliates, employees and authorized agens) from any and all liability whatsoever for, and forever discharge and waive any claim that arises in connection with, the release of the Information for the purposes described in this Authorization ("Waiver of Claims").

D. I may withdraw this Authorization and, thus, withdraw from participation in the Program, by making a written request to my CAA. I understand that if I withdraw this Authorization, the Parties will cease to further release Information about me upon the expiration of six months after the effective date my participation in the Program ends except as may be required by law. I also understand that my withdrawl of this Authorization does not affect my Waiver of Claims above related to a release of Information that occurs before the expiration of six months after the effective date that my participation in the Program ends.

X

Initial of Applicant/Authorized Representative

DISCLAIMER

The Program, including benefit amounts and eligibility requirements, may be changed from time-to-time, which changes in some cases may require the approval by the Kentucky Public Service Commission. Benefits will be paid only so long as funding is available and you remain eligible for the benefits. Participation in a Program during any Program Year does not make you eligible to participate in any Program during a subsequent Program Year, and you will be required to reapply, and your eligibility for benefits from any Program will be reassessed for each Program Year.

No part of any Program benefit will be refunded or paid to you in cash. If a final bill otherwise shows a credit balance, part or all of which is the result of the application of a Program benefit, a refund will be made of only that portion, if any, of the final credit balance that exceeds the total Program benefits applied during the current Program Year.

X Nataliya Williams / 12-5-24

Signature of Applicant/Authorized Representative **Date**

Print name and relationship to Applicant of person signing above:

X Nataliya Williams / Select Self

Printed Name **Relationship (POA, Spouse, Child, etc.)**

KU

a PPL company

Mailed 12/19/24 for Account [redacted]

AMOUNT DUE	DUE DATE
$123.54	**1/16/25**

BILLING SUMMARY

Previous Balance	188.45
Payment(s) Received	0.00
Balance as of 12/18/24	**$188.45**
Current Electric Charges	96.33
Current Taxes and Fees	5.76
Total Current Charges as of 12/18/24	**$102.09**
Total Amount Due	**$290.54**
Pending Pledges	-167.00
Total Pending Balance	**$123.54**

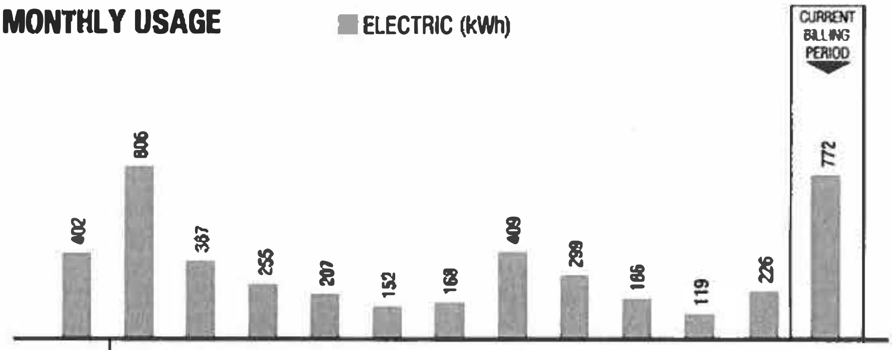
Past due balance subject to disconnection. See IMPORTANT INFORMATION.

App, online or phone payments made before 7 pm ET will be posted sam

Account Name:	**NATALIYA WILLIAMS**
Service Address:	107 Kenilworth Ct Apt C RADCLIFF KY
Payment Options *(fees may apply)*	Mobile app - LG&E KU ODP mobile app Online - lge-ku.com Phone - (800) 981-0600, press 1-2-3
Customer Service:	For fastest service, use our mobile app, websi automated phone system (800) 981-0600 24 hours a day. Phone reps available M-F, 7am - 7pm ET.

Next read will occur 1/17/25 - 1/22/25 (Meter Read Portion 13)

MONTHLY USAGE



	DEC 2023	JAN 2024	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
AVERAGE ▶	43°	34°	45°	51°	55°	66°	72°	80°	78°	74°	66°	80°	42°
▷	1.96	2.96	1.86	1.55	1.29	1.04	1.17	2.03	1.51	1.18	0.98	1.36	3.01

BILLING PERIOD AT-A-GLANCE

	THIS YEAR	LAST YEAR
Average Temperature	**42°**	**43°**
Number of Days Billed	32	29
▨ **Avg. Electric Charges per Day**	**$3.01**	**$1.96**
Avg. Electric Usage per Day (kWh)	24.13	13.86

Please return only this portion with your payment. Make checks payable to KU and write your account number on your check.

Amount Due **1/16/25**	**$123.54**
After Due Date, Pay this Amount:	$123.54
WinterCare Donation:	
Total Amount Enclosed:	

Account [redacted]
Service Address: 107 Kenilworth Ct Apt C

KU
~~a PPL company~~
PO Box 771670
St. Louis, MO 63177-1670

NATALIYA WILLIAMS
107 KENILWORTH CT APT C
RADCLIFF, KY 40160-8116

[redacted]

CURRENT USAGE

ELECTRIC

Meter Reading Infonnation	**Meter # 5369935**
Actual (R) kWh Reading on 12/17/24	2103
Actual (R) kWh Reading on 11/15/24	1331
Current kWh Usage	772
Meter Multiplier	1
Metered kWh Usage	**772**

CURRENT CHARGES

ELECTRIC **Rate: Residential Service - All Electric**

Basic Service Charge ($0.53 x 32 Days)	16.96
Energy Charge ($0.10533 x 772 kWh)	81.31
Electric DSM ($0.00165 x 772 kWh)	1.27
Fuel Adjustment ($-0.00429 x 772 kWh)	-3.31
Environmental Surcharge (0.210% CR x $96.23)	-0.20
Home Energy Assistance Fund Charge	0.30
Total Charges	**$96.33**

Taxes & Fees

Rate Increase For School Tax (3.00% x $96.03)	2.88
Franchise Fee-Radcliff (3.00% x $96.03)	2.88
Total Taxes and Fees	**$5.76**

BILLING INFORMATION

Rate Schedules

For a copy of your rate schedule, visit lge-ku.com/rates or call our Customer Service Department.

Want to pay cash? Visit checkfreepay.com/en/payment-locator to find locations near you. By accepting or using this barcode to make a payment, you agree to the full terms and conditions, available at vanilladirect.com/pay/terms. After successful payment using this barcode, you may retrieve your full detailed eReceipt at vanilladirect.com/pay/ereceipt. There is a limit of $500 at some locations. Customer Fee: $1.95. Learn more at lge-ku.com/inperson.

79936614458000637168832O341787

OFFICE USE ONLY:
MRU13241223, G000000
P188.45
PF:N eB:E

This barcode can be used at locations such as:

CVS DOLLAR GENERAL
FAMILY DOLLAR Walgreens

WinterCare Assistance Fund

Help your neighbors stay warm with KU's WinterCare program. KU matches customers' donations. Make your donation TODAY!

lge-ku.com/wintercare

IMPORTANT INFORMATION

Past Due Balance Subject to Disconnection - Immediate Action Required

The due date shown above applies only to the current charges. To avoid disconnection, the ENTIRE past due balance must be paid in full. You may be eligible for a new payment arrangement if previous arrangements have been paid in full. Use our mobile app, online My Account or our automated phone system for payments and/or arrangements.

Late Payment Charge Waiver

The Late Payment Charge waiver on this account will expire on 12/11/25.

Pending Pledges

There is a pending pledge on this account. We had not received the pledge payment by the time this bill was prepared. Pledges made on a customer's account are reflected as "pending" until the pledge payment is received or the pledge is canceled. When the pledge payment is received, the amount of the pledge will be reflected in the "Payments" section of the next bill. If the pledge payment is not received within 40 days from the date the pledge is made, the pledge is canceled and the total amount of the pledge is added to the next bill.

Late payment fees will be applied to the current charges if the current amount due, including the amount of the pending pledge is not received by the payment due date on this bill.

The total amount of this bill includes an unpaid balance, which may lead to a disconnection of service. Please contact us if you have any questions or to discuss payment arrangements.

a PPL company

Mailed 1/21/25 for Account [redacted]

AMOUNT DUE	DUE DATE
$219.85	**2/14/25**

BILLING SUMMARY

Previous Balance	290.54
Payment(s) Received	0.00
Balance as of 1/20/25	**$290.54**
Current Electric Charges	90.87
Current Taxes and Fees	5.44
Total Current Charges as of 1/20/25	**$96.31**
Total Amount Due	**$386.85**
Pending Pledges	-167.00
Total Pending Balance	**$219.85**

App, online or phone payments made before 7 pm ET will be posted sam

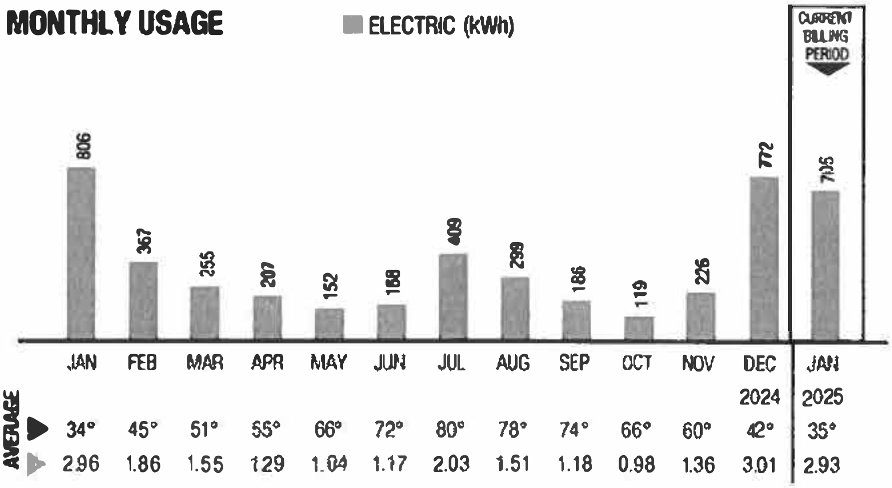
Account Name:	**NATALIYA WILLIAMS**
Service Address:	107 Kenilworth Ct Apt C RADCLIFF KY
Payment Options *(fees may apply)*	Mobile app - LG&E KU ODP mobile app Online - lge-ku.com Phone - (800) 981-0600, press 1-2-3
Customer Service:	For fastest service, use our mobile app, webs automated phone system (800) 981-0600 24 hours a day. Phone reps available M-F, 7am - 7pm ET.

Next read will occur 2/18/25 - 2/20/25 (Meter Read Portion 13)

BILLING PERIOD AT-A-GLANCE

	THIS YEAR	LAST YEAR
Average Temperature	**35°**	**34°**
Number of Days Billed	31	34
■ **Avg. Electric Charges per Day**	**$2.93**	**$2.96**
Avg. Electric Usage per Day (kWh)	22.74	23.71

MONTHLY USAGE



Please return only this portion with your payment. Make checks payable to KU and write your account number on your check.

Amount Due **2/14/25**	**$219.85**
After Due Date, Pay this Amount:	$219.85
WinterCare Donation:	
Total Amount Enclosed:	

Accoun[redacted]
Service Address: 107 Kenilworth Ct Apt C

a PPL company
PO Box 771670
St. Louis, MO 63177-1670

NATALIYA WILLIAMS
107 KENILWORTH CT APT C
RADCLIFF, KY 40160-8116

[redacted]

CURRENT USAGE

ELECTRIC

Meter Reading Information	**Meter # 5369995**
Actual (R) KWh Reading on 1/17/25	2808
Actual (R) KWh Reading on 12/17/24	2103
Current kWh Usage	705
Meter Multiplier	1
Metered kWh Usage	705

CURRENT CHARGES

ELECTRIC **Rate: Residential Service - All Electric**

Basic Service Charge ($0.53 x 31 Days)	16.43
Energy Charge ($0.10533 x 705 kWh)	74.26
Electric DSM ($0.00165 x 264 kWh)	0.44
Electric DSM ($0.00243 x 441 kWh)	1.07
Fuel Adjustment ($-0.00282 x 705 kWh)	-1.99
Environmental Surcharge (0.400% x $90.21)	0.36
Home Energy Assistance Fund Charge	0.30
Total Charges	**$90.87**

Taxes & Fees

Rate Increase For School Tax (3.00% x $90.57)	2.72
Franchise Fee-Radcliff (3.00% x $90.57)	2.72
Total Taxes and Fees	**$5.44**

BILLING INFORMATION

Rate Schedules
For a copy of your rate schedule, visit lge-ku.com/rates or call our Customer Service Department.

Want to pay cash? Visit checkfreepay.com/en/payment-locator to find locations near you. By accepting or using this barcode to make a payment, you agree to the full terms and conditions, available at vanilladirect.com/pay/terms. After successful payment using this barcode, you may retrieve your full detailed eReceipt at vanilladirect.com/pay/ereceipt. There is a limit of $500 at some locations. Customer Fee: $1.95. Learn more at lge-ku.com/inperson.

799366144580006371688320341787

OFFICE USE ONLY:
MRU13241223, G000000
P290.54
PF:N eB:E

This barcode can be used at locations such as:

CVS DOLLAR GENERAL
FAMILY DOLLAR Walgreens

COLD WEATHER TIPS

Replace furnace filters every 30 days or so. Use the day you receive your bill from us as a reminder!

Visit **lge-ku.com/tips** for more cool weather tips.

IMPORTANT INFORMATION

Late Payment Charge Waiver
The Late Payment Charge waiver on this account will expire on 12/11/25.

Pending Pledges
There is a pending pledge on this account. We had not received the pledge payment by the time this bill was prepared. Pledges made on a customer's account are reflected as "pending" until the pledge payment is received or the pledge is canceled. When the pledge payment is received, the amount of the pledge will be reflected in the "Payments" section of the next bill. If the pledge payment is not received within 40 days from the date the pledge is made, the pledge is canceled and the total amount of the pledge is added to the next bill.

Late payment fees will be applied to the current charges if the current amount due, including the amount of the pending pledge is not received by the payment due date on this bill.

The total amount of this bill includes an unpaid balance, which may lead to a disconnection of service. Please contact us if you have any questions or to discuss payment arrangements.

a PPL company

BILLING SUMMARY

Previous Balance	386.85
Payment(s) Received	-167.00
Balance as of 2/19/25	**$219.85**
Current Electric Charges	101.69
Current Taxes and Fees	6.08
Total Current Charges as of 2/19/25	**$107.77**
Total Amount Due	**$327.62**

Mailed **2/20/25** for Account [redacted]

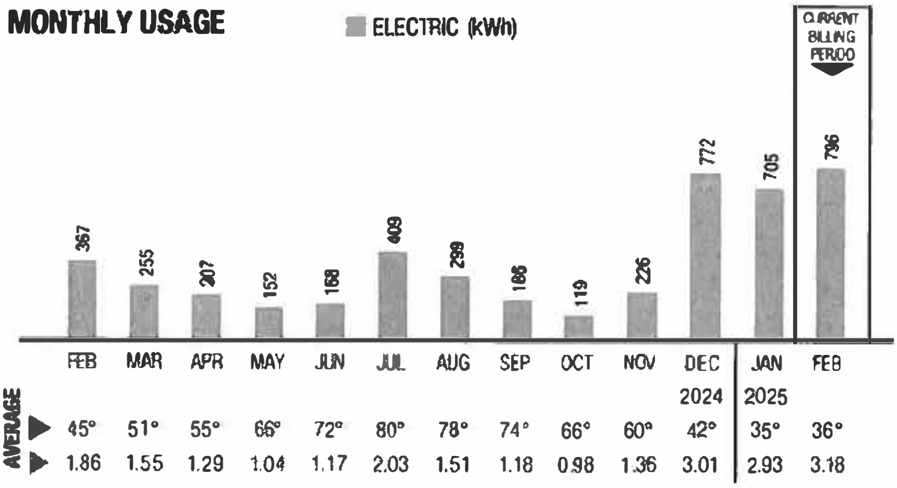
AMOUNT DUE	DUE DATE
$327.62	**3/17/25**

App, online or phone payments made before 7 pm ET will be posted san

Account Name:	NATALIYA WILLIAMS
Service Address:	107 Kenilworth Ct Apt C RADCLIFF KY
Payment Options *(fees may apply)*	Mobile app - LG&E KU ODP mobile app Online - lge-ku.com Phone - (800) 981-0600, press 1-2-3
Customer Service:	For fastest service, use our mobile app, web: automated phone system (800) 981-0600 24 hours a day. Phone reps available M-F, 7am - 7pm ET.

Next read will occur 3/19/25 - 3/21/25 (Meter Read Portion 13)

MONTHLY USAGE



BILLING PERIOD AT-A-GLANCE

	THIS YEAR	LAST YEAR
Average Temperature	**36°**	**45°**
Number of Days Billed	32	29
▨ **Avg. Electric Charges per Day**	**$3.18**	**$1.86**
Avg. Electric Usage per Day (kWh)	24.88	12.66

Please return only this portion with your payment. Make checks payable to KU and write your account number on your check.

Amount Due **3/17/25**	**$327.62**
After Due Date, Pay this Amount:	$327.62
WinterCare Donation:	
Total Amount Enclosed:	

Account [redacted]
Service Address: 107 Kenilworth Ct Apt C

a PPL company
PO Box 771670
St. Louis, MO 63177-1670

NATALIYA WILLIAMS
107 KENILWORTH CT APT C
RADCLIFF , KY 40160-8116

[redacted]

CURRENT USAGE

ELECTRIC

Meter Reading Information	Meter # 5369995
Actual (R) kWh Reading on 2/18/25	3604
Actual (R) kWh Reading on 1/17/25	2808
Current kWh Usage	796
Meter Multiplier	1
Metered kWh Usage	**796**

CURRENT CHARGES

ELECTRIC Rate: Residential Service - All Electric

Basic Service Charge ($0.53 x 32 Days)	16.96
Energy Charge ($0.10533 x 796 kWh)	83.84
Electric DSM ($0.00243 x 796 kWh)	1.93
Fuel Adjustment ($-0.00043 x 796 kWh)	-0.34
Environmental Surcharge (0.980% CR x $102.39)	-1.00
Home Energy Assistance Fund Charge	0.30
Total Charges	**$101.69**

Taxes & Fees

Rate Increase For School Tax (3.00% x $101.39)	3.04
Franchise Fee-Radcliff (3.00% x $101.39)	3.04
Total Taxes and Fees	**$6.08**

BILLING INFORMATION

Rate Schedules

For a copy of your rate schedule, visit lge-ku.com/rates or call our Customer Service Department.

IMPORTANT INFORMATION

Late Payment Charge Waiver

The Late Payment Charge waiver on this account will expire on 12/11/25.

Want to pay cash? Visit checkfreepay.com/en/payment-locator to find locations near you. By accepting or using this barcode to make a payment, you agree to the full terms and conditions, available at vanilladirect.com/pay/terms. After successful payment using this barcode, you may retrieve your full detailed eReceipt at vanilladirect.com/pay/ereceipt. There is a limit of $500 at some locations. Customer Fee: $1.95. Learn more at lge-ku.com/inperson.

799366144580006371688320341787

OFFICE USE ONLY:
MRU13241223, G000000
P386.85
PF:N eB:E

This barcode can be used at locations such as:

CVS DOLLAR GENERAL
FAMILY DOLLAR Walgreens

Standard Rate

RS
Residential Service

APPLICABLE
In all territory served.

AVAILABILITY
Available for single-phase secondary delivery to single family residential service subject to the terms and conditions on Sheet No. 100 of this Tariff. Three-phase service under this rate schedule is restricted to those Customers being billed on this rate schedule as of July 1, 2004.

RATE

Basic Service Charge per day:	$0.53			
Plus an Energy Charge per kWh:	Infrastructure	Variable	Total	
	$0.06556	$0.03653	$0.10209	I/I

"Variable" shall be the rate comprised of costs, such as fuel, that fluctuate with the production of energy used by customers.

"Infrastructure" shall be the rate comprised of costs associated with meeting system demand that do not fluctuate directly with energy usage as well as the portion of fixed customer-related expenses not recovered in the Basic Service Charge.

ADJUSTMENT CLAUSES
The bill amount computed at the charges specified above shall be increased or decreased in accordance with the following:

Demand-Side Management Cost Recovery Mechanism	Sheet No. 86
Fuel Adjustment Clause	Sheet No. 85
Off-System Sales Adjustment Clause	Sheet No. 88
Environmental Cost Recovery Surcharge	Sheet No. 87
Home Energy Assistance Program	Sheet No. 92
Franchise Fee	Sheet No. 90
School Tax	Sheet No. 91

MINIMUM CHARGE
The Basic Service Charge shall be the minimum charge.

DUE DATE OF BILL
Customer's payment will be due within sixteen (16) business days (no less than twenty-two (22) calendar days) from the date of the bill.

DATE OF ISSUE: May 24, 2024

DATE EFFECTIVE: With Service Rendered
On and After June 1, 2024

ISSUED BY: /s/ Robert M. Conroy, Vice President
State Regulation and Rates
Lexington, Kentucky

Issued by Authority of an Order of the Public Service Commission in Case No. 2023-00010 dated May 6, 2024

KENTUCKY
PUBLIC SERVICE COMMISSION
Linda C. Bridwell
Executive Director
EFFECTIVE
6/1/2024
PURSUANT TO 807 KAR 5:011 SECTION 9 (1)

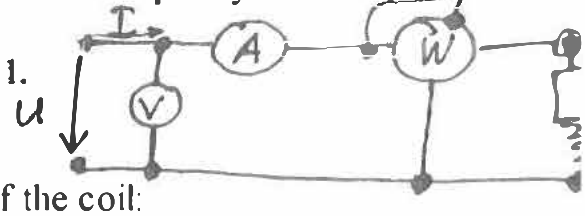
Solving problems on the topic "Alternating current and its characteristics"

Purpose: to acquaint students with solving problems of a practical nature, teach them to solve analytical and graphical problems, to build vector diagrams of current and voltage; **Developmental:** to develop critical thinking, the ability to use theoretical knowledge to solve graphic composition problems, to conduct analysis and make generalizing conclusions after solving the problem;

Educational: to cultivate responsibility, perseverance, the ability to plan one's own activities, to make decisions, to apply the acquired knowledge in practice. When solving problems on the topic "Alternating current", it is important to draw students' attention to the fact that sometimes it is necessary to determine the current values of measuring devices, to build vector diagrams of currents and voltages, to draw conclusions about whether the circuit diagram is capable of working under certain conditions. In my opinion, the given tasks can help at the initial stage to establish knowledge that will help solve problems of applied value in future activities, while students will not have a feeling of insecurity in the face of difficulties of this nature. So let's consider our tasks.

Problem 1 The voltage, current and power in the circuit **(Fig. 1)** with an inductance coil were experimentally measured: U = 100 (V), I = 10 (A), P = 600 (W). Determine the parameters of the coil R and L, if the frequency of the current in the circuit f = 50 (Hz).

Figure 1 – Electric circuit diagram for problem 1.



The solution. Let's determine the total resistance of the coil:

$$z = \frac{u}{I} = \frac{100}{10} = 10 \text{ Ом}$$

The active resistance of the coil can be determined from the ratio for active power.

$$P = I^2 \cdot R \qquad R = \frac{P}{I^2} = \frac{600}{10^2} = 6 \text{ Ohm}$$

We determine the reactive resistance of the coil from the triangle of resistances:

$$X = \sqrt{Z^2 - R^2} = \sqrt{10^2 - 6^2} = 8 \text{ Ohm}$$

Coil inductance:

$$X = \omega \cdot L = 2\pi \cdot f \cdot L \qquad L = \frac{X}{2\pi f} = \frac{8}{2\pi f} = 0{,}0255 \text{ Hz}$$

You can solve this problem in another way - using the ratio for active power:

$$P = U \cdot I \cos\varphi \qquad \cos\varphi = \frac{P}{U \cdot I} = \frac{600}{100 \cdot 10} = 0{,}6$$

From the known values of cosφ, we determine sinφ.

$$\sin\varphi = 0{,}8$$

Active and reactive resistance of the coil:

$$R = z \cdot \cos\varphi = 10 \cdot 0{,}6 = 6 \text{ Ohm} \qquad X = z \cdot \sin\varphi = 10 \cdot 0{,}8 = 8$$

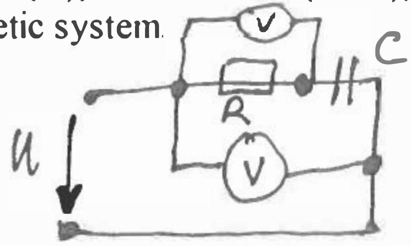
Coil inductance:

$$X = \omega \cdot L = 2\pi \cdot f L \qquad L = \frac{X}{2\pi \cdot f} = \frac{8}{2\pi \cdot 50} = 0{,}0255 \text{ Hz}$$

Answer: R = 6 (Ohm), L = 0.0255 (H[illegible]).

Problem 2 What is the value of the voltmeter V2 included in the sinusoidal current circuit **(Fig. 2)**, if the voltmeter V1 shows 60 (V); while R = 30 (Ohm); CS = 40 (Ohm). Both voltmeters of the electromagnetic system.

Figure 2 – Circuit diagram for problem 2



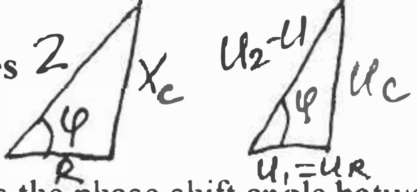
The solution

$Z=\sqrt{R^2+X_c^2}=\sqrt{30^2+40^2}=50$

Total ~~circuit resistance~~:

We have a right-angled triangle for the circuit **(Fig. 3)**, where the active resistance R and the reactive resistance XC in the resistance scale represent the legs, and the total resistance Z is the hypotenuse.

Figure 3 – Triangles of resistances and voltages



From this triangle, we determine cosφ, where φ is the phase shift angle between current and voltage: $\cos\varphi=\frac{R}{Z}=\frac{30}{50}=0,6$

For one circuit, the resistance and voltage triangles are similar.

Taking into account the fact that the devices of the electromagnetic system show the current values of sinusoidal values, from the voltage triangle:

$$U=U_2=\frac{U_1}{\cos\varphi}=\frac{60}{0,6}=100\,B$$

Answer: U = 100 (B).

Problem 3 Draw the receiver replacement scheme, instantaneous current and voltage values $i=I_m\sin(\omega t+30°)$ (A)

if they have the following expressions: $u=U_m\cdot\sin(\omega t-30°)$ B

The solution $\varphi=\psi_u-\psi_i$

Let's determine the phase shift angle between current and voltage:

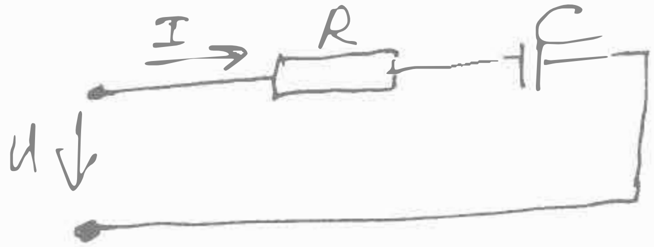
where ψu and ψi are voltage and current phases, respectively, $\psi_u=30$ $\psi_i=30$

$\varphi=\psi_u-\psi_i=-30°-30°=-60°$

The "minus" sign indicates either active-capacitive or purely capacitive nature of the load, in which the current sinusoid precedes the voltage sinusoid. If the value of φ was "-900", the circuit replacement circuit would have only capacitance C. With purely active resistance in the circuit, the phase shift angle would be zero. The value of the phase shift angle in the range from 0 to "-900" indicates that the substitution circuit has 2 elements: active resistance and capacitance (Fig. 4).

Figure 4 – Scheme of replacing the receiver

Answear:



Example 10.12.1: Power Losses Are Less for High-Voltage Transmission a) What current is required to transmit 100 MW of power at 200 kV? (b) What is the power dissipated in the transmission lines if they have a resistance of 1.00 Ω? (c) What percentage of power is lost in transmission lines?

Strategy

We are given Pave =100 MW,Vrms=200 kV, and the resistance of the lines is R=1.00 Ω. Using these data, we can find the current flowing (from P=IV), and then the power dissipated in the lines ($P=I^2R$), and we take the ratio to the total transmitted power.

Decision

To find the current, rearrange the ratio Pave = Irms×Vrms and substitute the known values. It gives $I_{rms} = \frac{P_{ave}}{V_{rms}} = \frac{100 \times 10^6 W}{200 \times 10^3 V} = 500 A$

Decision

Knowing the current and the specified resistance of the lines, the power dissipated in them is found from $P_{ave} = I^2_{rms} \times R$

Substitution of known values gives $P_{ave} = I^2_{rms} \times R = (500 A)^2 \times (1.00 \Omega) =$.

Decision

The loss percentage is the ratio of this lost power to the total or input power multiplied by 100: $\% loss = \frac{250 kW}{100 MW} \times 100 = 0.25\%$

Discussion

One-fourth of a percent is an acceptable loss. Note that if 100 MW of power was transmitted at 25 kV, a current of 4000 A would be required. This would result in a power loss in the lines of 16.0 MW, or 16.0%, not 0.250%. The lower the voltage, the more current is required, and the more power is lost in fixed resistance transmission lines.

Of course, lines with lower resistance can be built, but this requires larger and more expensive wires. If superconducting lines could be produced economically, there would be no losses in power transmission lines at all. But, as we will see in the next section, there is a current limit in superconductors too. In short, higher voltages are more economical to transmit power, and AC voltage is much easier to step up and down, so AC is used in most large-scale power distribution systems.

Summary section

Ohm's law for alternating current is $I_{rms} = \frac{V_{rms}}{R}$

The expressions for the average power of an AC circuit are ,

$P_{ave} = I_{rms} \times V_{rms} \times P_{ave} = \frac{V_{rms}^2}{R}$, i $P_{ave} = I^2_{rms} R$

similar to the expressions for direct current circuits.

Lecture 2 ELECTRIC CIRCUITS OF SINGLE-PHASE SINUSOIDAL CURRENT Modern electrification is created on alternating current, although historically its predecessor was direct current. Industrial power plants around the world produce sinusoidal alternating current electricity.

Alternating current has become the most widespread, because: 1 Alternating current is easier to create than direct current with the help of electric generators, the rotor of which is rotated by a third-party drive; 2 Alternating current can be easily converted into a current of another voltage with the help of transformers; 3 Alternating current can be transmitted over long distances with little loss. To do this, the alternating voltage U1 at power stations is increased to the value of U2 with the help of transformers, thereby reducing the value of the current from the value of I1 to I2. Power transmission is carried out with the help of high-voltage power lines with a relatively small current. At the same time, the losses, which are proportional to the square of the current $P=I^2R$, are significantly reduced.

Alternating current means a current whose value and direction change periodically. **The most common form of alternating current is sinusoidal, because: it is easiest to obtain this form of current; relative simplicity of calculating sinusoidal current circuits; The efficiency of electric machines and devices is higher with sinusoidal current.**

2.1. Characteristics and parameters of sinusoidal current It is possible to distinguish 4 forms of presentation of sinusoidal current: • mathematical - in the form of formulas; • graphic - in the form of graphs over time; • vector - in the form of vectors; • symbolic - in the form of complex numbers. Sinusoidal voltage and current in mathematical form have the following form:

$$u=U_m\sin\left(\frac{2\Pi}{T}t+\psi_u\right);\quad i=I_m\sin\left(\frac{2\Pi}{T}t+\psi_i\right)\qquad(2.1)$$

where u, i - instantaneous values of voltage and current - values at any moment of time;

Um, Im – amplitude values – the largest voltage and current values;

T - period - the time interval during which a complete cycle of change of the considered quantity takes place. The period is measured in seconds [s];

$f=\frac{1}{T}$ = – current frequency – number of periods per time unit (per second). Frequency is measured in hertz [Hz]. In Ukraine and most countries of the world, 50 Hz is accepted as the standard industrial frequency, and in the USA and Canada - 60 Hz.

$\frac{2\Pi}{T}=2\Pi f=\omega$ angular frequency – (one revolution per period). It is measured in [rad/s];

- the argument of the sine is a phase that characterizes the value of the function at a given time; $(\omega t+\psi_\omega)$

ψ_u, ψ_i – Primary voltage phase and, current (at t=0); The initial phase is this constant angle, on which sine wave on the beginning is shifted relative to the beginning
coordinates (at t=0) to the left $\psi > 0$ or to the right
$\psi < 0$.

Fig. 2.2. Graphic representation of currents and voltages at $\varphi=0$ (a), and $\varphi > 0$ (b)

Figure 2.2 shows a graphical representation of sinusoidal voltage and current. The phase shift φ is the difference between the initial phases of voltage and current

(2.2) $\varphi = \psi_u - \psi_i$

If the initial voltage and current phases are equal $\psi_u = \psi_i$ then the phase shift $\varphi=0$, and the current and voltage coincide in phase (Fig. 2.2, a).

If $\psi_u > \psi_i$ then $\varphi>0$, and the voltage is ahead of the current in phase the value of the angle φ (Fig. 2.2, b).

The phase shift φ between sinusoidal voltage and current is the same frequency does not depend on the selection of the start of accounting (t=0).

2.3. Representation of sinusoidal functions by vectors and complex numbers.

The same laws are used when calculating alternating current circuits Ohm and Kirchhoff, which are valid for instantaneous values of quantities. But in this in this case, it is necessary to perform complex trigonometric operations.

The calculation is simplified if the currents, voltages and emfs are presented by vectors rotating counterclockwise with a constant angle at speed ω - one revolution per period (Fig. 2.4).

Let's write down the expression for the sinusoidal current $i = I_m \sin(\omega_t + \psi_i)$

In moment t=0 current i=Im*sin*ωi. This is the projection of the current on the vertical axis. Suppose that the radius vector with length i=Im rotates with a constant angular frequency $\omega = \frac{2\pi}{T} = 2\pi f$
against the direction of rotation of the time arrow - one turns per period. At the moment of time t1 is a vector will return to the angle ωt1 and current projection on the vertical axis will be add $I_m \sin(\omega t_1 + \psi_i)$

Using vectors that rotates, allows compactly present in one drawing a set of different sinusoidal variable values of the same frequency in the analysis of electric circuits sinusoidal current.

Fig. 2.4. The rotation vector Em and the graph of the function $e = E_m \sin \omega t$

A vector can be represented as a complex number. On $i = I_m \sin(\omega t + \psi_i)$ complex current plane $I_m = I_m e^{j\omega i}$ corresponds to a complex number $t=0$ **(Fig. 2.5.).** The effective length of the vector in defined scale is equal to the amplitude value of the current, and the initial phase ψi is the angle between the axis of real numbers and vector.

Fig. 2.5. Current image in the form of a complex numbers.

Синусоїдальні напруга і струм в математичній формі мають наступний вигляд:

$$u = U_m \sin\left(\frac{2\pi}{T}t + \psi_u\right); \quad i = I_m \sin\left(\frac{2\pi}{T}t + \psi_i\right), \qquad (2.1)$$

де u, i – миттєві значення напруги і струму – значення у будь-який момент часу;

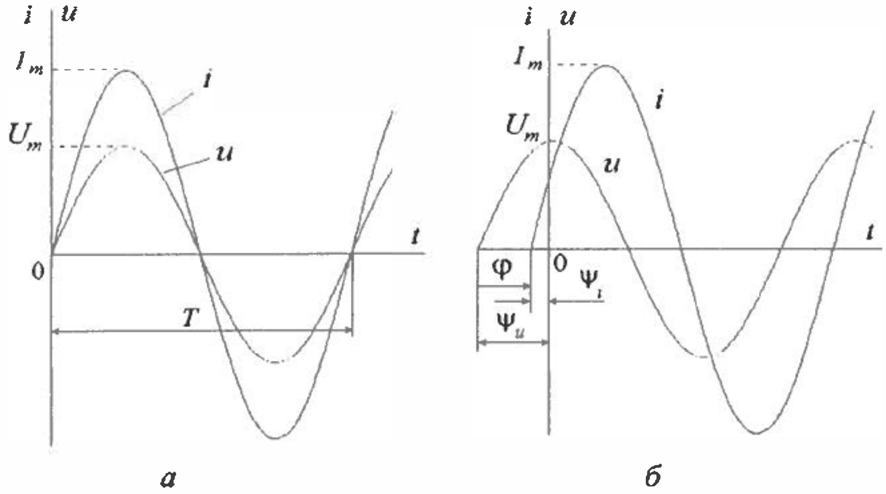
U_m, I_m – амплітудні значення – найбільші значення напруги і струму;

T – період – проміжок часу, за який відбувається повний цикл змінення величини, що розглядається. Період вимірюється в секундах [с];

$f = \frac{1}{T}$ – частота струму – число періодів за одиницю часу (за секунду). Частота вимірюється в герцах [Гц]. В Україні і більшості країн світу як стандартна промислова частота прийнято 50 Гц, а в США та Канаді – 60 Гц.

$\frac{2\pi}{T} = 2\pi f = \omega$ – кутова частота – (один оберт за період). Вимірюється в [рад/с];

$(\omega t + \psi_u)$ – аргумент синуса – це фаза, характеризує значення функції у даний момент часу;



а б

Рис.2.2. Графічне представлення струмів та напруг при φ=0 (*а*), та φ>0 (*б*)

ψ_u, ψ_i – початкова фаза напруги і струму (при t=0); Початкова фаза – це постійний кут, на який синусоїда на початку зсунута відносно початку координат (при t=0) вліво $\psi > 0$ або вправо $\psi < 0$.

На рис.2.2 показане графічне зображення синусоїдальних напруги та струму.

Зсувом фаз φ називається різниця початкових фаз напруги та струму

$$\varphi = \psi_u - \psi_i . \qquad (2.2)$$

Якщо початкові фази напруги та струму рівні $\psi_u = \psi_i$, то зсув фаз φ=0, і струм та напруга співпадають за фазою (рис.2.2,*а*).

Якщо $\psi_u > \psi_i$, то $\varphi>0$, і напруга випереджає за фазою струм на значення кута φ (рис.2.2,*б*).

Зсув фаз φ між синусоїдальними напругою та струмом однакової частоти не залежить від вибору початку обліку (t=0).

2.3. Зображення синусоїдальних функцій векторами і комплексними числами

При розрахунку кіл змінного струму використовують ті ж самі закони Ома і Кірхгофа, що справедливі для миттєвих значень величин. Але в цьому випадку необхідно виконувати складні тригонометричні операції.

Розрахунок спрощується, якщо струми, напруги та ЕРС представити векторами, що обертаються проти годинникової стрілки з постійною кутовою швидкістю ω - один оборот за період (рис.2.4).

Запишемо вираз для синусоїдального струму $i = I_m \sin(\omega t + \psi_i)$. У момент t=0 струм $i=I_m\ sin\ \omega_i$. Це є проєкцією струму на вертикальну вісь. Припустимо, що радіус-вектор довжиною $i=I_m$ обертається з постійною кутовою частотою $\omega = \frac{2\pi}{T} = 2\pi f$ проти напряму обертання часової стрілки – один оберт за період. В момент часу t_1 вектор повернеться на кут ωt_1 і проєкція струму на вертикальну вісь буде складати $I_m sin(\omega t_1+\psi_i)$.

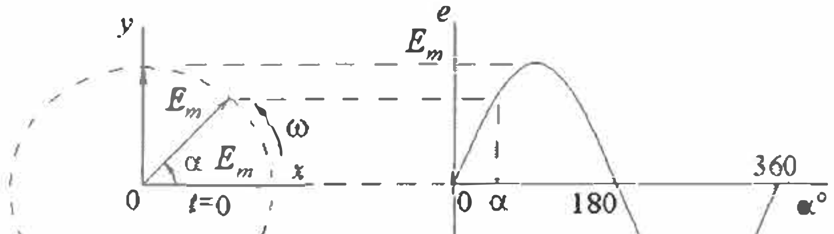


Рис.2.4. Обертовий вектор E_m та графік функції $e = E_m \sin \omega t$

Використання векторів, що обертаються, дозволяє компактно представити на одному рисунку сукупність різних синусоїдально змінних величин однакової частоти при аналізі електричних кіл синусоїдального струму.

Вектор можна представити у вигляді комплексного числа. На комплексній площині струму $i = I_m \sin(\omega t + \psi_i)$ відповідає комплексне число $\underline{I}_m = I_m e^{j\psi_i}$ при t=0 (рис.2.5.). Дійсна довжина вектора у визначеному масштабі дорівнює амплітудному значенню струму, а початкова фаза ψ_i – куту між віссю дійсних чисел та вектором.

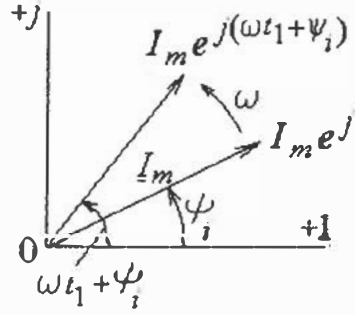


Рис.2.5. Зображення струму у вигляді комплексного числа

При t=0 проекція вектора на уявну вісь дорівнює миттєвому значенню струму: $i(0) = I_m \sin \psi_i$.

Відтак, якщо радіус-вектор обертати проти часової стрілки з кутовою швидкістю ω, то в будь-який момент часу проекція цього вектора на уявну вісь буде дорівнювати миттєвому значенню струму у момент часу, що розглядається.

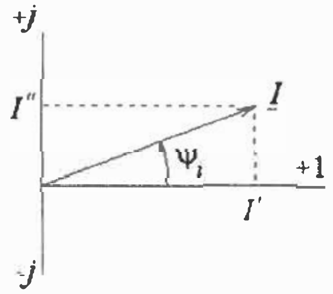


Рис.2.6. Зображення струму на комплексній площині

Існують 3 форми запису комплексного числа, наприклад для струму (рис.2.6):

$\underline{I} = I_m e^{j\psi_i}$ - показова форма;

$\underline{I} = I_m(\cos\psi_i + j\sin\psi_i)$ - тригонометрична форма;

$\underline{I} = I' + jI''$ - алгебраїчна форма,

де I', I'' - відповідно дійсна та уявна складова комплексного струму.

Ці форми виражають одне й те ж значення струму, тому що між ними існує зв'язок

$$\underline{I} = I_m e^{j\psi_i} = I_m(\cos\psi_i + j\sin\psi_i) = I' + jI'' \qquad (2.11)$$

Домовились синусоїдальні струм, ЕРС і напругу позначати для моменту часу t=0, тобто струму $i = I_m \sin(\omega t + \psi_i)$ відповідає вектор $\underline{I} = I_m e^{j\psi_i}$.

I_m – комплексна амплітуда струму. Розділивши на $\sqrt{2}$ отримаємо комплексне діюче значення струму: $\underline{I} = \frac{I_m}{\sqrt{2}} e^{j\psi_i} = I e^{j\psi_i}$.

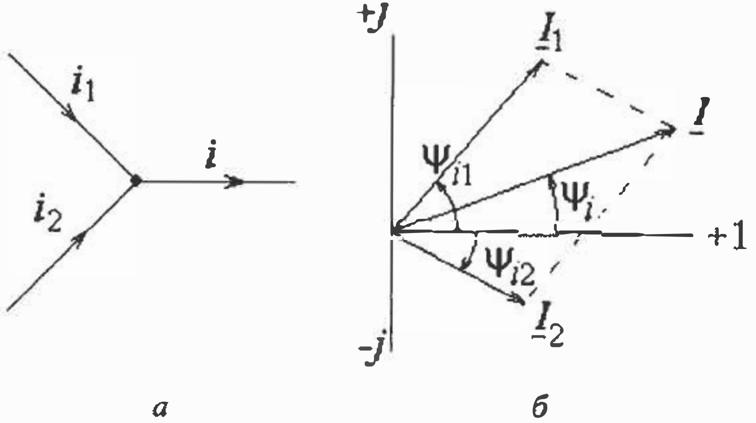
At t=0, the projection of the vector onto the imaginary axis is equal instantaneous current value: $i(0)=I_m \sin\psi_i$ Therefore, if the radius vector is rotated against of the time arrow with angular velocity ω, then at any moment of time the projection of this vector on the imaginary axis will be equal to the instantaneous value of the current y the point in time under consideration. There are 3 forms of writing a complex number, for example, for current **(Fig. 2.6)**: - demonstrative form; $\underline{I} = I_m e^{j}$ - trigonometric form; $\underline{I} = I_m(\cos\omega_i + j\sin\psi_i)$ algebraic form, $\underline{I} = I' + I''_j$ Where $\underline{I}', \underline{I}''$ - respectively real and imaginary component complex current. These forms express the same current value, therefore that there is a connection between them $\underline{I} = I_m e^{j\psi_i} = I_m(\cos\psi_i + j\sin\psi_i) = \underline{I}' + j\underline{I}''$ (2.11)
It was agreed that the sinusoidal current, EMF and voltage should be indicated for moment of time t=0, i.e. current $i = I_m \sin(\omega t + \psi_i)$ corresponds to a vector $\underline{I} = I_m e^{j\omega_i}$
Im is the complex current amplitude. Dividing by $\sqrt{2}$ we will get a comprehensive effective current value: $\underline{I} = \frac{I_m}{\sqrt{2}} e^{j\omega_i} = I e^{j\omega_i}$
If we have two currents: $i_1 = I_{m1}\sin(\omega t + \psi_1)$ and $i_2 = I_{m2}\sin(\omega t + \psi_2$
then them sum according to Kirchhoff's first law $i = i_1 + i_2$ determined by the rule addition of vectors or of complex numbers **(Fig. 2.7).** With vector diagram is possible graphically both the amplitude Im and initial phase ψi of current i. Algebraic sum of currents corresponds to the geometric sum vectors that represent the specified functions.

Fig. 2.7. The section of an electric circuit (a) is vector its current diagram (b)

The set of vectors on complex plane is called a vector diagram. Vector quantities on the diagram are indicated by uppercase letters with a dash below. Usually, on the vector diagram, not the amplitude, but the current is delayed values of quantities. When constructing it, the direction of one of the vectors is chosen arbitrarily, and other vectors are located to it at angles which are equal to the corresponding phase shifts. Representation of sinusoidal electric quantities in the form of rotating ones of vectors makes it possible to add and subtraction of identical values. Calculation method based on the representation of functions as complex numbers, called complex or symbolic. **2.4. Elements of an alternating current circuit.** In the process of calculation and analysis, the real circle is replaced an equivalent circuit containing a number of elements. To passive elements of the electric circuit include: active resistance, inductance and capacitance. **Active resistance R (Fig. 2.8, a)** characterizes the property the element irreversibly transforms electrical energy into thermal Active resistance is a resistive parameter element R in an alternating current circuit. The relationship between voltage and current on a resistive circuit element has the form: (2.12) $u_a = i$
At the same time, it is necessary to take into account that the resistance of a resistive element on alternating current is higher than it DC resistance. This is due to the effect current displacement at high frequencies to the external the surface of

Якщо маємо два струми: $i_1 = I_{m1}\sin\left(\omega t + \psi_1\right)$ і $i_2 = I_{m2}\sin\left(\omega t + \psi_2\right)$, то їх сума за першим законом Кірхгофа $i = i_1 + i_2$ визначається за правилом додавання векторів або комплексних чисел (рис.2.7). З векторної діаграми можна графічно як амплітуду I_m, так і початкову фазу ψ_i струму *i*.

Алгебраїчній сумі струмів відповідає геометрична сума векторів, які зображають вказані функції.



а *б*

Рис.2.7. Ділянка електричного кола (*а*) та векторна діаграма її струмів (*б*)

Сукупність векторів на комплексній площині називають ***векторною діаграмою.*** Векторні величини на діаграмі позначають прописними літерами зі рискою знизу.

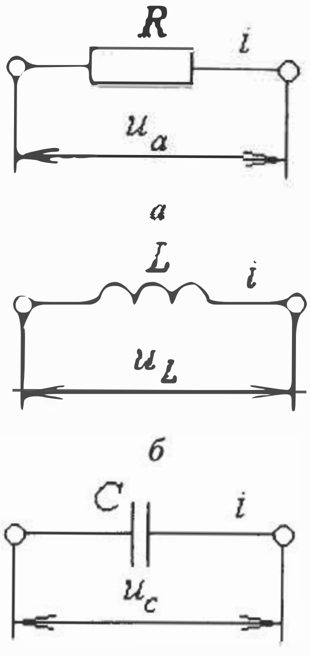
Зазвичай на векторній діаграмі відкладають не амплітудні, а діючі значення величин. При її побудові напрям одного з векторів вибирають довільно, а інші вектори розташовуються до нього під кутами, які дорівнюють відповідним зсувам фаз.

Уявлення синусоїдальних електричних величин у вигляді обертових векторів дає можливість на векторних діаграмах здійснювати складання та віднімання однойменних величин.

Метод розрахунку, базований на представленні функцій комплексними числами, називають комплексним або символічним.

2.4. Елементи кола змінного струму

У процесі розрахунку і аналізу реальне коло заміюється еквівалентною схемою, яка вміщує ряд елементів. До пасивних елементів електричного кола відносять: активний опір, індуктивність та ємність.



а

б

в

Рис.2.8. Активний опір (*а*), індуктивність (*б*) та ємність (*в*)

Активний опір

Активний опір *R* (рис.2.8,*а*) характеризує властивість елемента незворотне перетворювати електричну енергію у теплову. Активний опір є параметром резистивного елемента *R* в колі змінного струму.

Зв'язок між напругою і струмом на резистивному елементі має вигляд:

$$u_a = i \cdot R\,. \tag{2.12}$$

При цьому необхідно враховувати, що опір резистивного елемента на змінному струмі вищий за його опір на постійному струмі. Це пояснюється ефектом витіснення струму на високих частотах на зовнішню поверхню елемента, що призводить до фактичного зменшення площі поперечного перетину, по якій протікає струм.

Індуктивність

Індуктивність *L* (рис.2.8,*б*) характеризує властивість елемента електричного кола, наприклад, котушки індуктивності, під дією струму в ньому створювати власне магнітне поле:

$$L = \frac{\Psi}{i}, \tag{2.13}$$

де Ψ – потокозчеплення самоіндукції елемента. Індуктивність вимірюється в генрі [Гн].

При змінюванні потокозчеплення Ψ у витках котушки за законом електромагнітної індукції наводиться ЕРС самоіндукції

$$e_L = -\frac{d\Psi}{dt}. \tag{2.14}$$

Індуктивність враховує енергію магнітного поля $W = \frac{L \cdot i^2}{2}$ і явище the element, which leads to the actual reduction of the cross-sectional area over which it flows current. **Fig. 2.8. Active resistance (a), inductance (b) and capacity**

Inductance The Inductance L (Fig. 2.8, b) characterizes the property of the element of an electric circuit, for example, an inductor, under the action of a current in it can create its own magnetic field: $L=\frac{\Psi}{i}$ (2.13) where Ψ is the flux coupling of the element's self-induction. Inductance measured in henry [Hn]. When changing the flux linkage Ψ in the turns of the coil according to the law of electromagnetic induction, the EMF of self-induction is induced $e_L=\frac{d\Psi}{dt}$ (2.14) Inductance takes into account the energy of the magnetic field $W=\frac{Li^2}{2}$ and phenomenon, And self-induction, that is, when current flows in the inductance, an emf is induced: $e_L=-L\frac{di}{dt}$ (2.15) In order for current to flow through the inductance, it must be connected to it voltage, at each moment of time, is opposite to the emf of self-induction (2.16) $U_L=-e_L=L\frac{di}{dt}$

Capacity C (Fig. 2.8, c) characterizes the property of the electric element circuit, for example, a capacitor, accumulate electric charges and create electric field $C=\frac{q}{U_C}$ (2.17) But since the current is equal to, a electric charge $i=\frac{dq}{dt}$, then $q=C\times U_C$ (2.18) From there, we get the relationship between voltage and current on the capacitor elements: $U_C=\frac{1}{C}\int i\,dt$ (2.19) Capacitance is measured in farads [F] **2.6. The ratio of sinusoidal voltages and currents in the circuit with serial connection of ideal R, L, C elements.** A voltage is added to the circuit by ideal R, L, C – elements $U=U_m\sin(\omega t+\psi_u)$ **(Fig. 2.12). Circle with serial connection ideal R, L, C – elements.** According to Kirchhoff's 2nd law, we write for the instants values of quantities: $u=U_R+U_L+U_C=i\cdot R+L\frac{di}{dt}+\frac{1}{C}\int i\,dt$ (2.30) When using current voltage values it is necessary to use vector or complex form In this sense, the complex of active voltage is equal to the sum of the complex values of the voltage drop: $U=U_R+U_L+U_C=IR+jx_LI-jx_CI$ (2.31) Let's construct a vector diagram for this circuit. **Fig. 2.13. Vector circle diagram with serial connection ideal R, L, C – elements.** From the vector diagram, namely from the triangle 0AB, we can write: $U^2=U_R^2+(U_L-U_C)^2=(IR)^2+(Ix_L-Ix_C)^2=$ (2.32) $=I^2[$

$i=d$

$=C\frac{d}{}$

From where we get the expression of Ohm's law for a circuit alternating current, including series-connected ideal R, L, C – elements $I=\frac{U}{\sqrt{R^2+(x_L-x_C)^2}}=$ (2.33) $\frac{U}{Z}$ $\{x_L-X$

$Z=\sqrt{R^2+(X_L-X_C)^2}$ is the total resistance of the circuit. ~~If there are several~~ resistances (k), then total resistance takes the form $Z=\sqrt{(\sum R_k)^2+(\sum x_{L_k}}$ (2.34) $-\sum x_{C_k})$ Similarly, it can be written from equation (2.31) expression for total resistance in complex form: $Z=R+j(X_L-X_C)=R+jX$ (2.35) where $X=X_L-X_C$ is the reactive resistance of the circuit.

From the vector diagram (fig.) it is possible to distinguish Δ 0AB - this is the so-called voltage triangle **(Fig. 2.14, a)**. By dividing each line of the tension triangle on the current, we get a triangle of resistances **(Fig. 2.14, b).**

За 2-им законом Кірхгофа запишемо для миттєвих значень величин:

$$u=u_R+u_L+u_C=i\cdot R+L\frac{di}{dt}+\frac{1}{C}\int idt. \qquad (2.30)$$

При використанні діючих значень напруг необхідно використовувати вектору або комплексну форму. В такому сенсі комплекс діючої напруги дорівнює сумі комплексних значень падіння напруги:

$$\underline{U}=\underline{U}_R+\underline{U}_L+\underline{U}_C=\underline{I}R+jx_L\underline{I}-jx_C\underline{I}. \qquad (2.31)$$

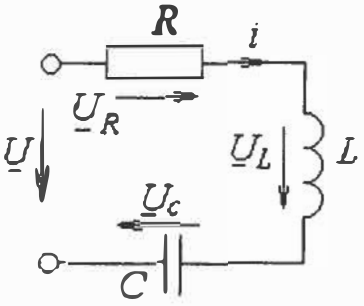


Рис.2.12. Коло з послідовним з'єднанням ідеальних *R*, *L*, *C* - елементів

Побудуємо векторну діаграму для цієї схеми (2.13).

З векторної діаграми, а саме з трикутника 0АВ можна записати:

$$U^2=U_R^2+\left(U_L-U_C\right)^2=\left(IR\right)^2+\left(Ix_L-Ix_C\right)^2=I^2\left[R^2+\left(x_L-x_C^{\,2}\right)\right]; \qquad (2.32)$$

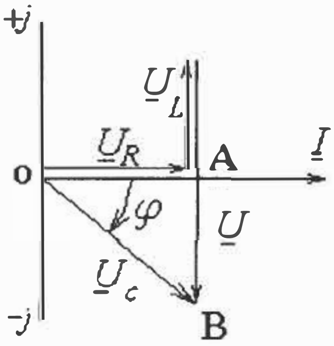


Рис.2.13. Векторна діаграма кола з послідовним з'єднанням ідеальних *R*, *L*, *C* - елементів

Звідки отримуємо вираз закону Ома для кола змінного струму, що включає послідовно з'єднані ідеальні *R*, *L*, *C* – елементи

$$I=\frac{U}{\sqrt{R^2+\left(x_L-x_C\right)^2}}=\frac{U}{z}, \qquad (2.33)$$

$z=\sqrt{R^2+\left(x_L-x_C\right)^2}$ – повний опір кола.

Якщо опорів декілька (*k*), то повний опір приймає вигляд

$$z=\sqrt{\left(\sum R_k\right)^2+\left(\sum x_{L_k}-\sum x_{Ck}\right)^2}. \qquad (2.34)$$

Аналогічно можна записати з рівняння (2.31) вираз для повного опору в комплексній формі:

$$\underline{Z}=R+j\left(X_L-X_C\right)=R+jX, \qquad (2.35)$$

де $X=X_L-X_C$ – реактивний опір кола.

З векторної діаграми (рис.) можна виділити Δ 0АВ – це так званий трикутник напруг (рис.2.14,*а*). Розділивши кожну строчку трикутника напруг на струм, отримаємо трикутник опорів (рис.2.14,*б*).

Fig. 2.14. The triangle of voltages (a) and resistances (b) of the electric circuit with serial connection of ideal R, L, C – elements. which is the angle of phase shift between current and voltage, it is possible express in terms of voltages and resistances: $\varphi = arctg\frac{U_L - U_C}{U_a} = arctg\frac{X_L - X_C}{R}$ (2.36) You can also write expressions for cosφ and sinφ $\cos\varphi = \frac{R}{Z}$ $\sin\varphi = \frac{X_L - X_C}{Z}$ (2.37)

2.7. Kirchhoff's laws for sinusoidal current circuits Kirchhoff's laws in alternating current circuits are valid for instantaneous values (that is, at each moment of time) of electrical quantities, or for vectors and complex values of operating quantities. Kirchhoff's 1st law: Algebraic sum of instantaneous values of currents in nodes is zero. $\sum_{k=1}^{n} i_k = 0$ (2.38) The algebraic sum of the complex values of the currents in the node is zero. Or the geometric sum of the vectors representing the currents in the node is equal to zero $\sum_{k=1}^{n} I_k = 0$ (2.39) Kirchhoff's 2nd law: If each section of the contour of an electric circuit has R, L, C elements, then the instantaneous EMF values operating in closed circuit contour, are equal to the algebraic sum of instantaneous values of voltage drops on sections of this contour: $\sum_{k=1}^{n} e_k = \sum_{k=1}^{n} \left(i_k R_k + L_k \frac{di_k}{dt} + \frac{1}{C_k}\int i_k dt \right)$ (2.40) The sum of the complex values of EMF operating in a closed circuit, is equal to the sum of the complex values of the voltage drops on its sections outline: $\sum_{k=1}^{n} E_K = \sum_{k=1}^{m} I_K Z_K$ (2.41) **2.8. Active, reactive and full circuit conductivity.** Unlike single-conduction DC circuits in AC circuits include active, reactive and full electric circuits conductivity. All of them are measured in siemens [Cm]. The total conductivity of an alternating current circuit is the inverse value proportional to total resistance. Complex conductivity of the circle in an indicative form $Y = \frac{1}{Z} = \frac{1}{Ze^{j\varphi}} = \frac{1}{Z}e^{-j\varphi} = Ye^{-j\varphi}$ (2.42) In algebraic form, the complex conductivity of a circuit can be expressed as:

$$Y = \frac{1}{Z} = \frac{1}{R+jX} = \frac{1}{R+jX} \times \frac{R-jX}{R-jX} = \frac{R-jX}{R^2+X^2} = \frac{R}{R^2+X^2} - j\frac{X}{R^2+X^2} = \frac{R}{Z^2} - j\frac{X}{Z^2} = G - jB \quad (2.43)$$

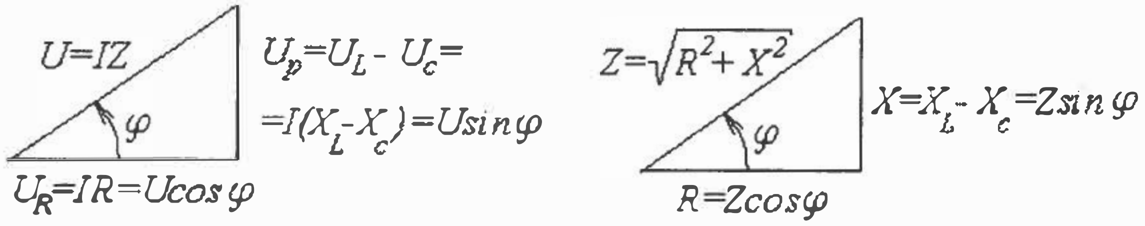
Where $G = \frac{R}{R^2+X^2}$ $\frac{R}{Z_2}$ active conductivity of the circuit (note that at in the absence of reactive resistance X=0, the active conductivity is equal to G=I/R; it has a similar appearance in direct current circuits). $B = \frac{X}{R^2+X^2} = \frac{X}{Z^2}$ – reactive conductivity of the circuit. $B = \frac{X_L - X_C}{Z^2} = \frac{X_L}{Z^2} - \frac{X_C}{Z^2} = B_L - B_C$ (2.44) where BL, BC are inductive and capacitive conductivity, respectively. Taking this into account, the complete complex conductivity can be written in in the form $Y = G - jB = G - j(B_L - B_C)$ (2.45)

Ohm's law can be written using both total resistance and total conductivity:

$I = \frac{U}{Z} = UY$ (2.46)

Substitute equation (2.45) into (2.46) $I = UY = U(G - jB) = UG - jUB = I_a + I_p$ (2.47)

Where $I_a = UG$ – active component of current I; it coincides in phase with the current; $I_p = jUB$ – reactive component of current I; it lags behind by 90°, or predates the voltage. Vector diagram of an electric circuit in which the current lags in phase from voltage on the shear angle φ, using conductivities has the form



а   б

Рис.2.14. Трикутник напруг (*а*) та опорів (*б*) електричного кола з послідовним з'єднанням ідеальних *R*, *L*, *C* - елементів

φ, що представляє собою кут зсуву фаз між струмом і напругою, можна виразити через напруги та опори:

$$\varphi = arctg\frac{U_L - U_C}{U_a} = arctg\frac{X_L - X_C}{R}. \qquad (2.36)$$

Також можна записати вирази для *cos*φ та *sin*φ

$$\cos\varphi = \frac{R}{Z}; \quad \sin\varphi = \frac{X_L - X_C}{Z}. \qquad (2.37)$$

2.7. Закони Кірхгофа для кіл синусоїдального струму

Закони Кірхгофа в колах змінного струму справедливі для миттєвих значень (тобто в кожен момент часу) електричних величин, або для векторів та комплексних значень діючих величин.

1-й закон Кірхгофа: *Алгебраїчна сума миттєвих значень струмів у вузлі дорівнює нулю.*

$$\sum_{k=1}^{n} i_k = 0. \qquad (2.38)$$

Алгебраїчна сума комплексних значень струмів у вузлі дорівнює нулю. Або геометрична сума векторів, що зображають струми у вузлі, дорівнює нулю.

$$\sum_{k=1}^{n} \underline{I}_k = 0. \qquad (2.39)$$

2-й закон Кірхгофа: *Якщо кожна ділянка контуру електричного кола має R, L, C елементи, тоді миттєві значення ЕРС, діючі у замкненому контурі, дорівнюють алгебраїчній сумі миттєвих значень падінь напруги на ділянках цього контуру*:

(Fig. 2.15, a): From the vector diagram you can highlight a triangle. If you divide all of it values on U, we get conduction triangle **(Fig. 2.15, b).** Through the triangle conductivity can be obtained the following dependencies between circuit conductances: $G = Y\cos\varphi;\ B = Y\sin\varphi;\ Y = \sqrt{G^2+B^2}$ (2.48) **Fig. 2.15. Vector diagram of an electric circuit, c which the current ~~lags in phase from the voltage by an~~ angle shift φ, (a) and the conductivity triangle (b)** $\to Y=\sqrt{}$

2.9. Energy and power in sinusoidal current circuits. In the direct current circuit, the power was determined as $P = U \times I$. In circles alternating current, which include R, L, C elements of magnetic energy and of electric fields continuously change in time. For analysis energy processes, consider an alternating current circuit with a series one connection of R, L, C elements **(Fig. 2.12).** Let's take the initial phase of the current equal to zero. In this case write the current in the form $i = I_m \sin\omega t$. Given that ψi=0, and the phase shift angle $\varphi = \psi_u - \psi_i$, we get that . $\psi_u =$ In this case, the applied voltage can be written as: $u = U_m\sin(\omega t + \varphi)$. Note that if XL >XC, then φ > 0, and vice versa, if XL <XC, then φ < 0. For instantaneous values, the expression is valid: $p = u\cdot i = U_m\sin(\omega t + \varphi)\cdot I_m\sin\omega t$ (2.49) We will separately consider the components of this equation: $U_m I_m = \sqrt{2}U \times \sqrt{2}I = 2UI$,and

$$\sin(\omega t + \varphi)\times\sin\omega t = \frac{1}{2}[\cos(\omega t + \varphi - \omega t) - \cos(\omega t + \varphi + \omega t)] = \frac{1}{2}[\cos\varphi - \cos(2\omega t + \varphi)]$$

By substituting the components into formula (2.49), we obtain an expression for the instantaneous power values in general form for a circle with R, L, C elements:

$$p = UI\cos\varphi - U\cos(2\omega t + \varphi)$$

. (2.50) Thus, the instantaneous power of an alternating current circuit consists of two components: a constant value and a harmonic component that changes with doubled angular frequency. The energy entering the circle is determined by the average value capacity for the period:

$$P = \frac{1}{T}\int_0^T p\,dt = \frac{1}{T}\int_0^T UI\cos\varphi\,dt - \frac{1}{T}\int_0^T UI\cos(2\omega t + \varphi)\,dt$$

(2.51) But $\to \left(\frac{1}{T}\int_0^T UI\cos\right.$ $-\frac{1}{T}\int_0^T UI$ $(2\omega t$ therefore cosφ is the power factor. From the voltage triangle, so the average power value for period is an active power $P = UI\cos\varphi = I^2R$. (2.52)

Therefore, the average power for the period is called active power.

2.9.4. Full, active and reactive power In an electric circuit, in which there are both active and reactive elements **(Fig. 2.12)**, both phenomena occur simultaneously: and irreversible conversion of source energy into heat, and exchange (oscillations) of electromagnetic energy between the source and consumers. Multiply each side of the voltage triangle **(Fig. 2.14, a)** by the current i we get a power triangle **(Fig. 2.19)**. The sides of this triangle are formed by the following powers. Active power that is converted into heat or mechanical work

$$P = I^2R = UI\cos\varphi$$

(2.60) It is measured in watts [W]. Reactive power, which is spent on creating magnetic and electric fields in reactive L, C elements, and then returns to sources $Q = I^2X = I^2X_L - I^2X_C = UI\sin\varphi$ (2.61)

З урахуванням цього повну комплексну провідність можна записати у вигляді

$$\underline{Y} = G - jB = G - j(B_L - B_C). \qquad (2.45)$$

Закон Ома можна записати, використовуючи як повний опір, так і повну провідність:

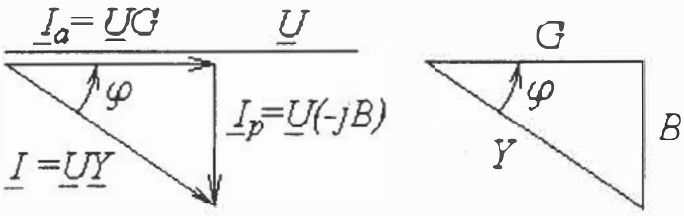
$$\underline{I} = \frac{\underline{U}}{\underline{Z}} = \underline{U}\,\underline{Y}. \qquad (2.46)$$

Підставимо в (2.46) рівняння (2.45)

$$\underline{I} = \underline{U}\,\underline{Y} = \underline{U}\left(G - jB\right) = \underline{U}G - j\underline{U}B = \underline{I}_a + \underline{I}_p, \qquad (2.47)$$

де $\underline{I}_a = \underline{U}G$ – активна складова струму I; вона співпадає по фазі зі струмом; $\underline{I}_p = j\underline{U}B$ – реактивна складова струму I; вона на 90° або відстає, або опереджає напругу.

Векторна діаграма електричного кола, в якому струм відстає по фазі від напруги на кут зсуву φ, з використанням провідностей має вигляд (рис.2.15,*а*):



а *б*

Рис.2.15. Векторна діаграма електричного кола, в якому струм відстає по фазі від напруги на кут зсуву φ, (*а*) та трикутник провідностей (*б*)

З векторної діаграми можна виділити трикутник. Якщо розділити всі його величини на U, отримуємо трикутник провідностей (рис.2.15,*б*).

Через трикутник провідностей можна отримати наступні залежності між провідностями кола:

$$G = Y\cos\varphi; \quad B = Y\sin\varphi; \quad Y = \sqrt{G^2 + B^2}. \qquad (2.48)$$

2.9. Енергія і потужність у колах синусоїдального струму

У колі постійного струму потужність визначалась як $P = U \cdot I$. В колах змінного струму, які включають *R, L, C* елементи енергія магнітного та електричного полів безперервно змінюються у часі. Для аналізу енергетичних процесів розглянемо коло змінного струму з послідовним з'єднанням *R, L, C* елементів (рис.2.12).

Приймемо початкову фазу струму рівною нулю. В такому випадку

It is measured in var [var]. Full power $S = UI = I^2 Z = \sqrt{P^2 + Q^2}$ (2.62) It is measured in volt-amperes [VA]. Active and reactive ~~power can be~~ expressed in terms of total $P = S\cos\varphi,\ Q = S\sin\varphi$ (2.63) The power factor expressed in terms of powers makes sense $\cos\varphi = \frac{P}{S}$ (2.64) The power factor shows the active power relative to full power source or receiver. **2.11. An electric circuit with a parallel connection ideal R, L, C elements.** When parallel connection of ideal resistive, inductive and of capacitive elements, the currents in the branches are determined by Ohm's law, and the current in unbranched part of the circle - according to Kirchhoff's first law in the complex form (Fig. 2.24): $I_1 = \frac{U}{R}$ $I_2 = \frac{U}{jX_L}$ (2.69) $I_3 = -$

$I = I_1 + I_2 + I_3$ (2.70) The currents in the branches can be determined by complex conductivities. From the general expression for conductivity (formula) $Y = G - j(B_L -$ you can write down the expressions for the currents in the branches

$I_1 = GU$ $I_2 = -jB_L U$ $I_3 = jB_C U$, (2.71)

So, we have $I_a = I_1 = GU$ – active current component;

$I_p = I_2 + I_3 = -j(B_L - B_C)U = -jBU$ the reactive component of the current.

The total current is equal to the sum of the components in complex form

$I = I_a + I_p$. (2.72) The modulus of this current is found by the Pythagorean formula $I = \sqrt{I_a^2 + I_p^2}$. (2.73)

The currents in the branches with inductive and capacitive elements are in opposition phase, and the reactive current is equal to their difference. This phenomenon is used for phase shift compensation.

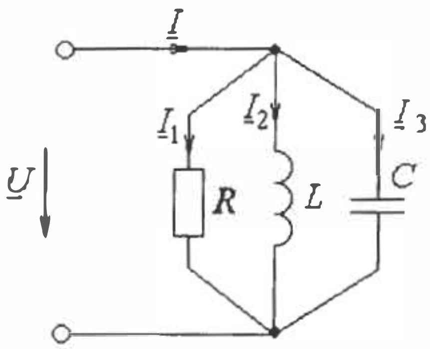


Рис.2.24. Електричне коло з паралельним з'єднанням ідеальних *R, L, C* елементів

$$\underline{I}_1=\frac{\underline{U}}{R};\quad \underline{I}_2=\frac{\underline{U}}{jX_L};\quad \underline{I}_3=-\frac{\underline{U}}{jX_C},\qquad (2.69)$$

$$\underline{I}=\underline{I}_1+\underline{I}_2+\underline{I}_3.\qquad (2.70)$$

Струми у вітках можна визначити через комплексні провідності. Із загального виразу для провідності (формула) $\underline{Y}=G-j\left(B_L-B_C\right)$ можна записати вирази для струмів у вітках

$$\underline{I}_1=G\underline{U};\quad \underline{I}_2=-jB_L\underline{U};\quad \underline{I}_3=jB_C\underline{U},\qquad (2.71)$$

Отже, маємо

$\underline{I}_a=\underline{I}_1=G\underline{U}$ – активну складову струму;

$\underline{I}_p=\underline{I}_2+\underline{I}_3=-j\left(B_L-B_C\right)\underline{U}=-jB\underline{U}$ – реактивну складову струму.

Повний струм дорівнює сумі складових у комплексній формі

$$\underline{I}=\underline{I}_a+\underline{I}_p.\qquad (2.72)$$

Модуль цього струму знаходиться за формулою Піфагора

$$I=\sqrt{I_a^2+I_p^2}.\qquad (2.73)$$

Струми у гілках з індуктивним і ємнісним елементами знаходяться у проти фазі, а реактивний струм дорівнює їх різниці. Це явище використовують для компенсації зсуву фаз.