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ელექტრომოწყობილობათა
ტექნიკური დიაგნოსტიკა

(I ნაწილი)

„ტექნიკური უნივერსიტეტი“

საქართველოს ტექნიკური უნივერსიტეტი

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ელექტრომოწყობილობათა ელემენტებისა და
აღრიცხვის კვანძების დიაგნოსტიკა

(I ნაწილი)



დამტკიცებულია სტუ-ს
სარედაქციო-საგამომცემლო
საბჭოს მიერ

თბილისი
2009

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ნაშრომი წარმოადგენს პრაქტიკულ სახელმძღვანელოს და განკუთვნილია, როგორც ძირითადი სახელმძღვანელო, “ელექტრომოწყობილობათა დიაგნოსტიკის” სპეციალობის უმაღლესი პროფესიული განათლებისა და ბაკალავრიატის სტუდენტებისა და მაგისტრანტებისათვის. იგი დიდ დახმარებას გაუწევს აგრეთვე ელექტროსადგურების, ელექტროქსელებისა და სამრეწველო დაწესებულებების ინჟინერ-ტექნიკურ პერსონალს ელექტროდანადგარების ექსპლუატაციის, რემონტისა და დიაგნოსტიკის საკითხების გადაწყვეტის დროს.

რეცენზენტი პროფ. დ. ლაომვილი

სახელმძღვანელო გამოცემა შპს „აკაკასუს ელექტრომარკეტის“ ფინანსური მხარდაჭერით.

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ISBN 978-9941-14-572-8 (ყველა ნაწილი)

ISBN 978-9941-14-573-5 (პირველი ნაწილი)

<http://www.gtu.ge/publishinghouse/>



ყველა უფლება დაცულია. ამ წიგნის არც ერთი ნაწილი (იქნება ეს ტექსტი, ფოტო, ილუსტრაცია თუ სხვა) არანაირი ფორმით და საშუალებით (იქნება ეს ელექტრონული თუ მექანიკური), არ შეიძლება გამოყენებულ იქნას გამომცემლის წერილობითი ნებართვის გარეშე.

საავტორო უფლებების დარღვევა ისჯება კანონით.

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winasi tyvaoba

el eqtromowyobil obis teqnikuri mdgomareobis swor diagnostikaze damyarebul ia xarisxiani remonti da eqspl uataciis Tanamedrove meTodebis gamoyeneba, rac uzrunvel yofs saxal xo meurneobis yvel a dargis uwyvet muSaobas, el eqtromowyobil obis eqspl uataciisa da remontis xarjebis Semcirebas, muSao-bis xangrZl ivobis gazrdas.

ukanasknel xanebsi moxda el eqtromowyobil obis diagnostikis, kontrolisa da gamocdisaTvis gankuTvnil i aparaturis arsebiti cvlil ebani.

winamdebare saxel mZRvanel os mizania diagnostikis progresul i meTodebis, Tanamedrove el eqtromowyobil obebisa da marTvis wredebis uwesivrobis moZebnis ZiriTadi probl emebis Rmad Seswavl a.

naSromi warmoadgens profesiul i donis praktikul masal as damwyebi el eqtroteqnikosebisa da im special istebisaTvis, roml ebsac esaWiroebaT arsebul i special izaciis mixedvit axal i sferoebis atviseba an Tavisi codnis gaRrmaveba da ganmtkiceba, rac saSual ebas miscemT swrafad gamoasworon el eqtromowyobil obis momsaxureobisa da eqspl uataciis dros warmoSobil i probl emebi.

masal is ukeT atvisebis miznit sasargebl oa minimal uri codnis dagroveba el eqtrul i wredebis TeoriaSi, ristvisac saxel mZRvanel o pirvel TavSi moyvanil ia Teoriul i sakiTxebi, xol o danarTSi warmodgenil ia ZiriTadi pirobiti aRniSvnebi, romel Ta

codna aucil ebel ia el eqtromowyobil obis diagnostikis dros.

saxel mZRvanel os momzadebis saqmeSi mniSvnel ovani daxmarebis gavevisatvis uRrmes madl obas vuxdiT inJinrebs: mixeil qadagiSvil s, Temur gvencaZes (saqarTvel os teqnikuri universiteti), gia musel iansa da vaJa nozaZes (s/s "Tel asi").

aRniSnul i saxel mZRvanel o pirvel sawyisia el eqtromowyobil obis diagnostikis sferoSi da dazRveul i ara varT mcire Secdomebisagan. avtorebi didi madl ierebit miiReben mkiTxvel Ta yovel SeniSvnas, rac gaTval iswinebul i iqneba Semdgom gamocebSi.

Sesaval i

el eqtromowyobil obis teqniki diagnostika SedarebiT axal i mecnierebaa, romel ic aRmocenda gasul i saukunis meore naxevarSi teqniki moTxovnebTan dakavSirebiT.

teqniki diagnostika – es aris mecniereba el eqtromowyobil obis mdgomareobis garCevis Sesaxeb, romel ic moicavs probl emebis farTo wres dakavSirebul s diagnostikuri informaciis miRebasa da SefasebasTan.

nebismieri samecniero disciplinis warmocena miRebul ia dawyebul iqnas am disciplinis zogadi daxasiaTebiT anu kvlevis sagnisa da ZiriTadi amocanebis dasmiT. teqniki diagnostikaSi aseTi winaswari aRwera garTul ebul ia rigi garemoebebis gamo, radgan saubaria codnis axal sferoze, romel ic imyofeba Tavisi formirebis stadiaSi. erTis mxriv aq SeiZl eba movniSnoT da gamovyoT amocanebis sakmaod farTo wre, roml ebic eqvemdebarebian gamokvl evebs; meores mxriv maTi umniSvnel o nawil i moicavs sakvl ev samuSaoebis da warmodgenil ia konkretul i SedegebiT. Aamitom teqniki diagnostikis zogad winaswar aRweras aqvs dadgenil ebiTi xasiaTi.

el mowyobil obis teqniki diagnostikis kvlevis obieqti SeiZl eba iyos nebismieri Zalovani da marTvis sistema. sistemis qveS igul isxmeba nebismieri teqniki mowyobil oba, romel ic asrul ebs garkveul funqcias. TiToeul i sistema SeiZl eba daxasiaTdes rigi parametrebiT, romel Tagan erT-erTi ZiriTadia, xol o danarCenebi – meorexarixovani.

teqniki diagnostikis specifika mdgomareobis imaSi, rom is ganxil avsteqniki sistemas moqmedebasi, roml is amocanaa dazianebul i el ementis Zieba, sadac mniSvnel ovania dazianebul i el ementis Ziebis da gamovlenis meTodebi. el eqtromowyobil obis dazianebis mizezi SeiZl eba iyos erTi an ramdenime el ementis dazianeba an el ementebis Soris kavSiris darRveva, xol o TviT el ementis dazianeba SeiZl eba gamovveul i iyos el ementis TviTdazianebiT, gareSe zemoqmedebiT, araswori eqspl uataci iTa da sxva.

el eqtromowyobil obis el ementebis mdgomareobis gansazRvris dros Semowmebis Tanamimdevroba swarmoebs winaswar Sedgenil i diagnostikuri programis mixedviT.

Semowmebebis erTobl ioba, romel ic sakmarisia mowyobil obis mdgomareobis Sefasebisatvis warmoadgens diagnostikuri testirebas, romel ic defeqtebis gamovlenis ZiriTadi saxea. diagnostikuri testirebis meTodebs miekuTvneba: izolaciis winaRobis, gajonvis denebis, Sinagani winaRobis, gragnil ebis diel eqtrikul i danakargebis kuTxis tangensis gazomva da sxva.

el eqtromowyobil obebis da konstruqciebis diagnostikis mizania maTi narCeni saeqspl uatacio maxasiaTebel ebis mixedviT dal ageba. AmaxasiaTebel ebis mixedviT el mowyobil obebi iyofa sam jgufad: pirvel jgufSi Sedian resursebis gagrZel ebis mowyobil obebi, anu romel Tac miuxedavad maTi muSaoebis vadis gasvl isa kidev gaaCniaT sakmarisi saeqspl uatacio maxasiaTebel ebis resursi.

meore j gufSi Sedian is el mowyobil obebi, romel -
Ta narCeni saeqspl uatacio maxasiaTebI ebi SeiZl eba
aRdgenil iqnan mimdinare an kapital uri remontiT.

mesame j gufSi Sedian is el mowyobil obebi, romel -
Ta narCeni saeqspl uatacio maxasiaTebI ebi remontis
Sedegad aRar eqvemdebarebian aRdgenas.

teqnikurad dasabuTebul i diagnozis dasma Sesa-
Zl ebel ia mxol od srul yofil i informaciis pirobe-
bis statistikuri monacemebis Sekrebis, gare daTva-
l ierebisa da special uri xel sawyoebis saSual ebiT
Catarebul i eqsperimentul i gamokvl evebis Sedegad.

Tanamedrove pirobebSi saqarTvel oSi el momar-
agebis sistemis erT-erTi umniSvnel ovanesi mowyobi-
l obebis - Zal ovani transformatorebis mniSvnel o-
vanma nawil ma amowura Tavisi muSaobis resursi. qvey-
nis ekonomiuri situacia, agreTve transformatoreb-
is saerTo raodenobis didi ricxvi ar izl eva uax-
l es xanSi maTi Secvl is saSual ebas. amitom trans-
formatorebis eqspl uataciis saimedobis SesanarCune-
bl ad mniSvnel ovani rol i eniWeba maT diagnostikur
kontrol s.

dReisaTvis Zal ovani transformatorebis, av-
tottransformatorebis, maSuntirebul i reaqtorebisa
da sxva el eqtromowyobil obebis saeqspl uatacio ma-
xasiaTebI ebis gansazRvrisa da sistemebis defeqtebis
ganviTarebis donis mdgomareobis SefasebisaTvis, sul
ufro farTod mimarTaven kompl eqsur diagnostikur
gamokvl evas. aseTi gamokvl evebi saSual ebas gvaZl ev-
en ara mar to gamovavl inoT ganviTarebadi defeqtebi,
SevafasoT maTi saSiSroebis done, aramed davasabu-

ToT kapital uri remontis saWiroeba, mocul oba da
vadebi.

ukanasknel xanebSi farTo gavrcel eba hpova el -
eqtroapartebis, rogorc el eqtromowyobil obis Zvi-
radRirebul i da sapasuxismgebl o el ementebis diag-
nostikis sxvadasxva meTodebma.

msofl io masStabiT ganuwyvetl iv muSavdeba da
praqtikaSi inergeba qvesadgurebis, transformatore-
bis, el eqtro generatorebisa da Zravebis, maRal i Zab-
vis amomrTvel ebis, sahaero xazebis, Camiwebis winaRo-
bis, kabel ebis, kontakaturi SeerTebebis, izol aciis,
sarel eo dacvis, marTvis wredebisa da sxvaTa diag-
nostikuri meTodebi.

damuSavebul ia Tanamedrove vibrodiagnostikis,
Tbovizorul i kontrol is, qromatografiul i anal i-
zis da sxva meTodebi, roml ebic saSual ebas gvaZl ev-
en qsel idan gamorTvis gareSe davinaxoT Zal ovan
transformatorSi l okal uri gacxel ebebi da SeerTe-
bis gardamaval i winaRobebi.

ukanasknel xanebSi energetikaSi gamoyeneba hpova
infrawitel i teqnikis xel sawyoebma, gansakuTrebiT
el eqtromowyobil obisa da misi dengamtari nawil eb-
is Tburi mdgomareobis Sefasebisas. infrawitel i me-
Todi diagnostikis, rogorc aramrRvevi da maRal efeq-
turi saSual eba, aris el eqtromowyobil obis teqni-
kuri eqspl uataciis kontrol is saerTo sistemis Ziri-
Tadi Semadgenel i nawil i. infrawitel i diagnostikis
Sedegi, romel ic axasiaTebis sakontrol o obieqtis
Tbur mdgomareobas, bevrad aris damokidebul i mis
konstruqciaze, Tbogamomyofi wyaros ganl agebis ker-

aze, mis intensivobasa da gare zemoqmedebaze. miRebul i Sedegebi unda Sedardes sxva fazebSi an identur mowyobil obaSi miRebul SedegebTan.

miRebul ia, rom zeTiT Sevsebul i el mowyobil obis kompl eqsuri diagnostika yovel Tvis dawyebul i unda iqnas zeTis qromatografiul i anal iziT, radganac zeTis gamocda tardeba yvel aze ufro regul arul ad da saSual ebas gvaZl evs Tval yuri vadevnoT aseT mowyobil obebSi mimdinare procesebs.

nebismeri obieqtis mdgomareobis Sefaseba eyrdnoba Sesabamis kl asifikaciis da maT Soris gamonakl isi arc Zal ovani transformatoria, roml isTvisac SemoTavazebul ia amgvari kl asifikaciis sxvadasxva midgomebi. magal iTad *TDM* (transformatoris diagnostikis monitoringi) sistemis daniSnul ebaa maRali Zabvis Zal ovani transformatorebis uwyveti kontrol i da teqniki mdgomareobis anal izi. igi gamoiyeneba uwyveti monitoringisa da kontrol is reJimsi informaciis registraciisa da SedarebisaTvis. igi saSual ebas gvaZl evs gavaanal izoT transformatoris ZiriTadi qvesistemebis parametrebis mdgomareoba da Camovayal iboT transformatoris mdgomareobis Sesaxeb kompl eqsuri daskvna.

cvl adi denis el eqtrul i Zravebi el eqtrul i energiis udidesi momxmarebl ebi arian. ukanasknel i gamokvl evebiT dadgenil ia, rom evropis masStabiT gamomuSavebul i energiis 80%-ze meti moixmareba swored am tipis el eqtrul i Zravebis mier. amasTanave sxvadasxva mi zeziT gamowveul i avariul oba Seadgens 25%-ze mets. Zravas mwyobridan gamosvl as mi vyavarT did

material ur zaral amde, rac dakavSirebul ia teqno logiuri danadgaris mocdenasa an produqciis wunTan. zaral s damatebiT emateba el eqtro da saxanZro usafRTxoebis moTxovnebis daweva, romel ic dakavSirebul ia el eqtroZravas statoris an rotoris gragnil Si momxdar mokl ed SerTvasTan.

sayovel Taod miRebul i dacvis saSual ebebi yovel Tvis ver uzrunvel yofen Zravas dacvas. saWiroeba moiTxovs el eqtroZravas diagnostikas misi muSaobis procesSi. muSa ZravaSi adreul stadiaze defeqtis ganviTarebis aRmoCena ara marto amcirebs remontis xarj ebs, aramed axangrZl ivebs misi muSaobis vadasac. Tanamedrove pirobebSi el eqtroZravebis diagnostikisaTvis gamoiyeneba vibroakustikuri; moTxovnil i denis speqtral uri anal izisa da "xel ovnuri neironul i qsel ebis- safuZvel ze agebul i kompl eqsuri diagnostikis meTodebi. es ukanasknel i warmoadgens programul -aparaturul kompl eqss, romel ic Sedgeba kompiuterisagan da cifrul i mowyobil obisagan. cifrul i mowyobil oba awarmoebis saWiro gazomvebs da gadascems maT kompiuters Semdgomi damuSavebisaTvis.

el momaragebis sistemaSi mniSvel ovani adgil i uWiravT agreTve maRali Zabvis amomrTvel ebs, romel Ta mtyunebaTa 80% modis meqanikur defeqtebze, romel nic saWiroeben agreTve droul aRmoCenasa da aRmofxvras. sistemis normal uri muSaobis warmarTvisatvis.

mxedvel obaSi viRebT ra zemoTTqmul s SeiZl eba davaskvnaT, rom teqniki diagnostika es aris samecnie-

ro discipl ina, romel ic ikvl evs el mowyobil obis dazianebis gamovl enis formebs, amuSavebs maTi aRmoCenis meTodebs da diagnostikuri sistemebis konstruirebis principebs.

**Tavi I. el eqtrul i wredebi da
el eqtroteqniki mowyobil obebi
1.1. el eqtroteqniki ZiriTadi cnebebi da
ganmartebebi**

el eqtromowyobil obis efeqturi diagnostikisaTvis aucil ebel ia gvqondes sakmarisi codna el eqtroteqnikaSi.

aqedan gamomdinare, pirvel rigSi, Cven ganvixil avT el eqtroteqniki ZiriTad cnebebsa da ganmartebes, el eqtrul sqemebSi gamoyenebul ZiriTad aRniSvnebs. TiToeul i Tavisi dasawyisSi moviyvanT sadiagnostiko el mowyobil obis aRweras, moqmedebis principebs, eqspl uataciisa da momsaxureobis wesebsa da diagnostikis Catarebis Tanmimdevrobas.

nebismier samrewvel o mowyobil obaSi sxvadasxva kvanZebisa da meqanizmebis gadaadgil eba xdeba el eqtroZravas muSaobis Sedegad. el eqtroZravebi kvebas iReben el eqtromomargebis qsel idan an warmoebis sakuTari el eqtrogenatoridan. moTxovnil i Zabvis donis misaRebad gamoiyeneba transformatorebi.

el eqtroteqniki danadgarTa erTobl iobas, romel Ta daniSnul ebaa Seqmnas Sekrul i gza el eqtrul i denisaTvis, **el eqtrul i wredi** ewodeba.

el eqtrul i energiis saxebidan damoukidebl ad el eqtrul i wredi fl obs sam ZiriTad mdgenel s: Zabva, deni da winaRoba.

Zabva ewodeba or wertil s Soris potencial Ta sxvaobas. igi aRiniSneboda U da u asoebiT, amJamad aRiniSneba V da v asoebiT. Zabva izomeba vol tebsi

(v). gamoiyeneba j eradi erTeul ebic: kil ovol ti (kv) = 10^3 vol ts; mil ivol ti (mv) = 10^{-3} vol ts; mikrovol ti (mkv) = 10^{-6} vol ts.

deni ewodeba damuxtul i nawil akebis mimarTul mowesrigebul moZraobas. denis raodenobrivi maxasiaTebel ia denis Zal a. denis Zal a es aris gamtaris ganivkveTSi drois erTeul Si gamaval i muxtebis raodenoba. igi aRiniSneba I an i asoTi da gamoisaxeba formul iT:

$$I = \frac{q}{t} \text{ an } i = \frac{q}{t}, \quad (1.1)$$

sadac q muxtebis raodenobaa da izomeba kul onebSi (kl), xol o t aris dro da izomeba wamebSi (wm).

denis Zal is erTeul ia amperi (a). praqtikaSi gamoiyeneba denis Zal is j eradi erTeul ebic: kil oamperi (ka) = 10^3 a; mil iamperi (ma) = 10^{-3} a; mikroamperi (mka) = 10^{-6} a.

nebismieri el eqroteqnikuri mowyobil oba muSaobs cvl ad an mudmiv densa da Zabvaze. cvl adi deni (ingl isuri aRniSvniT AC) da Zabva (ingl isuri aRniSvniT AV) droSi icvl ebian, rogorc sidi iT, aseve mimarTul ebiT, xol o mudmivi deni (ingl isuri aRniSvniT DC) da Zabva (ingl isuri aRniSvniT DV) droSi ucvl el i sidi deeba.

praqtikaSi umetesad gamoyenebul ia is cvl adi denebi da Zabvebi, roml ebic icvl ebian sinusis kano iT:

$$i = I_m \sin(\omega t + \psi_i) \text{ da } v = V_m \sin(\omega t + \psi_v), \quad (1.2)$$

sadac i da v denisa da Zabvis myisi mniSvnel obebia anu maTi mniSvnel obebi drois nebismier momentSi;

I_m da V_m denisa da Zabvis maqsimal uri anu ampl ituduri mniSvnel obebia;

$(\omega t + \psi_i)$ da $(\omega t + \psi_v)$ maTi fazebia;

ψ_i da ψ_v sawyisi fazebia. isini izomebian gradusebSi an radianebSi da gviCveneben myisi sididis mniSvnel obas dakvirvebis dawyebis ($t=0$) momentSi;

$$\omega = 2\pi f \text{ - aris kuTxuri sixSire } \left[\frac{rad}{wm} \right];$$

f aris sixSire anu erT wamSi Sesrul ebul i rxevaTa ricxvi; misi erTeul ia herci (hc).

samrewvel o sixSire Cvens qveyanaSi miRebul ia 50 hc, xol o amerikasa da iaponiaSi - 60hc. sixSiris Se-

brunebul sidi des periodi ewodeba $T = \frac{1}{f}$. misi er-

Teul ia wami [wm]. periodi is umciresi drois Sual edia, roca myisi sidi deebi iwyeben Tavianti mniSvnel obis ganmeorebas.

garda myisa da ampl ituduri mniSvnel obisa cvl adi denis wredebSi gvaqvs agreTve moqmedi anu efeqturi mniSvnel oba, romel ic ampl itudur mniSvnel obaze nakl ebia $\sqrt{2}$ -j er da denisa da ZabvisaTvis gvaqvs:

$$I = \frac{I_m}{\sqrt{2}}; \quad V = \frac{V_m}{\sqrt{2}}.$$

sazomi xel sawyoebi zomaven moqmed mniSvnel obebs.

mowyobil obas, romel ic saSual ebas gvaZl evs, mivi-RoT gamtaris bol oebze potencial Ta sxvaoba el - eqtrul i **energiis wyaro** ewodeba. aseT wyaroebad gvevl ineba gal vanuri el ementebi, akumul atorebi da generatorebi. aseTi wyaroebi xasiaTdebian el eqtro-mamoZravebel i Zal iT (emZ).

emZ ewodeba im muSaobas, romel sac asrul ebs el eqtrul i energiis wyaro wredSi erTeul ovani da-debiTi muxtis gadasatanad. igi aRiniSneba E an e aso-Ti da izomeba Zabvis erTeul ebSi anu vol tebSi.

winaRoba aris gamtaris Tviseba xel i SeuSal os masSi gamaval i Tavisufal i el eqtronebis gadaadgi-l ebas. igi aRiniSneba R an r asoebiT. winaRobis erTeul ia omi (om). praqtikaSi gamoiyeneba j eradi erTeul ebic: kil oomi (kom)= 10^3 omi; megaomi (mom)= 10^6 omi.

winaRobis Sebrunebul sidides ewodeba **gamtar-oba**. gamtaroba aris nivTierebis Tviseba gaataros masSi el eqtrul i deni. gamtaroba aRiniSneba G an g

asoTi $\left(G(g) = \frac{1}{R(r)}\right)$ gamtarobis erTeul ia simensi [sim].

winaRobas cvl adi denis wredSi **aqtiuri wina-Roba** ewodeba. gamtaris winaRoba damokidebul ia im masal aze, roml isganac is aris damzadebul i. amitom gamtaris winaRobas axasiaTeben kuTri winaRobiT. kuTri winaRoba aRiniSneba ρ asoTi da igi warmoad-gens 1m sigrZisa da 1mm² ganivkveTis gamtaris winaR-

obas. **kuTri winaRobis** erTeul ia $\left[\frac{\text{Omi} \cdot \text{mm}^2}{\text{m}}\right]$ an

[omi · m]. misi mniSvnel obebi gamtaris masal is mixed-viT mocemul ia special ur cxril ebSi.

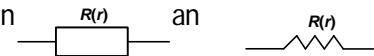
gamtaris winaRoba damokidebul ia temper-aturaze. temperaturis 1^o-iT gazrdisas metal uri gamtaris winaRoba saSual od 0,4%-iT izrdeba, xol o Semcirebisas igive sididiT mcirdeba.

Zabva, deni da winaRoba el eqtrul wredSi erT-maneTTan dakavSirebul ia **omis kanoniT**:

$$I = \frac{V}{R}, \quad (1.3)$$

sadac V - Zabvaa; I - denis Zal a; R - winaRoba.

winaRobaSi denis gavl is dros j oul -l encis kano-nis Tanaxmad ($Q = I^2 R t$) el eqtrul i energia gardai-qmneba siTbur energiad. aseT el ementebis **rezis-torul i el ementebi** ewodebaT, isini grafikul ad aRiniSnebi an



garda winaRobisa el eqtrul wredSi gvxxdeba induqciuri el ementi - induqciurobis koWa da teva-duri el ementi - kondensatori.

induciuobis koWa aris wredis el ementi, romel ic agrovebs magnituri vel is energias. el eqt-rul sqemaze igi aRiniSneba L asoTi, xol o grafikul ad niSniT.



misi erTeul ia henri [hn]. praqtikaSi gamoiyeneba misi j eradi erTeul ebi: mil ihenri (mhn)= 10^{-3} hn; mikro-henri (mkhn)= 10^{-6} hn.

induqciurobis koWi xasiaTdeba sixSiris pirda-
pirproporciul i sididiT – induqciurobis reaqtu-
ri winaRobiT, romel ic gamoisaxebe formul iT:

$$X_L = \omega L = 2\pi fL \text{ [omi]}. \quad (1.4)$$

garda am winaRobisa induqciurobis koWas gaaCnia
xviebis aqtiuri winaRobac R_k .

kondensatori aris wredis el ementi, romel ic
agrovebs el eqtrul i vel is energias. el eqtrul sqema-
ze igi aRiniSneba C asoTi, xol o grafikul ad niS-
niT.

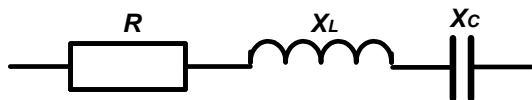


misi erTeul ia farada (f). farada Zal ian didi
erTeul ia da amitom praqtikaSi gamoiyeneba misi j era-
di mcire erTeul ebi: mikrofarada (mkf)= 10^{-6} f; nano-
farada (nf)= 10^{-9} f; pikofarada (pf)= 10^{-12} f.

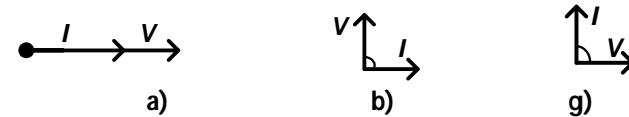
kondensatori xasiaTdeba sixSiris ukuppor-
ciul i sididiT – tevadobis reaqtul i winaRobiT,
romel ic gamoisaxebe formul iT:

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi fC}. \quad (1.5)$$

Tu wredSi (nax. 1.1) mimdevrobiT CarTul ia aqti-
uri (R), induqciuri (X_L) da tevaduri (X_C) winaR-



nax. 1.1. MmimdevroboT SeerTebul i R, X_L, X_C wredi



nax. 1.2. Zvris kuTxeebi denebsa da Zabvebs SorisM

obebi maSin i angariSeba wredis srul i winaRoba for-
mul iT:

$$Z = \sqrt{R^2 + (X_L - X_C)^2}, \quad (1.6)$$

a) aqtiur winaRobaSi deni da Zabva faziT erTmaneTs
emTxveva (nax. 1.2. a)

b) induqciurobaSi Zabva uswrebs dens 90° -iT (nax. 1.2. b)

g) tevadobaSi deni uswrebs Zabvas 90° -iT (nax. 1.2. g)

el eqtro da radioteqnikaSi garda gamtari masa-
l ebisa gamoyenebul ia **diel eqtrikebi** anu izol a-
torebi, es is masal ebia (mina, rezina, faifuri, qarsi
da sxva), romel Tac ar gaaCniaT Tavisufal i el eqtrone-
bi. magram Tu maTze movdebT maRal Zabvas, maSin Sei-
Zl eba moxdes diel eqtrikis garRveva da igi gar-
daiqmneba gamtarad. praqtikaSi amis gamo adgil i aqvs
kondensatorisa da transformatoris gragnil ebs
Soriss moTavsebul i izol aciis garRvevas.

el eqtrul i denis mier muSaobis Sesrul ebis un-
ars **energia** ewodeba. igi ricxobrivad tol ia Zabvis,
denisa da denis dinebis drois namravl isa da gamoi-
saxebe formul iT:

$$W = VI t. \quad (1.7)$$

energiis erTeul ia [vt.wm.] anu j oul i [j]. energi-
is es erTeul i Zal ian mcirea da amitom praqtikaSi
gamoiyeneba didi erTeul i kil ovatsaaTi [kvt.sT].

$$1 \text{ kvt.sT} = 1000 \text{ vt} \cdot 3600 \text{ wm} = 3,6 \cdot 10^6 \text{ vt} \cdot \text{wm} = 3,6 \cdot 10^6 \text{ joul i.}$$

drois erTeul Si moxmarebul energias simZl avre ewodeba da mudmivi denis SemTxvevaSi gamoisaxeba formul iT:

$$P = \frac{W}{t} = \frac{VI}{t} = VI. \quad (1.8)$$

am simZl avris erTeul ia vati [vt]. vati mcire erTeul ia da amitom praqtikaSi gamoiyeneba didi erTeul ebi:

$$\text{kil ovati [kvt]} = 10^3 \text{ vt} ; \text{ megavati [mvt]} = 10^6 \text{ vt.}$$

formul a (1.8) samarTl iania agreTve cvl adi denis im wredebisatvis, roml ebic Seicaven mxol od rezistorul el ementebis.

zogad SemTxvevaSi simZl avre ar warmoadgens ubral od Zabvisa da denis namravl s. cvl adi denis wredSi gvaqvs Semdegi saxis simZl avreebi:

srul i simZl avre - $S = VI$ [vol tamperi (va)];

aqtiuri simZl avre - $P = VI \cos \varphi$ [vati (vt)];

reaqtiul i simZl avre - $Q = VI \sin \varphi$ [vol tamperreaqtiul i (var)].

simZl avris koeficienti warmoadgens aqtiuri simZl avris fardobas srul simZl avrestan

$$K_p = \cos \varphi = \frac{P}{S} = \frac{P}{VI}. \quad (1.9)$$

misi maqsimal uri mniSvnel oba 1-is tol ia.

gamosaval i Zabvis arastabil uroba datvirTvis denis mixedviT

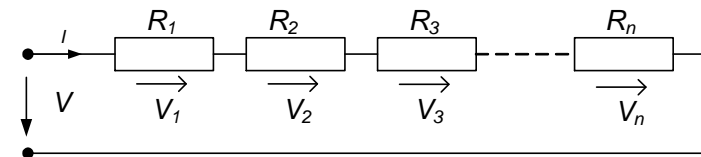
$$\text{arastabil uroba} = \frac{\text{Zabva datvirTvis gareSe-Zabva srul i datvirTvisas}}{\text{Zabva srul i datvirTvisas}}$$

daxarjul i el energiis raodenoba gani-sazRvreba 1 saatis ganmavl obaSi moxmarebul i simZl avriT. am raodenobas gansazRvraven kil ovatsaatIT [kvt.sT].

arsebobs el eqtrul i wredebis SeerTebis sami saxe: mimdevrobiTi, paral el uri da Sereul i.

mimdevrobiTi SeerTebis dros (nax. 1.3) erTi el ementis bol o uerTdeba meoris sawyiss, meoris bol o mesamis sawyiss da a.S. aseTi SeerTebisas yvel a el ementSi gadis erTi da igive deni, xol o Zabvebi damokidebul ia am el ementebis winaRobebze.

$$V = V_1 + V_2 + V_3 + \dots + V_n = I(R_1 + R_2 + R_3 + \dots + R_n) = I \cdot R, \quad (1.10)$$



nax.1.3. mimdevrobiT SeerTebul i wredi

$$\text{sadac } R = R_1 + R_2 + R_3 + \dots + R_n. \quad (1.11)$$

paral el uri SeerTebis dros (nax. 1.4) el ementebis sawyisebi erT kvanZad aris Sekrul i, xol o bol oebi - meore kvanZad. am dros yvel a el ementze moqmedebis erTi da igive Zabva, xol o denebi damokidebul ia am el ementTa winaRobebze.

$$I = I_1 + I_2 + I_3 + \dots + I_n = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3} + \dots + \frac{V}{R_n} = \frac{V}{R}, \quad (1.12)$$

$V_x = \sqrt{3}V_f$ fazuri Zabvebia V_A, V_B, V_C , xol o xazuri Zabvebia V_{AB}, V_{BC}, V_{CA} .

samkuTxedad SeerTeba naCvene bia nax. 1.7-ze.

samkuTxedad SeerTebis dros xazuri da fazuri Zabvebi erTmaneTis tol ia: $V_x = V_f$; xol o xazuri deni $\sqrt{3}$ -j er metia fazur denze. $I_x = \sqrt{3}I_f$ xazuri denebia I_A, I_B, I_C ; fazuri denebia: I_{AB}, I_{BC}, I_{CA} .

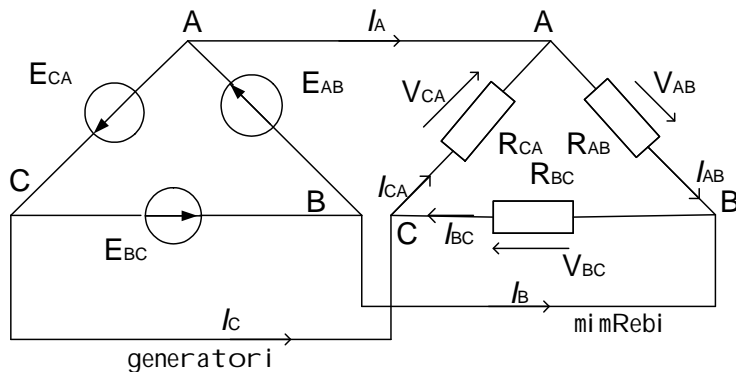
samfaza wredSi aqtiuri, reaqtiul i da srul i simZl avreebi tol ia:

$$P = V_A I_A \cos \varphi_A + V_B I_B \cos \varphi_B + V_C I_C \cos \varphi_C,$$

$$Q = V_A I_A \sin \varphi_A + V_B I_B \sin \varphi_B + V_C I_C \sin \varphi_C,$$

$$S = \sqrt{P^2 + Q^2}.$$

Tu datvirTva simetriul ia anu yvel a fazis datvirTva erTnairia, maSin:



nax. 1.7. samkuTxedad SeerTebul i samfaza wredi

$$P = 3V_f I_f \cos \varphi_f = \sqrt{3}V_x I_x \cos \varphi_x,$$

$$Q = 3V_f I_f \sin \varphi_f = \sqrt{3}V_x I_x \sin \varphi_x,$$

$$S = \sqrt{P^2 + Q^2}.$$

nax. 1.6-ze mocemul i SeerTebas pirobiTad aRniS-naven Δ/Δ - iT, xol o nax. 1.7-ze mocemul s Δ/Δ - garda amisa arsebobs Semdegi saxis SeerTebebi: varskvl avi – samkuTxedze (Δ/Δ), samkuTxedi – varskvl avze (Δ/Δ).

1.2. mowyobil obebisa da danadgarebis gamosaxvis ZiriTadi saSual ebani. el eqtrul i sqema. el eqtrul i sqemis tipebi da saxeebi

mowyobil obebisa da danadgarebis sxvadasxva wredebis gamosaxvis saSual ebad, agreTve maTi montaJisa da eqspl uataciis gasacnobad gamoiyeneba special-uri naxazebi – sqemebi. mowyobil obaSi Semaval i el ementebis saxeebis mixedvit arsebobs kinematikuri, hidravlikuri, pnevmaturი, el eqtrul i da sxva saxis sqemebi. arsebobs agreTve kombini rebul i sqemebi, რომლებიც სდება სხვადსხვა სaxis el ementebisagan. მაგალიტად el eqtrohidravlikური sqemebi Seicaven rogorc el eqtrul , aseve hidravლიკური el ementებს.

el eqtrul i sqema ewodeba el eqtrul i wredis pirobiT grafikul gamosaxul ebas. Tavisi daniSnul ebis mixedvit el eqtrul i sqemebi iyofa Semdeg saxee-

bad: struqturul i, funqcional uri, principul i, SeerTebebis, CarTvebis, saerTo da ganl agebis.

struqturul i sqema gviCvenebs mowyobil obis ZiriTad funqcional ur nawil ebs, maT daniSnul ebas da maT Soris urTierTkavSirs. aseTi sqemebi ZiriTadad srul deba sxva tipis sqemebis winaswari damuSavebis stadiaze da gamoiyeneba mowyobil obis gasacnobad.

funqcional uri sqemebi gviCveneben mowyobil obis an danadgaris wredebSi mimdinare cal keul procesebs da gamoiyeneba maTi moqmedebis zogadi principis Sesaswavl ad.

principul i sqemebi warmoadgenen sakonstruqtoro dokumentaciis damuSavebis safuZvels. aseT sqemebsi mocemulia yvela el ementi da maT Soris kavSiri. isini iZi evian mowyobil obis moqmedebis principze detalur warmodgenas.

SeerTebis sqemebi gviCveneben mowyobil obis el ementebs Soris kavSirs. am kavSiris ganxorciel ebis saSual ebebs (sadenebi, Cal iCebi, (“?aoo”) mil sadenebi da sxva), agreTve SeerTebebis da Semyvanebis adgil ebs. es sqemebi gamoiyeneba sakonstruqtoro dokumentaciis damuSavebis dros, gansakuTrebiT sakonstruqtoro naxazebis damuSavebisas, roml ebic gansazRvraven sadenebis, Cal iCebis, kabel ebis, mil sadenebis, aparatebisa da sxvaTa ganl agebisa da damagrebis sakiTxebis.

CarTvis sqemebi gviCveneben mowyobil obis gare CarTvis adgil ebs.

saerTo sqemebi gviCveneben kompl eqsebis Semadgenel nawil ebs da eqspl uataciis adgil ze maT Soris SeerTebebs.

ganl agebis sqemebi gviCveneben mowyobil obaTa Semadgenel i nawil ebis ganl agebas.

sqemebi SeiZi eba iyos SeTavsebul i. magal iTad, SeerTebis sqemaze SeiZi eba naCvenebi iyos mowyobil obis gare CarTva; struqturul i sqema SeiZi eba SeTavsebul i iyos funqcional ur sqemasTan da a.S.

rogorc cnobil ia, el eqtroenergiis miRebis, gardaqmni s, gadacemis, ganawil ebis da moxmarebis procesebi xdeba el eqtromowyobil obisa da el eqtrodanadgarebis el eqtrul wredebSi. amitom el eqtromowyobil obisa da danadgarebis gamosaxvis ZiriTad saSual ebad gamoiyeneba iseTi sqemebi, roml ebic saSual ebas gvaZi evs gavigoT el eqtrodanadgaris yvela el ementebs Soris urTierTqmedeba. aseT sqemebs warmoadgenen principul i el eqtrul i sqemebi.

1.3. el eqtrul sqemebSi gamoyenebul i pirobiTi grafikul i aRniSvnebi

nebismeri el eqtrul i sqema warmoadgens el eqtrul i sistemis an wredis model s, romel ic saSual ebas aZi evs adamians swrafad gaerkves sqemis struqturasi, rac metad mniSvel ovania diagnostikis Catarebis dros.

aTasobiT adami ani adgens el eqtrodanadgaris sqemebs, xol o mil ionobiT adami ani muSaobs am sqemebze. amitom sqemebi Sedgenil i unda iqnas kargad cnobil i pirobiTi aRniSvnebiT; sxvagvarad adami anebi erTma-

neTs ver gaugeben, ver waikiTxaven sqemebs an waikiTxaven SecdomiT, rac migviyvans araswor moqmedebamde.

amitom pirobiTi aRniSvnebi da el eqtrul i sqemebis Sesrul ebis wesebi ganisazRvreba saxel mwifo standartebiT.

el eqtrul sqemaze yvel aze metad gavrcel ebul i zogierTi aRniSvnebi mocemul ia danarTSi 1.

1.4. Zal ovani da marTvis wredebi

el eqtrul i wredebi Cveul ebriv iyofian Zal ovan da marTvis wredebad. Zal ovani wredi Seicavs mTavar Zal ovan mowyobil obebs (transformatorebi, el eqtrul i Zravebi, generatorebi da sxva) mZI avri gamtarebiT, kontaktozebiTa da mcvel ebiT.

Zal ovani wredebi gadascemen did simZI avreebs mZI avr el eqtromowyobil obebs. isini izol atorebis, amomrTvel ebisa da denmkveTebis daxmarebiT ganamxol oeben; kontaktozebis, gadamrTvel ebis da sxvaTa daxmarebiT marTaven, xol o **gadatvirTvis** Tburi rel eebis, el eqtromagnituri rel eebis, avtomaturi amomrTvel ebis, gadasaxsnel ebis mcvel ebisa da sxvaTa daxmarebiT gadatvirTvisa da mokl ed SerTvisagan icaven el eqtrul wredebs.

marTvis wredebi emsaxurebian mowyobil obisa da damcavi bl okirebis marTvas; adgenen mowyobil obisa an manqanis operaciis Sesrul ebis Tanmimdevrobas.

marTvis wredebi Sesdgebian gadamrTvel ebis, momwrebebis sxvadasxva daniSnul ebis rel eebis, maTi kontaktozebis, koWebis, mricxvel ebisa da SemaerTebel i sadenebisagan. isini warmoadgenen Sesaval kontaktozebs,

roml ebic asaxaven sxvadasxva mdgomareobas. am mdgomareobidan gamomdinare gamosaval gragnil ebze miwodeba an ar miwodeba kveba.

Sesaval i kontaktozebi asaxaven or mdgomareobas "CarTul ia- an "gamorTul ia-. amis gamo arsebobs ori tipis kontaktozebi: normal urad Caketil i (n.C) da normal uri Ria (n.R) kontaktozebi.

Sesaval i kontaktozebia: rel eebis, kontaktozebis, taimerebis, mricxvel ebis, magnituri da Ril akiani gadamrTvel ebis, sabol oo amomrTvel ebis da sxvaTa kontaktozebi.

gamosaval i gragnil ebi SeiZI eba imyofebodnen or mdgomareobaSi - CarTul an gamorTul Si. gamosaval gragnil ebi SeiZI eba mivakuTvnoT mTavar an damatebiT kontaktozers.

1.5. principul i el eqtrul i sqema

principul i el eqtrul i sqema es aris gaSI il i saxiT Sesrul ebul i el eqtrul i SeerTebebis sqema. igi warmoadgens sawarmoo meqanizmebis el eqtromowyobil obis proeqtis ZiriTad sqemas da gvaZI evs zogad warmodgenas mocemul i meqanizmis el eqtromowyobil obis Sesaxeb; asaxavs meqanizmis avtomaturi marTvis sistemis muSaobas da gamoiyeneba SeerTebebis da CarTvis sqemebis Sedgenis, konstruqciul i kvanZebebis daproeqtebis da el ementebis CamonaTval is gaformebebis wyarod.

Tavisi daniSnul ebis mixedvit principul i sqemebi iyofa: marTvis, teqnologiuri kontrol isa da

signal izaciis, avtomaturi regul irebisa da kvebis sqemebad.

principul i sqemis ZiriTadi daniSnul ebaa sakmarisi sizustiTa da Tval saCinoebiT asaxos urTierTkavSiri avtomatizaciis sistemebis funkcional urkvanZebSi Semaval xel sawyoebis, avtomatizaciis saSual ebebsa da damxmare aparaturas Soris maTi muSao-bisa da moqmedebis principis Tanmimdevrobis mxedvel obaSi miRebiT.

principul i sqemis mixedviT xorciel deba el eqtromowyobil obis montaJisa da gawyobis dros el eqtrul i SeerTebis sisworis Semowmeba. am sqemebis damuSavebis xarisxzea damokidebul i sawarmoo meqanizmebis muSaobis mkafiooba, misi mwarmoebl oba da eqspl uataciaSi saimedooba.

principul i sqemebi warmoadgenen proeqtis damuSavebis sxva dokumentebis, samontaJo sqemebisa da pul tebisa da farebis cxril ebis, gareSe sadenebis SeerTebis sqemebis da sxvaTa safuZvel s.

zogadad principul i sqema Seicavs:

1) avtomatizaciis sistemis ama Tu im funkcional uri kvanZis moqmedebis principis pirobiT gamosaxvas;

2) ganmarTEbiT warwerebs;

3) mocemul i sqemis cal keul i el ementebis (xel sawyoebis, el eqtrul i aparatebis) nawil ebs, roml ebic gamoyenebul ia sxva sqemaSi, agreTve sxva sqemebis mowyobil obebis el ementebis.

4) mraval poziciani mowyobil obebis kontakTEbis gadarTvis diagramas.

5) mocemul sqemaSi gamoyenebul i xel sawyoebisa da aparaturis CamonaTval s.

6) im CamonaTval s, romel ic ekuTvnis mocemul sqemas, Tavisi ganmarTEbebiTa da SeniSvnebiT.

1.6. el eqtrul i sqemebis wakiTxva

el eqtrul i sqemis wakiTxva niSnavs, rom mi sgan mi viRoT is maqsimal uri informacia, romel ic saWiroa gansazRvrul i samuSaos Sesasrul ebl ad. saangariSo sqemebis wakiTxvisas mi viRoT monacemebi Canacvl ebis sqemis SedgenisaTvis. Canacvl ebis sqemis wakiTxviT gansazRvrebis sidideebi, roml ebic unda Caisvas gaangariSebis sabol oo Sedegis misaReb formul ebSi.

principul i sqemebis dazepirebis mcdel oba usargebl o mecadineobaa da imisaTvis, rom wavikiTxoT sqema saWiroa raRac sakiTxebis damaxsovrebis, iseve rogorc unda gvaxsovdes gamravl ebis tabul a an Semoklebul i gamravl ebis formul ebi.

1. unda gvaxsovdes yvel aze ufro gavrcel ebul i pirobiTi aRniSvnebi; magal iTad, gragnil ebis, kontakTEbis, transformatorebis, Zravebis, gammarTvel ebis, naturebis da a.S.

2. unda gvaxsovdes profesidan gamomdinare xSi-rad gamoyenebul i pirobiTi aRniSvnebi.

3. yvel aze ufro gavrcel ebul i el eqtrodanad-garebis kvanZebis, Zravas, gammarTvel is, ganaTEbis qselis da sxvaTa sqemebi.

4. unda vicodeT mimdevrobiT da paral el urad CarTul i kontakTEbis, gragnil ebis, winaRobebis, induqciurobebisa da tevadobebis Tvi sebebi.

5. yovel i konkretul i SemTxvevisaTvis unda vfl obdeT el teqnkis Sesabamis codnas da agreTve unda vicodeT sqemis wakiTxvis Tanmimdevroba.

6. sqemis wakiTxvis procesSi unda SevamowmoT gakeTebul i varaudis siswore.

el eqtrul i sqemebis wakiTxvis Tanmimdevroba aseTia:

1. el eqtrul i sqemebis wakiTxvisas yovel Tvis iwyeben misi da CamonaTval i el ementebis zogadi gacnobiT. poul oben sqemaze TiToeul el ements, ecnobi-an yvel a SeniSvnasa da ganmar tebas;

2. gansazRvraven el eqtrul i Zravebis, magnituri gamSvebis gragnil ebis, rel eebis, el eqtromagnitebis, xel sawyoTa kompl eqtebis, regul atorebisa da sxvaTa kvebis sistemebs. amisaTvis sqemaze poul oben yvel a kvebis wyaros, gamoavl enen TiToeul i maTganisaTvis denis saxeobas, nominal ur Zabvas, fazirebas cvl adi denis wredesi da pol arobas mudmivi denis wredesi da miRebul Sedegebs Seapi rebireben gamoyenebuli i aparaturis nominal ur monacemebTan.

sqemis mixedviT gamoavl enen saerto sakomunikacio aparatebs, agreTve dacvis aparatebs: avtomatur amomrTvel ebs, mcvel ebs, maqsimal uri denisa da minimal uri Zabvis rel eebis da sxva. warwerebis, cxril ebis an SeniSvnebis mixedviT gansazRvraven aparatebis dayenebas da afaseben TiToeul i maTganis dacvis zonas.

3. swavl oben TiToeul i el eqtromimRebis: el eqtroZravas, magnituri amamuSavebel s. gragnil is, rel es, xel sawyos da sxva yvel a SesaZl o wreds. sqemaSi el eqtromimRebebis didi raodenobaa da sul erTi

ar aris saidan daviwoT sqemis wakiTxva. es ganisazRvrebada dasmul i amocanis mixedviT. Tu sqemis mixedviT unda ganisazRvros el mimRebis muSaobis pirobebi, maSin wakiTxvas iwyeben ZiriTadi el eqtromimRebidan da Semdegi el eqtromimRebi TviTon gamocndeba.

magal iTad, el eqtroZravas gaSvebisatvis unda CavrToT magnituri amamuSavebel i. saTanadod Zravas Semdegi el mimRebi unda iyos magnituri amamuSavebel is gragnil i. Tu wredi Seicavs saSual edo rel es kontakts, maSin unda ganvixil oT misi gragnil is wredi da a.S. magram SeiZl eba iyos meore amocana: wredis raRac el ementi magal iTad, sasignal o naTura ar ainto, maSin pirvel i el mimRebi iqneba swored igi.

unda aRiniSnos, rom Tu sqemis wakiTxvisas ar gagvacnia gansazRvrul i mizanimarTul eba, maSin SeiZl eba ise davxarj oT bevri dro, rom veraferic ver gadavwyvitoT.

amgvarad, vswavl obT ra arCeul el mimRebs, unda miwyvet mis yvel a wreds pol usidan pol usamde (fazidan fazamde an fazidan nul amde kvebis sistemidan gamomdinare). am dros pirvel rigSi unda gamoavl inoT wredesi Semaval i yvel a kontakti, diodi, rezistori da sxva el ementebi.

unda aRiniSnos, rom ar SeiZl eba erTdroul ad ganxil ul iqnes ramdenime wredi. saWiroa pirvel ad Seviswavl oT magal iTad, "win- magnituri amamuSavebel is gragnil is CarTvis wredi adgil obrivi marTvis dros. davadginoT am SemTxvevasi ra mdgomareobaSi unda iyos am wredesi Semaval i el ementebi (reJimebis

gadamarTvel i unda iyos mdgomareobaSi -adgil obrivi marTva", xol o magnituriA amamuSavebel i -ukan" _ gamorTul i). imisaTvis, rom CavrToT magnituri amamuSavebel i (davaWiroT TiTi Ril aks -win") da a.S. amis Semdeg azrobrivad gamovrToT magnituri amamuSavebel i -win" da isev azrobrivad gadaviyanoT reJimebis gadamarTvel i mdgomareobaSi -avtomaturi marTva" da Seviswavl oT Semdegi wredi.

el eqtrul i sqemis TiToeul i wredis gacnobas aqvs mizani:

1. ganvsazRvroT moqmedebis piroba, romel sac akmayofil ebs sqema;

2. gamovavl inoT Secdomebi: magal iTad, wredSi mimdevrobiT SeiZl eba SeerTebul i iqnes kontaqtebi, roml ebic erTdroul ad arasdros ar iqneba CarTul i;

3. ganvsazRvroT mtyunebis yvel a mizezi;

4. davadginoT wredis el ementebi, roml ebSiC SeiZl eba darRveul i iqnas droiTi damokidebul eba araswori regul irebis an damproeqtebl is mier eqspl uataciis pirobemis araswori SefasebiT. risi tipiuri magal iTia Zal ian mcire an Zal ian didi xangrZl ivobis impul sebi;

5. gamovavl inoT aparatebi, romel Tac SeiZl eba mieces araswori dayeneba; amis tipiuri magal iTia denuri rel es araswori dayeneba marTvis wredSi;

6. gamovavl inoT yovel gvari cru wredi, rogorc normal ur aseve gardamaval reJimebSi. magal iTad, kondesatorebis gadamuxtva. cru wrededi SeiZl eba Camoyal ibdes mkvebavi Zabvis miwodebis rigiTobis

darRvevis dros, rac gviCvenebs proeqtirebis dabal xarixs;

7. SevafasoT sqemis TiToeul wertil Si izol acis darRvevis gamo mosal odnel i Sedegi;

8. davadginoT sqemis moqmedeba kvebis nawil obrivi gamorTvis dros.

sqemis anal izis dros did daxmarebas giweven urTierTmoqmedebis droiTi diagramebi, roml ebic asaxaven sqemis muSaobis dinamikas.

1.7. sadenebisa da kl emebis numeracia

nebismeri marTvis el eqtrul sistemaSi aris sadenebi, roml iTac erTmaneTTan SeerTebul ia sxvadasxva el ementebi. saWiroa. rom es el ementebi erTmaneTTan SeerTebul i iqnas Sesabamisi sadenebiTa da swori pol arobiT. darwmunebul i rom viyoT sadenebis CarTvis sisworeSi, el ementebsa da maT kl emebis eniWebat e.w. unikal uri nomrebi. aseTi praqtika gamoyenebul ia damuSavebis, montaJisa da momsaxureobis dros. es numeracia gvexmareba agreTve dignostikis procesSi el ementebis, sadenebisa da kl emebis identifikciaSi.

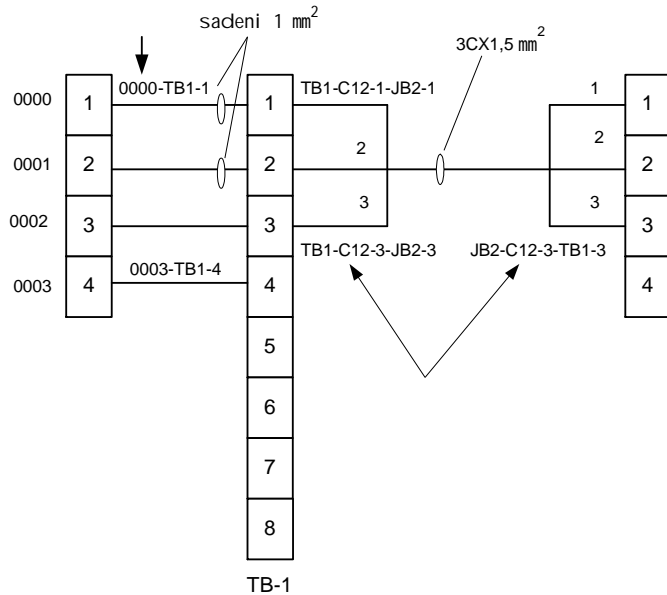
kl emebi emsaxureba sadenebis SeerTebas el eqtrul panel Si. isini Cveul ebriv gaerTianebul ia j gufSi, e.w. "kl emis kal apotsi-. isini j gufdebian an funkcional uri daniSnul ebis an mowyobil obis raime kuTvnil ebis mixedvit. TiToeul i kl emis kal apots miniWebul i aqvs Tavisi unikal uri nomeri. Cveul ebriv kl emis erTi mxare emsaxureba Siga el ementebis CarTvas, xol o meore mxare – gare el ementebis CarTvas.

el eqtrul panel ebSi gamoiyeneba sadenebi da mraval ZarRva kabel is ZarRvebi. sadenebi da ZarRvebi CarTul ia mowyobil obis kl emebTan da kl emis kal - apotebTan. yvel aisini danomril ia. amisaTvis sadenebi markirebul ia asoebiTa da cifrebiT.

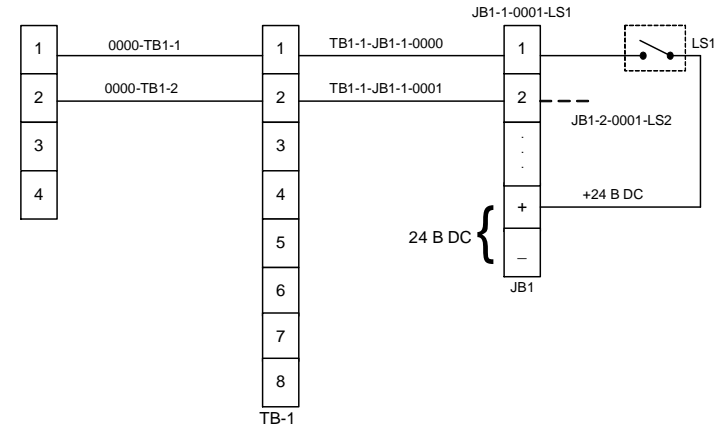
sadenebis numeracia unda SeiCavdes:

- kabel is nomers;
- sadenis an mraval ZarRva kabel is ZarRvis nomers;
- kl emis kal apotis nomers;
- kl emis nomers, romel zec unda Cai rTos sadeni.

radganac sadeni irTveba ori mxariT, amitom Zal ian moxerxebul ia gamovi yenoT sadenebis numeraci is j varedini meTodi. sadenis an kabel is ZarRvis j varedini



nax.1.9. sadenebis j varedini numeracia da kl emebis numeracia



nax. 1.10. sadenebis numeracia programul -l ogikuri kontrol eris (pl k) panel ze damatebiTi el emente biT pl k misamarTebis saxiT

nomeri SeiCavs informacias imaze, Tu sad aris CarTul i meore bol o. agreTve SeiZl eba SeiCavdes iseT informacias, rogoricaa "panel is nomeri~", "kl emis kal - apotis nomeri~ da "kl emis nomeri~.

nax. 1.9-ze naCvenebia sadenebisa da kl emebis tipi uri j varedini numeracia. SeiZl eba praqtikaSi gamoyenebul i iqnas mraval ricxovani wesebi da meTodebi.

j varedini numeracia warmoadgens kabel ebis Cadebisa da CarTvis, "garekvisa- da diagnostikis dros gamoyenebul erT-erT meTods.

rogorc nax. 1.9-zea naCvenebi C12 kabel is ZarRvisTvis TB1 da JB2 kl emebis kal apotebs Soris gamoyenebul ia j varedini markireba. TB1 kl emebis kal - apotze markireba. gviCvenebs, Tu sad aris CarTul i kabel is ZarRvis meore bol o.

magal iTad, nax. 1.10-ze naCvenebs sqemaze pl k-s panel ze sadenebis j varedin markirebas emateba kidev erTi samisamarTo informacia. misamarTi sadenis markirebaSi kabel is, ZarRvisa da kl emis nomerTan erTad Zal ian sasargebl oa diagnostikis dros.

nax. 1.10-ze naCvenebs j varedini markireba gamoyenebul ia savel e xel sawyoebisa da kl emebis kal apotebis SesaerTebI ad; agreTve kl emaTa Soris SeerTebisaTvis. miuxedavad imisa, rom markirebis aseT saxes miyavarT grZel nomrebTan, mainc praqtikaSi aseTi markireba Zal ian gamarTl ebul ia.

1.8. raze unda gavamaxvil oT yuradReba sqemebis wakiTxvisas

1. el ementebis aRniSvna sqemaze gviCvenebs mis gamorTul mdgomareobas, anu roca el eqtrul i kveba ar miwodeba. es SeiZl eba iyos taimeris an rel es normal urad Ria (nR) an normal urad Caketil i (nC) kontaktebi. garda amisa amomrTvel ebi da kontaktozebi momaragebul ia damatebiTi nR da nC kontaktebiT, raTa asaxos mowyobil obis mdgomareoba sasignal o da mabli okirebel wredebSi.

2. el eqtrul sqemas gaaCnia furcl is nomeri, xol o TiToeul i furcel i iyofa 1, 2, 3, 4... da a.S. strigonebad da A, B, C, D ... da a.S. svetebad. aseTi matricul i saxe gvexmareba swrafad movZebnoT furcel ze gansazRvrul i el ementi an kontakti. amgvარი wesi gamoiyeneba kontaktebis j varedini aRniSvnisatvis.

3. gragnil isa da misi kontaktis erTmaneTisagan gansxvavebis mizniT pirobiTi aRniSvnis gverdiT iw-

ereba asoebi da cifrebi. magal iTad: K1, K2 an C1, C2. kontaktozebi aRiniSneba igive asoebiT, rogorc TviT kontaktozebi gragnil i.

4. erTi da igive rel es sxvadasxva kontaktebi SeiZl eba gamoyenebul i iqnes sxvadasxva wredebSi. gaugebrobis Tavidan acil ebis mizniT TiToeul kontakts aqvs j varedini nomeri, romel ic gviCvenebs furcl isa da mis matricul nomers.

5. msxvil i xazebi gviCvenebs mZl avri denebis sadenebs (kvebis xazebi, el eqtroZravas gamomyvanebi da sxva), xol o wril i xazebi gamosaxaven susti denebis sadenebs (marTvis wredebi).

6. marTvis wredebSi kvebis xazebi aRiniSneba L1 da L2 asoebiT; datvirTva (rel es gragnil i) mimdevrobit CairTveba gadamrTvel Tan, mcvel ebTan da a.S.

7. erTmaneTis gadamkveT sadenebs ara aqvs erTmaneTs Soris el eqtrul i kontakti Tu gadakveTis adgil as ar aris wertil i da piriqit, Tu arsebobs wertil i, maSin gvaqvs gadamkveT gamtarebs Soris el eqtrul i kontakti.

8. el eqtrul sqemaze wyvetil i xazi gviCvenebs meqanikur SeerTebas. umTavresad es miekuTvneba RiI akebs an gadamrTvel ebs. zogjer aseTi xazebi gviCveneben or an met el ements Soris meqanikur urTierTkavSirs; magal iTad, kontaktozebsa da amomrTvel ebs Soris.

9. punqtiri xaziT aRiniSneba agreTve xel sawyotTa gare korpusebi.

10. SeerTebis el eqtrul i sqema gviCvenebs sxvadasxva el ementebis fizikur ganl agebasa da maT Soris el eqtrul kavSirs.

11. sadenebi el eqtrul sqemaze markirebul ia iri-bi xazebiT da gverdiT naCvenebia maTi zomebi.

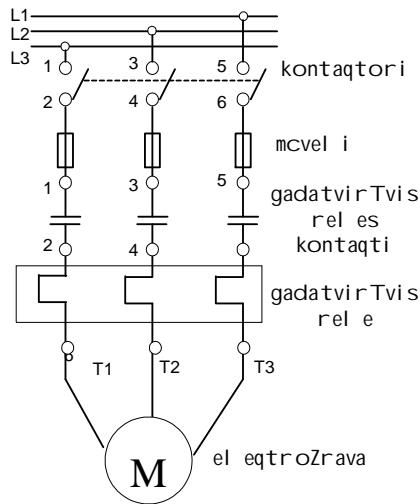
qvemoT yvel aferi es ganmartebul ia ramdenime el eqtrul i sqemis magal iTiT.

1.9. sqemebis wakiTxvis magal iTebi

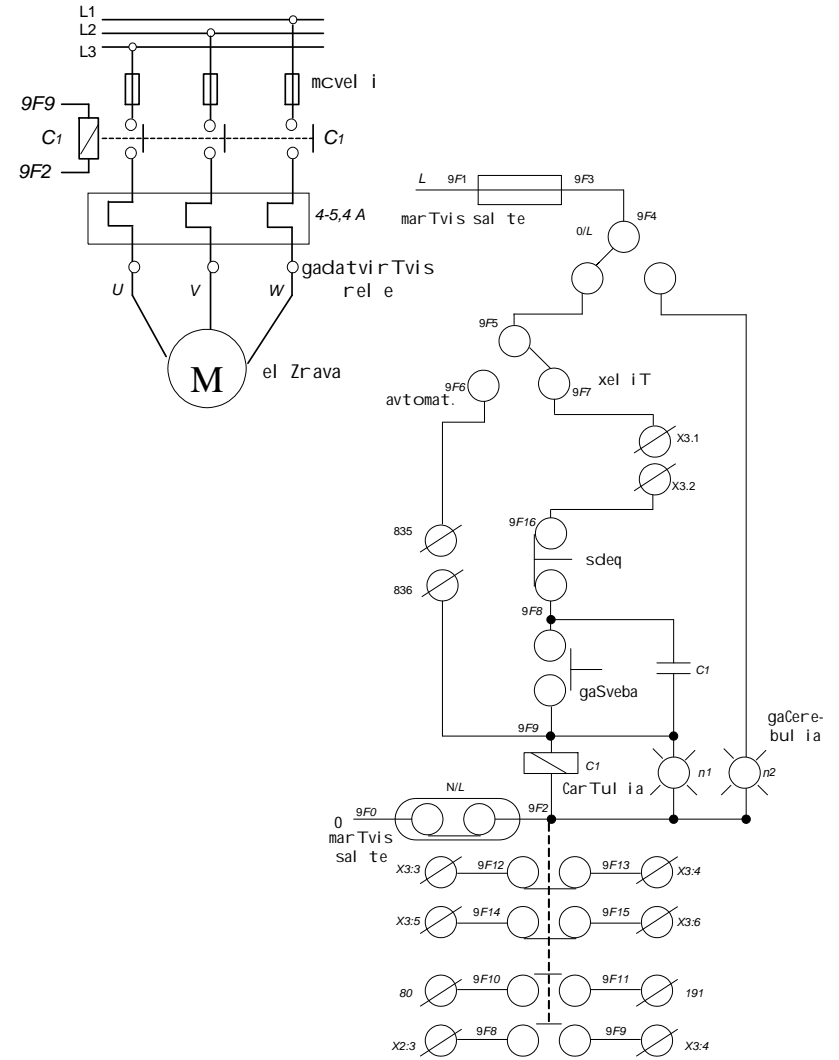
magal iTi 1. nax. 1.11-ze naCvenebia el eqtroZravas Zal ovani wredi. naxazidan Cans, rom samfaza wredi (L1, L2, L3) el eqtroZravasTan CarTul ia kontaqtoris gavl iT. el eqtroZravas kveba miwodeba mxol od kontaqtoris kontaqtEBis (1-2, 3-4, 5-6) Caketvis dros. el Zravas muSaobis dros avariul i situaciebis Tavidan

acil ebiS miZniT el Zravas mimdevrobit CarTul ia dacvis mowyobil obebI, rogorebicaa mcveli ebi da gadatvirTvis rel e.

magal iTi 2. nax. 1.12-ze warmodgenil ia samfaza el eqtroZravas magnituri gamSvebiT pirdapiri gaSvebis Zal ovani (nax.1.12-a) da marTvis (nax.1.12-b) wredebis tipiuri el eqtrul i sqema.



nax.1.11. el eqtroZravas Zal ovani wredis sqema



a) b)
nax. 1.12. samfaza el eqtrul i Zravas magnituri gamSvebiT pirdapiri gaSvebis Zal ovani da marTvis wredebis tipiuri el eqtrul i sqema

Zal ovani wredi iwyeba samfaza kvebis (L1,L2,L3) qsel idan mcvel ebis nakrebTan erTad. Semdeg CarTul ia Zal ovani kontaktoris kontaktebi. kontaktoris gamosaval kl emebTan CarTul ia gadatvirTvis rel e da bol os rel es gamosasvl el ze CarTul ia el eqtroZravas gamomyvanebi.

el eqtroZravas marTvis wredi muSaobs 110v sidi-dis erTfaza cvl adi deniT. kvebis wyaros faza CarTul ia gadatvirTvis rel es nC kontaktebTan. (0/L) am rel edan sadeni midis "avtomaturi/xel iT- reJimebis gadamrTvel Tan.

avtomatur reJimSi el eqtroZrava iRebs "gaSveba/gaCerebis- brZanebas rel es e.w. "mSral i- (anu gal vanurad ganmxol oebul i) kontaktebis gavliT (835-836 kl emebi).

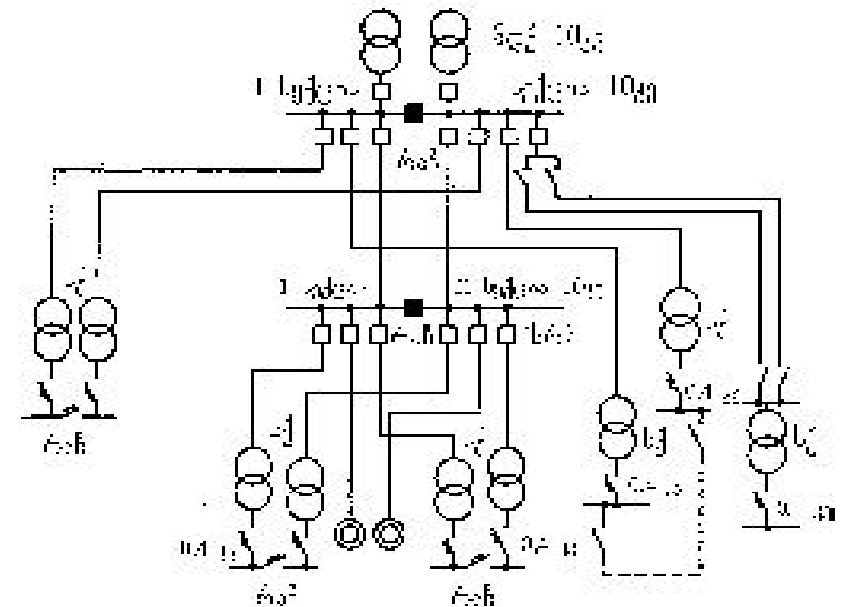
rel e imarTeba programul -l ogikuri kontrol -eris (pl k) gamosasvl el iT (romel ic naxazze naCvene-bi ar aris), xel iT marTvis reJimSi el eqtroZravas gaSveba xdeba "gaSveba- Ril akis daxmarebiT. am Ril akze xel is daWeriT marTvis wredi CairTveba da amuSavde-ba C1 kontaktoris gragnil i. ris Sedegad CaikeTeba am kontaktoris 'mSral i- C1 nR kontaktebi da Ril akze xel is aSvebis Semdeg kveba miwodeba C1 gragnil s. CarTul i kontaktoris dros el eqtroZravas kvebis wredi CarTul ia da is imuSavebs manam, sanam C1 kontaktori ar gamoirTveba da ar gaTiSavs wreds.

xel iT marTvis reJimSi muSaobis dros X3.1 da X3.2 kl emebs Soris SeiZl eba CarTul i iqnes el eqtroZravas bl okirebis sxvadasxva mowyobil obebi (magal iTad, sab-

ol oo amomrTvel ebi). el eqtroZravas gaCereba swar-moebs "sdeq- Ril akze xel is daWeriT. am Ril akis nC kontaktebi gaiTiSeba da el eqtrokveba Seuwydeba kon-taktoris — gragnil s, rac Tavis mxriv gaTiSavs Tavis Zal ovan kontaktebs da el energiis miwodebas Seuwyvi-tavs el eqtroZravas da Zrava gaCerdeba.

marTvis wredis saerto wertil i CarTul ia nei-tral uri (nul ovani) xazis N/L kl emasTan. el eqt-roZravas CarTvis indikaciisaTvis kontaktors paral e-l urad CarTul ia sasignal o naTura n1, romel ic ain-Teba kontaktoris CarTvis dros.

el eqtroZravas gaCerebis indikacias ukeTebis n2 naTura, romel ic CarTul ia gadatvirTvis rel es nor-mal urad Ria kontaktebTan. es kontaktebi CaikeTeba

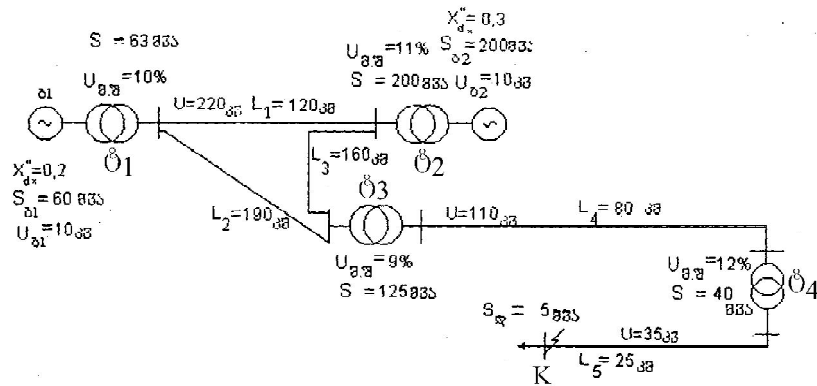


nax. 1.13. el momaragebis radial uri sqema

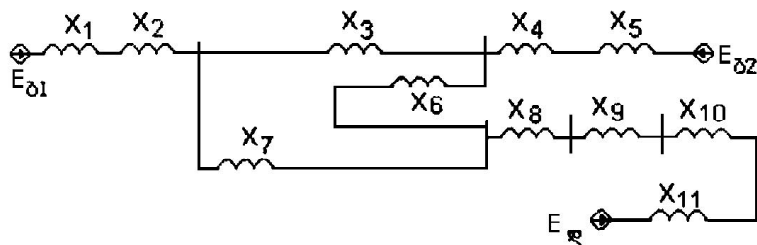
Zravas gadatvirTvis dros da naTura anTia manam sanam gadatvirTvis rel e ar Camoiyreba.

X3:3 - X3:4; X3:5 - X3:6; 80-191 da X2:3 - X2:4 kl emebis wyvil ebTan CarTul ia C1 kontaktoris ori wyvil i nC da ori wyvil i nR ~mSral i" kontaktebi.

nR kontaktebi gamoyenebul ia CarTul mdgomareobaSi kontaktoris fiqsaciisaTvis. es kontaktebi



ნახ. 1.14. ელ ეტრული სისტემის საანგარიშო სქემა



ნახ. 1.15. ელ ეტრული სისტემის განაცვლებების სქემა ფარდობით ერტულ ებსი ცატარებულ ი გამოტვლებიტი მიიReba, რომ:

$X1=0,33$; $X2=0,158$; $X3=0,09$; $X4=0,055$; $X5=0,15$; $X6=0,012$;
 $X7=0,143$; $X8=0,072$; $X9=0,24$; $X10=0,3$; $X11=0,73$

ცაირტევა X2:3 და X2:4 კლ ემებთან გამსვი რილ აკის ნრ კონტაქტების პარალელურად. ეს კარგად განს 9F8 და 9F9 არნი სვნებიტ, რომლებიც გვიცვენებენ კონტაქტების მდგომარეობას სქემაზე.

მაგალიტი 3. ნახ. 1.13-ზე მოყვანილია ელ ეტრომომარგების რადიალური სქემა.

ამ სქემიდან განს, რომ მთავარ დამწვევ კვესადგურსი (მდკ) ტრანსფორმირის სასუალ ებიტი xდება 110kv ზაბვის დავევა 10kv ზაბვამდე. მდკ-სი დგას ორი ზალ ოვანი ტრანსფორმირი ტავისი სეკციებიტი (I სეკცია, II სეკცია). სეკციებს სორის გატვალის ვინებულ ია რეზერვის ავტომირი ცართვა (რაც), როგორც 10kv, ისე 0,4kv ზაბვის მხარეს.

ორ ტრანსფორმირიან კვესადგურებსი (სკ1...სკ2) ტიტოეული ტრანსფორმირი კვებას ირებს სხვადახვა სეკციიდან დამოუკიდებელი ხაზიტი. აკ გამოყენებულ ია როგორც ერტი, ისე ორსაფეხურიანი სქემა სასუალ ედო (სრ) რელ ეტი.

სკ 4 და სკ 5 კვესადგურებსი დგას ტიტო ტრანსფორმირი, მაგრამ მათ სეუზლიატი ერტმანეტთან დამაკავსირებელი დაბალი (0,4kv) ზაბვის კაბელიტი სავიროების სემტხვევასი ტავის ტავზე აიროს მეორე ტრანსფორმირის დატვირტვა. სკ 6-სი დგას ერტი ტრანსფორმირი, მაგრამ გააჩნია ორი მკვებავი კაბელი.

მაგალიტი 4. ნახ.1.14-ზე K ვერტილ სი მოკლედ სერთვის დენების საანგარიშოდ მოცემულია ელ ეტრული სისტემის სქემა, რომელიც გვაკვს ოტი ზაბვა. გენერირის ნომიალური ზაბვა 10 kv-ია, t1, t2 და t3 ტრანსფორმირების ზაბვა 220kv-ია. t-4 ტრანსფორმირის t-3 ტრანსფორმირთან სემაერთებელი ხაზის ზაბვა 110 kv, ხოლო დატვირტვისა და მისი მკვებავი ხაზის ზაბვა-35 kv.

vkiTxul obT sqemas. pirvel rigSi vsazRvraT Tu ra saxis winaRobebiT (aqturi, induqciuri, tevaduri) unda Sevcval oT saangariSo sqemis el ementebi. mocemul SemTxvevaSi yvel a el ementi unda Seicval os misi Sesabamisi induqciuri winaRobiT. meore rigSi vsazRvraT rogor unda SeerTdes es winaRobebi erTmaneTTan. amis Semdeg monacemebis mixedviT vangariSobT Canacvl ebis sqemis winaRobebis da bol os vxazavT Canacvl ebis sqemas, romel sac aqvs nax. 1.15-ze naCvenebi saxe da vatarebT sabol oo gaangariSebas.

Tavi II. diagnostikis ZiriTadi principiebi da meTodebi

2.1 diagnostikis safuZvl ebi

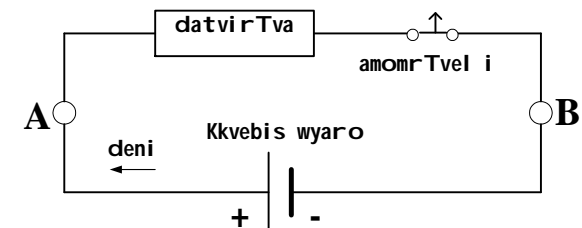
nebismieri el eqtrul i wredi, romel ic Seicavs kvebis wyarosa da datvirTvas gamarTul mdgomareobaSi unda iyos Caketil i ise, rogorc naCvenebia nax. 2.1-ze.

deni gadis Caketil wredSi sxvadasxva potencia- l is mqone or wertil s Soris *A* da *B* aris wertil ebi romel Ta Soris izomeba Zabva. sadeni qmnis garkveul winaRobas el eqtrul i denis anu muxtebis moZraobis mimarT, roml is sidide damokidebul ia sadenis masal aze.

el eqtrul i uwesivrobani SeiZl eba davyoT or j gufad:

1. ar aris SeerTeba iq, sadac unda iyos. am uwesivrobas ewodeba wredis gawyveta da igi SeiZl eba aRmoCenil iqnas testeriT. es uwesivroba naCvenebia nax. 2.2-ze.

2. arsebobs SeerTeba iq, sadac is ar unda iyos. am uwesivrobas ewodeba mokl ed SerTva. man SeiZl eba migviyvanos denis gazrdamde da amasTanave wredis



nax. 2.1 Caketil i el eqtrul i wredi

sadenis gaxurebamde. amgvari uwesivroba SeiZl eba gamowveul i iyos izol aciis darRveviT, romel ic gansazRvrebA izol aciis winaRobis sazomiT.

uwesivrobis gansazRvris process da wredis dab-runebas normal ur muSa mdgomareobaSi teqnikiuri diagnostika ewodeba.

ganvixil oT wredis gawyveta:

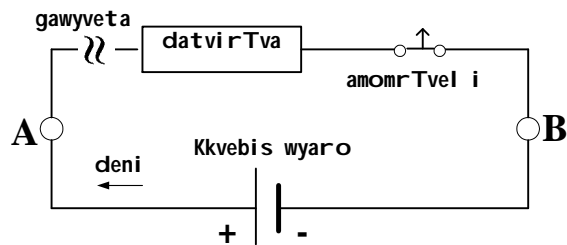
deni gaedineba sxvadasxva potencial is mqone or wertil s Soris Tu es wertil ebi erTmaneTTan SeerTe-bul ia sadeniT.

wredis diagnostikis dros unda Semowmdes:

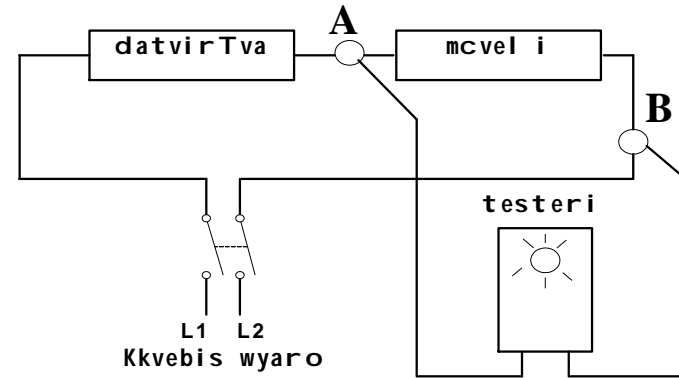
- _ sadenis mTI ianoba (izomeba winaRoba);
- _ wredis ubnis or wertil s Soris el eqtrul i potencial i (izomeba Zabva);
- _wredis ubanze el eqtronebis nakadis arseboba (izomeba el eqtrul i deni).

el eqtrul i wredi Sedgeba sxvadasxva Zabvis mqone ubnebisagan. amgvarad Cven SegviZl ia ganvsazRvroT wredis ubnis mTI ianoba da Tu wredis ubani gaw-yvetil ia, SegviZl ia ganvsazRvroT gawyvetic mizezi.

Semowmeba "gawyvetaze" swarmoebs udeno wredze misi mTI ianobis aRdgenis mizniT. amisaTvis SeiZl e-



nax. 2.2 tipiuri uwesivroba: wredis gawyveta



nax.2.3.Semowmeba "gawyvetaze" testeris daxmarebiT

ba gamoviyenoT testeris xmovani signal izaciiT. tes-teris daxmarebiT Semowmebis magal iTi moyvanil ia nax. 2.3-ze.

am testeriT mowmdeba el eqtrul i wredis mTI iano-ba, anu mtkicdeba, rom wredis es ubani Caketil ia.

Tu wredi Caketil ia, maSin ismis xmovani signal i, rac amtkicebs wredis mTI ianobas. zogierT xel saw-yoSi xmovani signal is magier gamoyenebul ia Suqdio-di an sxva vizual uri indikacia.

wredis "gawyvetaze" Sesamowmebl ad SeiZl eba aseve gamoyenebul i iqnes ommetri an mul timetri. ommetri (mul timetri) Seicavs kvebis wyaros batareas da winaRobis sazoms. ommetriT wredis Semowmebis sqema mocemul ia nax. 2.4-ze.

ommetris winaRobebis skal a dagraduirebul ia nul idan winaRobis did (praqtikul ad usasrul o) mniSvnel obamde. Tu sazomis Cveneba nul is tol ia, es ni Snavs, rom wredis ubanze gawyveta ara gvaqvs. gawyve-

ta rom yofil iyo, maSin winaRobis sazomis Cveneba iqneboda usasrul od didi.

“gawyvetaze” SemowmebiT dgindeba:

_ kabel ebis, el eqtrul i wredebisa da damiwebis sistemebis mTI ianoba;

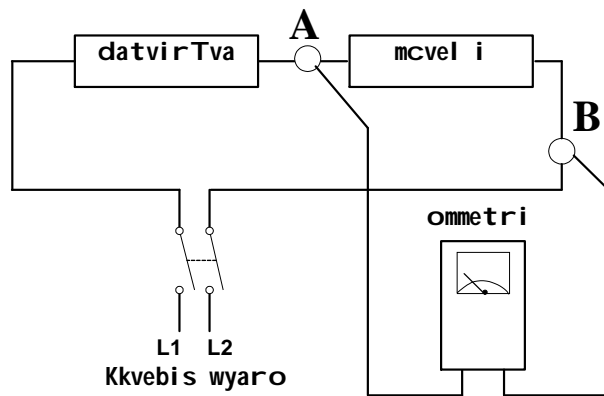
_ Zal ovani da marTvis wredebis Sesabamis kl emebTan CarTvis siswore;

_ mowyobil obasTan CarTvis win aqtiuri da neutral uri sadenebis ganmxol oeba.

_ Zal ovani da marTvis wredebs Soris SecdomiT SeerTebis SesaZl ebl oba da mokl ed SerTul i ubnebis arseboba.

_ gadamrTvel ebis, mcvel ebisa da sxva el ementebis wesivrul oba.

yuradsaRebia, rom paral el uri wredebis arsebobis dros “gawyvetaze” Semowmebam SeiZl eba mogvces cru Sedegebi, ami tom koreqtul i Sedegebis mi saRebad umj obesia gamovrToT Sesabamisi kl emebi.



nax.2.4.wredis “gawyvetaze” Semowmeba ommetriT

Zal ovan wredebs SeuZl iaT SemogvTavazon siurprizebi. xSirad wredebis Semowmebis dros, romel - Sic aris gawyveta, mcire simZl avris testerian ommetri gviCvenebis wredis mTI ianobas. magram muSa Zabvis miwodebis dros deni ar gadis. amis mizezi aris wredis nawil obrivi gamtaroba, romel ic fiqsirdeba sazomi xel sawyoTi. amasTanave didi el eqtrul i Zabvis dros, Tavs iCens misi maRal i winaRoba. amis magal iTad SeiZl eba ganvixil oT gamwvari kabel i, romel is ZarRvebs gaaCniaT unari Seqmnan maRal omiani kontaqt.

uwesivrobis aseTi saxe gani sazRvrebada datvirTvis qveS testirebiT, Zabvis gazomviT.

izol aciis Semowmeba ZiriTadad gamoiyeneba maRal vol tiani Zal ovani kabel ebis miwasi Cadebisa da CarTvis dros. aseTi Semowmebis mizania dadgindes Zal ovani wredisa da kabel is izol aciis mTI ianoba.

nax. 2.5-ze naCvenebia el eqtroZravas amomrTvel Tan, mcvel ebTan da gadatvirTvis rel esTan CarTvis sqema.

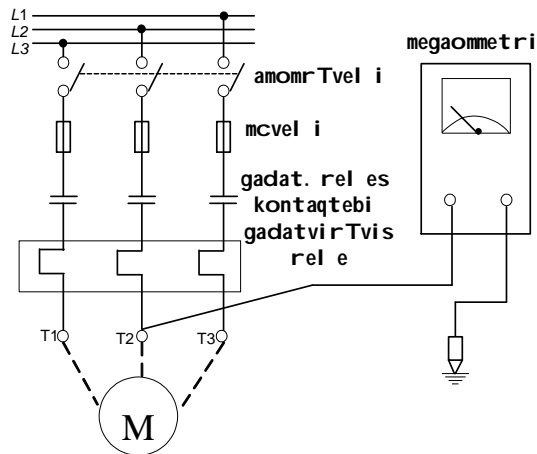
wredis izol aciis Sesamowmebl ad (garda el eqtroZravasi) amomrTvel is daxmarebiT amovrToT wredikvebis wyarodan. Semdeg T1, T2 da T3 kl emebi dan gamovrToT TviT el eqtroZrava. dasawyisSi SevamowmoT izol aciis winaRoba miwasa da T1, Semdeg miwasa da T2 da bol os miwasa da T3 kl emebis Soris.

Tu romel ime fazis izol aciis winaRoba nul is tol ia an gaaCnia Zal ian mcire mniSvnel oba, maSin adgili i aqvs izol aciis darRvevas.

es testi gamoiyeneba agreTve damiwebul i el eqtro-
Zravebis an kabel ebis Sesamowmebl ad da sadenebis
izol aciis darRvevis gamosavl enad.

samfaza el eqtroZravas TiToeul i fazis izol a-
cia SeiZl eba Semowmebul i iqnes mxol od im SemTx-
vevaSi, Tu gamoyvanil ia gragnil ebis eqvsive gamomy-
vani. satestirebel i gragnil i unda mierTdes test-
eris gamosavl el Tan, xol o danarCeni ori gragnil i
SevaerToT erTad da davamiwoT Zravas korpusTan. iq
sadic gamoyvanil ia mxol od sami gamomyvani, gragnil eb-
is izol acia SeiZl eba Semowmebul i iqnas mxol od
el eqtroZravas damiwebul korpusTan mimarTebaSi.

izol aciis winaRobebis sazomebs megaommetrebs
uwodeben. isini Seicaven kvebis wyaros (mudmivi de-
nis generators an batareas), romel ic gazomvisaTvis
gvaZl evs 500 v da met mudmiv Zabvas.



nax. 2.5. izol aciis Semowmeba megaommetriT

el eqtrul i wredebis Semowmebis dros gamoiy-
eneben sxvadasxva sididis Zabvebs. magal iTad, maRal i
Zabvis kabel ebis izol aciis winaRobis gasazomad
iyeneben aranagl eb 1000 v Zabvas, maSin roca martivi
wredebis Semowmebisatvis sakmarisia 500 v Zabva.

Zabvis qveS testireba moiTxovs gansakuTrebul
sifrTxil es da aseTi testireba unda Catardes mx-
ol od dabal i Zabvis qsel ebSi.

dengamtar nawil ebTan SemTxveviTi Sexebis Tavidan
acil ebis mizniT saWi roa davicvaT sifrTxil is zomebi.

xel sawyoebisa da instrumentebs unda hqondeT
SiSvel i gamtari nawil ebis minimumi, rac amcirebs
sxvadasxva potencial is mqone wertil ebis SemTxvevi-
Ti CarTvis al baTobas.

wredis mTI ianobis Semowmeba Zabvis qveS. Se-
saZl ebl obis mixedviT diagnostika unda vawarmooT
gamortul i kvebis wyaros dros, magram zogierT SemTx-
vevaSi dazianebis moZebna SesaZl ebel ia mxol od Zab-
vis qveS myof wredebSi. am dros Sesamowmebel i wre-
di rCeba CarTul i kvebis wyaroze, romel ic unda gam-
oviyenoT testirebis procesSi. testirebis es saxe
unda CavataroT gansakuTrebul i yuradRebiT, usafrTx-
oebis zomebis dacviT.

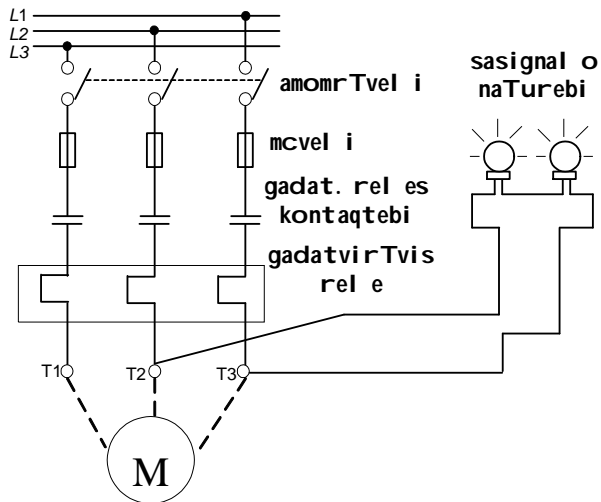
nax. 2.6.-ze naCvenebia rogor unda Semowmdes kveb-
is wyaros an wredis ubnis wesivroba sakontrol o
naturebis gamoyenebiT. es naturebi irTveba fazebis
Soris. wredis gawvyvetis martivi testirebisatvis
SeiZl eba gamoviyenoT vizual uri indikatori
el eqtrul i naturebiT. sadenebis mTI ianobis Sesa-

mowmebl ad da Zabvebis gasazomad SeiZl eba gamoviy-enoT vol tmetrebi an mul timetrebi.

samfaza sistemaSi Zabvebis Sesamowmebl ad gamoiy-eneba ara erTi, aramed mimdevrobiT SeerTebul i ori naTura. amJamad mraVal i mwar moebel i iZl eVa Zabvebis mniSvnel obas sakontrol o wertil ebSi, rac gvexmareba SevamowmoT wredis gansazRvrul i ubnis wesivroba. aseTi praqtika ZiriTadad gamoyenebul ia iseT mowyobil obebSi, roml ebic Seicaven pl atebS.

sakontrol o wertil ebSi Zabvebis Semowmebis sasozomma instrumentebma unda uzrunvel yon sakmarisi sizuste, maSin am Zabvebis SedarebiT SeiZl eba gavake-ToT Sesabamisi daskvnebi.

vizual uri indikatorebiT SesaZl ebel ia samfaza el eqtroZravebis diagnostireba. amisaTvis saWi roa



nax. 2.6. gavyvetaze Semowmeba Zabvis qveS

wredisa da sadenebis ganawil ebis safuZvl iani cod-na, raTa zustad ganvsazRvroT uwesivroba.

rekomendirebul ia, rom yovel Tvis Semowmdes Zabvebi fazebS Soris da ara fazasa da miwas Soris, radgan aseTma Semowmebam SeiZl eba SecdomaSi Segviy-vanos.

testirebis dros mkacrad unda iqnes dacul i usafRTxoebis zomebi.

2.2. teqniki diagnostikis zogierTi sawyisi cneba

el eqtromowyobil obis muSa unaris aRdgena mtyunebis cnobil i mizezebis dros. aseTi mizezebis kl asifikacia SeiZl eba movaxdinoT sxvadasxva niSnebis mi xedviT. SeiZl eba ganvasxvavoT gare da Si ga, uSual o da iribi zemoqmedebis mqone.

Tu el eqtromowyobil obam muSaoba Sewyvita im garemos parametris mwyobridan gamosvl is gamo, romel -Sic igi funqcionirebs, maSin saqme gvaqvs mtyunebis gareSe mizezebTan. Tu mowyobil obis mwyobridan gamosvl a ganpirobebul ia el ementis mtyunebiT, maSin saqme gvaqvs Si ga mizezTan.

cxadia, rom mizezTa aseTi dayofa pirobiTia da damokidebul ia imaze, Tu rogor aris gansazRvrul i el eqtromowyobil oba.

el eqtromowyobil obis mwyobridan gamosvl is mizezi SeiZl eba iyos erTi an ramdenime el ementis mtyuneba an kavSiris darRveva el ementebS Soris. Ti-Toeul i el ementis mtyuneba SeiZl eba gamowveul i iyos

bunibrivi daZvel ebiT, garemos zemoqmedebiT, mowyobil obis araswori eqspl uataciita da sxva.

teqniki diagnostiki Tval sazrisiT ara aqvs mniSvnel oba riT moxda el eqtromowyobil obis mwyobridan gamosvl a, el ementis mtyunebiT Tu el ementebS Soris kavSiris darRveviT, radganac kavSiri ganixil eba rogorc el ementi.

SesaZl ebel ia agreTve el mowyobil obis el ementebad danawil ebiS principi. teqniki diagnostikisaTvis el ementi warmoadgens ori mdgomareobis matarebel s: muSa unarianobisa da mtyunebis, amitom el eqtromowyobil obis el ementebad danawil eba faqtiurad emTxveva mraVal i SesaZl o mtyunebis gamoyofas.

el mowyobil obis el ementebis mdgomareoba ganisazRvreba diagnostiki programaSi Semaval i Semowmebebis garkveul i mimdevrobiT Sesrul ebiS gziT. Semowmeba warmoadgens diagnostiki obieqtze warmoebul i operaciebis erTobl iobas raime Sedegis miRebis mizniT, roml is mixedviTac SeiZl eba vimsj el oT ukidures SemTxvevaSi el mowyobil obis erTi el ementis Sesaxeb mainc.

Semowmebebis erTobl iobas, romel ic sakmarisia sistemis mdgomareobis Sesafasebl ad, diagnostikuri testi ewodeba.

qvemoT moyvanil ia testebi, romel sac atareben el eqtromowyobil obis eqspl uataciaSi Seyvanis an diagnostiki dros.

1. izol aciis testi. es aris erT-erTi yvel aze ufro mniSvnel obani testi nebismieri el eqtromowyobil obisaTvis. Zabva roml is drosac zomaven izo-

l aciis winaRobas sadensa da miwas Soris, damokidebul ia konkretul el mowyobil obaze.

2. Camiwebis mTI ianobis testi. mowmdeba kon-taqtu el mowyobil obis gaSiSvl ebul nawil ebsa da miwas Soris. am SemTxvevaSi winaRoba unda iyos mcire. Tu winaRoba didia, maSin gvaqvs cudi Camiweba.

3. el eqtrul i simtkicis testi. rom SevamowmoT kabel ebiS izol aciis simtkice, saWiroa maTze movdoT maRal i Zabva, iseve rogorc izol aciis winaRobis Semowmebis dros. amit ganisazRvreba kabel is izol aciis simtkice garRvevaze.

4. el eqtronul i Camiwebis testi. mikroproce-sorebisaTvis an mgrZnobiare el eqtronul i mowyobil obebisaTvis Cveul ebriv keTdeba cal ke Camiweba. am Camiwebas ewodeba el eqtronul i. el eqtronul da Zal ovan Camiwebas Soris Zabva ar unda aRematebodes 2 vol ts.

nax. 2.7-ze moyvanil ia el mowyobil obis magal iTi, romel ic gamoyenebul ia diagnostiki obieqtad.

sqema Sedgeba oTxi el ementisagan, roml ebiC gan-sazRvrul i saxiT reagireben S_1 da S_2 pirvel ad zemo-qmedebenze. el ementebi aRniSnul ia patara asoebiT, xol o bol o maTi reaqtiebi didi asoebiT. obieqti muSaunariania, Tu S_1 da S_2 Sesaval zemoqmedebaze mas gamosavl el ze gaaCnia B da D signal ebi, winaaRmdeg SemTxvevaSi el mowyobil oba uwesivro mdgomarobaSia.

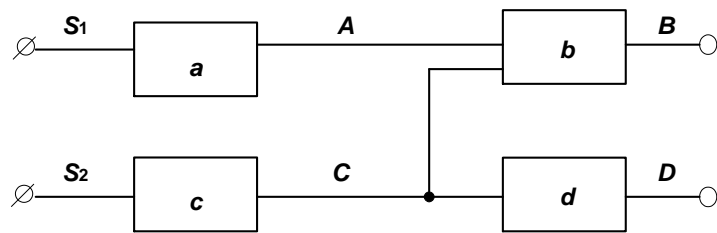
anal ogiurad TiToeul i el ementi iTvl eba muSau-narianad Tu igi reagirebs mocemul zemoqmedebaze.

el mowyobil obis mtyuneba mTI ianad SeiZI eba ganpirobepul i iyos misi erTi an ramdenime el ementis mtyunebiT. SeiZI eba gamovyot Semowmebis ramdenime saxe.

el ementobrivi Semowmeba. am dros mowmdeba Ti-Toeul i el ementi cal -cal ke. mag. 2.7-ze b el ementze A da C zemoqmedebis miwodebiT misi reaquiis mixedviT dgindeba am el ementis mdgomareoba.

Semowmeba modul ebis mixedviT. am dros mowmdeba el mowyobil obis cal keul i bl okebi, romel Tagan TiToeul i Sedgeba mTel i rigi el ementebisagan. magal iTad Tu nax. 2.7-ze davuSvebT, rom patara asoebiT aRniSnul ia ara el ementebi, aramed bl okebi, maSin el ementobrivi Semowmeba gardaiqmneba Semowmebad modul ebis mixedviT. dazianebul i bl okis gamovl ena am SemTxvevaSi j er kidev ar niSnavs Semowmebis proceduris damTavrebas.

Semowmeba el ementebis j gufebis mixedviT. am SemTxvevaSi dgindeba el ementTa im garkveul i j gufis muSaunarianoba roml ebic ar qmlian el mowyobil obis Semadgenl obaSi funqcional ur erTeul ebs, anu ar qmlian bl oks. magal iTad, nax. 2.7-ze S_1 da S_2 zemoqmede-



nax.2.7.diagnostikis obieqtis magal iTi.

bis miwodebiT da B reaquiis dafiqsirebiT SeiZI eba SevamowmoT a, b da c el ementebis muSaunarianoba.

diagnostikis obieqtis reaquiis gansazRvra swarmoebs gamosaval i parametris mimdinare mniSvel obis mocemul mniSvel obasTan Sedarebis gziT. am mizniT gamoiyeneba sazomi an kontrol is mowyobil obebi.

Secvl is an remontis meTodi. am meTodis arsi mdgomareobs dazianebul i el ementis an bl okis muSaunariani el ementiT an bl okiT Secvl is SesaZI ebl obaSi da mxol od am operaciis Sesrul ebis Semdeg miwodeba el mowyobil obas zemoqmedebani da mowmdeba Sesabamisi reaquiebi. Semowmebis aseT saxes gaaCnia gansazRvrul i upiratesoba.

2.3. el mowyobil obis diagnostikis zogadi principi

el eqtromowyobil oba Tavisi nomenkl aturiT Zal ian mraval ferovania, magram mas aqvs Tavisi daniSnul ebis mixedviT saerto kvanzebi: korpusi, magni togamtari, izol acia, statori, rotori, kol eqtori, sakisrebi, sakontaqto SeerTebebi, aparatebisa da amZravebis moZravi sistemis kinematika da sxva, agreTve daniSnul ebis mixedviT identuri marTvisa da signal izacis, kontrol isa da dacvis mowyobil obebi.

saerto konstruqciul i kvanzebi gansazRvraven mowyobil obebis saerto defeqtebs, roml ebic gamomJRavndebian umetes SemTxvevaSi diagnostikis procesSi. magal iTis saxiT SeiZI eba moviyvanoT diag-

nostikis dros yvel aze xSirad aRmoCeni l i el eqtro-
mowyobil obebis defeqtebi:

korpusebTan _ dazianebebi el mowyobil obis trans-
portirebisa da montaJis dros, SeduRebiTa da Wan-
WikebiT SeerTebis defeqtebi, arasimWidrove Sepira-
pirebaSi, SemWidrovebebis defeqti da sxva.

gragnil ebTan _ izol aciis danestianeba, roml eb-
sac yvel aze xSirad adgil i aqvs el eqtromowyobil o-
bebis xangrZl ivi da araswori Senaxvis dros, meqani-
kuri dazianeba, xviaTaSorisi izol aciis darRveva,
SeerTebebi gragnil ebSi, denmimyvanebsa da gamomyva-
nebSi, Seusabamoba gamomyvanebis markirebaSi standar-
tiT moTxovnil sa da saqarxno sqemebis pasportebsa
da Tanmxl eb dokumentacias Soris.

Zal ovani transformatoris gragnil ebis gadamrTvel
mowyobil obebTan meqanikuri dazianeba, araswori mir-
Cil viT SeerTeba an gadamrTvel is araswori muSaoba.

magnitogamtarebTan _ fol adis cal keul i furc-
l ebis erTmaneTTan SeerTeba, momWeri WanWikebis izo-
l aciis darRveva, fol adis furcl ebis korozia, saven-
til acio arxebis gaWuWyianebeba, WanWikebis susti moWera.

mudmivi denis manqanebis kol eqtorebTan _ "bibi-
l oebiT" mirCil vis defeqtebi, firfitebs Soris Su-
al edebis danagvianebeba.

sinqronul i generatoris sakisrebTan _ maTi fun-
damentis fil asTan izol aciis darRveva.

sakomutacio aparatebTan – sawevaris, amZravis da
sakontaqto sistemis aradamakmayofil ebel i regul ire-
ba, hermetul obis darRveva, sakontaqto zedapirebis
aradamakmayofil ebel i mdgomareoba.

fai furis izol aciasTan _ gare zedapiris dazia-
neba, Sinagani defeqtebi. sal teebis sakontaqto
SeerTebasTan _ dawnexvis mirCil vis da WanWikebiT
SeerTebis aradamakmayofil ebel i xarisxi.

Zal ovan kabel ebTan _ dabol oebebis an SemaerTebe-
l i bol oebis defeqtebi, ZarRvebis gawyveta, garsac-
mis dazianebeba.

damiwebis mowyobil obebTan _ el mowyobil obis
korpustan cal keul damamiwebel mowyobil obebs So-
ris damiwebis gamtaris SeerTebis defeqti damiwebis
konturis dasaSvebi winaRobis Seusabamoba usafrTx-
oebis teqniki moTxovnebTan.

el eqtromowyobil obis saimedo muSaobis uzrun-
vel yofisaTvis misi yvel a defeqti da agreTve monta-
Jis defeqtebi droul ad unda iqnes aRmofxvril i.

am defeqtebis aRmoCena warmoadgens diagnostikis
ZiriTad amocanas. meore amocanas warmoadgens el eqt-
romowyobil obis Seusabamoba teqniki moTxovnebTan
da proeqtTan, el mowyobil obis muSaobaSi CarTvis
SesaZl ebl obis Sefaseba, misi marTvis mowyobil obis,
sarel eo dacvisa da avtomatikis gawyoba.

mowyobil obis saerto defeqtebi da maT mier way-
enebul i moTxovnebi gansazRvraven maTi gamovl enis,
Semowmebis, gazomvis da gamocdis zogad meTodebs,
roml ebic SeiZl eba gaertianebul i iyvnen Semdeg
j gufebad:

1) meTodebi, roml ebic gansazRvraven el eqtro-
mowyobil obis meqanikuri nawil is mdgomareobas;

2) el eqtromowyobil obis magnituri sistemis mdgo-
mareobis gazomva da gamocda;

3) el eqtromowyobil obis dengamtari nawil ebisa da sakontaqto SeerTebbis mdgomareobis gazomva da gamocda;

4) el eqtromowyobil obis dengamtari nawil ebis izol aciis mdgomareobis gazomva da gamocda;

5) el eqtrul i SeerTebis sqemebis Semowmebis meTodebi;

6) sarel eo dacvis, avtomatikis, marTvis signal-izaciis da sxva meoreul i mowyobil obebis gawyobisa da gamocdis Semowmebis meTodebi;

7) el eqtromowyobil obis eqspl uataciisaTvis vargisianobis sabol oo Sefasebis meTodebi (el eqtromowyobil obis gasinj va).

yvel a zemoTCamoTvl il j gufebSi gamoiyeneba sxvadasxva saxis mowyobil obebisaTvis saerTo meTodebi da gazomvis saSual ebebi. energetikul i obieqtebis saswrafod mowesrigebis amocanebi, samontaJo samuSaoebis teqno logiuri Tanmimdevroba da defeqtebis droul ad gamosworeba mowyobil obis montajis procesSi mis srul damTavrebamde moiTxoven maqsimal uri raodenobis Semowmebasa da gamocdis Catarebas, rac gaTval iswinebul i unda iqnes diagnostikuri samuSaoebis organizaciisas. aseT samuSaoebs miekuTvneba: el eqtromowyobil obis revizia, sxvadasxva gazomvebi, roml ebic gansazRvraven gragnil ebsa da el manqanebisa da aparatebis sxva dengamtari nawil ebis izol aciis mdgomareobas, aweul i ZabviT izol aciis gamocdas, Zal ovani transformatorebis uqmi svl is danakargebis gazomvas mudmivi deniT; gragnil ebis pol arobis gansazRvras, damagnitebis maxasiaTebl is

gadaRebas, Zal ovani da mzomi transformatorebis transformaciis koeficientis gansazRvras, Zal ovani, marTvis, sarel eo dacvisa da avtomatikis sxvadasxva mowyobil obebis el eqtrul i sqemebis Semowmebas da gawyobas.

el eqtromowyobil obebis gazomvasa da gamocdas miekuTvneba agreTve el eqtrul i manqanebis maxasiaTebl ebis gadaReba da ZiriTadi teqnikuri parametrebis gazomva.

2.4. diagnostikis meTodika da meTodebi

winaswari rekomendaciebi. marTvis wredebis diagnostikis meTodika Seicavs mTel rig debul ebebs:

1. diagnostikis dros xel T unda gvqondes marTvis wredebis sqema, el ementebis aRwera da maT Soris urTierTkavSiri. el eqtromowyobil obaSi uwesivrobis Ziebis dros ukeTesi iqneba vasargebl oT "eqspl uataciis saxel mZRvanel o--Ti agreTve "uwesivrobis gamosworebis instruqci iT-.

2. diagnostikis procesSi unda visargebl oT bl okebisa da mowyobil obisa an manqanis marTvis mimdevrobis sqemi T.

3. uwesivrobis ZiriTadi principis gansazRvrisaTvis saWiroa gvqondes mowyobil obis an manqanis Zal ovani wredis, marTvis mowyobil obebis, kontaktoebis, drois rel es, mricxvel ebis, dacvis mowyobil obebis da sxvaTa aRwera da sqemebi.

4. mowyobil obis Zal ovani da marTvis sqemebis SemowmebisaTvis saxeze unda gvqondes Sesabamisi sazomi instrumentebi.

5. marTvis wredebis diagnostikis procesSi mowyobil obis uecari gaSvebis gamo avariis an ubeduri SemTxvevis Tavidan acil ebis mizniT kvebis wyaros ZiriTadi amomrTvel i unda iyos mdgomareobaSi 'gamortul ia-.

6. radganac marTvis wredebi erTmaneTisagan gansxvavdebian mowyobil obidan mowyobil obamde, manqanidan manqanamde, amitom SeuZl ebel ia Camoyal ibdes maTi diagnostikis erTiani saerTo meTodika. amastanave diagnostikis dros unda miyyeT standartul teqnikas da sawarmoo instruqciebs.

diagnostikisaTvis saWiro ZiriTadi dokumentebis sia unda Sedgebodes:

- marTvis wredebis sqemebisagan;
- uwesivrobis aRmofxvris instruqiisa da eqspl uataciis saxel mZRvanel osagan;
- bl okebis SeerTebisa da manqanis an mowyobil obis marTvis Tanmimdevrobis sqemebisagan;
- manqanis an mowyobil obis Zal ovani wredis aRwerisa da sqemebisagan;
- marTvis el ementebis, kontaqtoebis, drois rel es, mricxvel ebis, dacvis el ementebis mowyobil obis aRwerisagan.

diagnostikis meTodebi. rogorc ki gamovl enil i iqneba dazianebe ni Sani, Semdeg unda ganisazRvros misi gamomwvevi mizezi. gamosayenebel i meTodis arCeva damokidebul ia sqemis sirTul eze, gamovl enil ni Sanze da special istis personal ur al Roze.

qvemoT moyvani ia diagnostikis ZiriTadi zogadsamomxmarebl o meTodebi:

kvebis Semowmeba. muSaobis dakargvis unari xSirad xdeba ubral od mcvel is gadawva an damj dari batarea. amitom pirvel ad unda davrwmundeT rom kvebis zonari CarTul ia da mcvel ebi mwyobrSia. Tu sqema ikvebeba batareidan, maSin unda SevamowmoT, rom batareis Zabvis sidide misaRebia. Tu kvebis wyaros warmoadgens gammarTvel i, maSin unda Semowmdes Zabvis sidide gammarTvel s gamosavl el ze da misi CarTvis pol aroba.

vizual uri daTval iereba. es meTodi miekuTvneba e.w. sensoruri Semowmebis meTods. SesaZl o uwesivrobis gansazRvrisaTvis sensoruri Semowmeba dafuznebul ia adamianis grZnobis organoebze.

dengamtari bilikebit nabeWdi firfitis vizual uri daTval iereba diagnostikis yvel aze martivi (amavdroul ad umravl es SemTxvevaSi Zal ian efeqturi) meTodia. aseT firfitebze unda davaTval ierOT gadamwvari komponentebi. zogjer gadamwvari komponentebi firfitaze toveben yavisfer kval s. am komponentebis SeuZl iaT diagnostikis procesSi gamgzavni punqtis rol i. saWiroa mxol od ganvsazRvroT maTi gadaxurebis mizezi. ar aris rekomendebul i am gadamwvari komponentebis ubral od Secvl a. manam, sanam ar davadgenT maTi gadaxurebis mizezs. umravl es SemTxvevaSi komponentis mwyobridan gamosvl is mizezi imal eba mis gverdiT mdebare dazianebul komponentSi. amitom isic aucil ebl ad unda Seicval os.

Sexeba. warmoadgens kidev erT sensorul Semowmebas. gadaxurebul i komponenti SeiZl eba ganvsazRvroT ubral o SexebiT. amavdroul ad am dros saWiroa

davicvaT didi si frTxil e. sqema saWi roa gamovrToT da didi tevadobis kondensatorebs mivceT dro ganmuxtvisaTvis. komponents yovel Tvis unda SevexoT mxol od marj vena xel iT. es saWi roa imisaTvis, rom nakl ebi iyos denis gul iT gavl iT SesaZI ebl obis al baToba. SesaZI ebl obis mixedviT unda gvecvas izo- l irebul i fexsacmel i. Sexebis meTodi Zal ian efeq- turia iseTi sqemebis diagnostikis dros, roml ebic garkveul i drois ganmavl obaSi muSaobdnen normal urad, xol o Semdeg Sewyvites funqcionireba gansazRvrul i komponentis gadaxurebis gamo.

am komponentis povna gvexmareba ganvsazRvroT uwesivrobis SesaZI o mizezi. arsebobs special uri gamacivebel i aerezol ebi, roml ebic saSual ebas gva- ZI even gavacioT konkretul i komponenti. Tu amis Semdeg sqema daiwyebis normal urad muSaobas, maSin es komponenti aris uwesivrobis mizezi. komponentis Secvl is win saWi roa CavataroT Semdgomi gamokvl eva, raTa ganvsazRvroT gadaxurebis pirvel i mizezi.

SegrZneba. Tu gansazRvrul i komponenti gamovi- da mwyobridan gadaxurebis gamo. maSin umravl es SemTx- vevaSi SeiZI eba SevigrZnoT kvaml is suni, magram es moxdeba maSin, Tu special isti imyofeba iqve axl os. winaaRmdeg SemTxvevaSi uwesivro komponenti SeiZI e- ba vi povoT vizual urad.

komponentis Secvl a. diagnostikis es meTodi dafuZnebul ia ZiriTadad operatoris Cvevebsa da gamocdil ebaze. gansazRvrul i niSnebi cxadad ucveneben konkretul i komponentebis uwesivrobas. es mtkiceba samarTI iania el eqtronikaSi gamocdil i

special istebisaTvis. magal iTad, tel eteqnikis mom- saxure special ists gamocdil ebis safuZvel ze Seu- ZI ia tel evizoris gaxsnis gareSe uSecdomod gan- sazRvrul i dazianebul i komponenti. komponentis Secvl is meTodi kargia gamocdil i special istebisTvis, radgan zogavs drosa da ful s. nebismier SemTxvevaSi es meTodi izi eva warmatebul i remontis garantias, radganac sakmarisi raodenobis komponentebis Secvl isas sabol oo angariSSi icvl eba uwesivro kompo- nentis. amasTanave rekomendirebul ia, rom araspecial - istma dasawyisSi l ogikurad moifiqros diagnostikis procesi.

signal is gavl is Semowmeba. diagnostikis es meTodi nakl ebad gavr cel ebul ia, magram Semoqmedebi- Tad Zal ian sasargebl oa, radgan special istisagan moiTxovs gamWriaxobasa da l ogikur azrovnebas. me- Todi dafuZnebul ia sqemis sxvadasxva sakontrol o wertil Si signal is gazomvaze. sakontrol o wertil i sqemaze aris adgil i, sadac operatorisTvis cnobil - ia Zabvis forma da sidide (Tu gamoyenebul ia oscil - ografi). Semdeg eZeben wertil s, romel Sic signal i gansxvavdeba mosal odnel isagan. amgvarad, operatori gansazRvravs sqemis uwesivro ubans. sxva si tyvebiT rom vTqvaT, operatori mudmi vad amci rebs Zebnis ares, sanam ar moZebnis uwesivrobis mizezs.

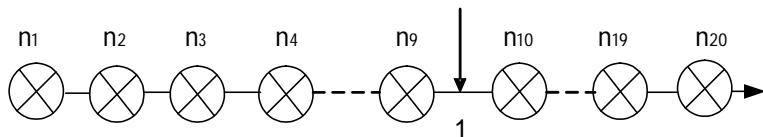
arsebobs gavl is Semowmebis ori midgoma. pirvel SemTxvevaSi Semowmeba iwyeba Sesaval idan da mimdevro- biT mowmdeba yvel a wertil i manam, sanam ar ipovian wertil s arakoreqtul i signal iT. meore midgomis dros sakontrol o wertil ebis Semowmeba iwyeba ga-

mosavl el idan da gagrZel deba manam, sanam ar gamoCn-deba wertil i koreqtul i signal iT.

Sua wertil is meTodi. Aam meTodis gamoyenebis dros sakvl evi obieqti an misi nawil i gaiyofa orad. erT nawil Si defeqti arsebobs xol o meoreSi – ara. Tu Semowmebis Semdeg SeuZl ebel ia konkretul ad vuCvenoT dazianebul i el ementi, maSin Zieba grZel deba. Aam dros yovel Tvis ganixil eba obieqtis is nawil i, romel Sic arsebobs defeqti. imis gamo rom obieqti an misi nawil i iyofa or j gufad, roml ebic daax- l oebiT Seicaven el ementebis Tanabar raodenobas, am meTods sxvanairad naxebrad danawil ebis meTodi ewodeba.

Aam meTodis sail ustraci od ganvixil oT nax. 2.8- ze moyvanil i naTurebis girdi andebis sqema.

rogorc naxazidan Cans girdi anda Sedgeba 20 na- Turisagan. muSaobis garkveul i drois Semdeg davuS- vaT rom giril anda mwyobridan gamovida anu Caqra, mwyobridan gamosvl is ufro savaraudo mizezia erT- erTi naTuris gadawva. imisaTvis rom gavigoT romel i naTura gadaiwva saWiroa SevamowmoT TiToeul i naTura da naTurebs Soris kavSiri. Aam xerxiT mizezis Zieba Sromatevadia, amitom Ziebis procesisi gamar- tivebis mizniT virCevT magal iTad n, naTuras da va- mowmebT gamomaval signal s. Tu gamomaval i signal i



Nnax. 2.8. naTurebis girdi andebis sqema

arsebobs, maSin dazianeba gvaqvs darCenil naxevarSi. DdarCenil naxevars ki dev vyofT Suaze da Aa.S. vi po- viT dazianebul naTuras.

Kkombinaciuri meTodi. Ddefeqtebis kombinaci- uri meTodis arsi mdgomareobs imaSi rom defeqtebis faqtis dadgenis Semdeg keTdeba teqnol ogiuri gada- svl ebi, roml is mizania danadgaris an misi romel ime el ementis maxasiaTebul is gansazRvra. Aam dros wina teqnol ogiuri gadasvl is Sedegi gavl enas ar axdens Semdegze.

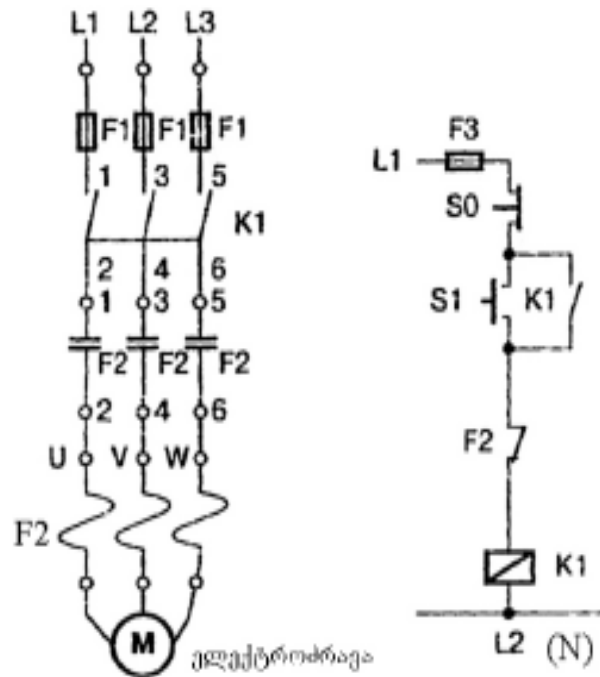
Ggadasvl is Sesrul ebis Sedegebis anal izisaTvis saWiroa gvqondes winaswari informacia obieqtis gamarTul i an dazianebul i mdgomareobis Sesaxeb. Aamis Semdeg vaanal izebT Sesrul ebul i gadasvl ebis winaswar Sedegebs, vadarebT mas yvel a gadasvl is Sem- deg miRebul informaciasTan da vsazRvraT daziane- bis mizezs.

Bbl okur-mimdevrobiTi meTodi. Bbl oki war- moadgens Cvens mier arCeul i raime mowyobil obis an sqemis ubans, TiToeul bl oks gaaCnia e.w. "Sesasvl e- l i" da "gamosasvl el i" signal ebis gadasacemad da Sesasvl el i "kveba". bl okebis saxiT SeiZl eba war- modgenil i iqnes nebismieri mowyobil oba. Aam meTo- dis gamoyenebis dros vaanal izebT TiToeul i te- qnol ogiuri gadasvl is Sedegs da vTvl iT rom de- feqti an napovnia an viRebT gadawyvetil ebas Semdgo- mi teqnol ogiuri gadasvl is Sesasrul ebl ad. te- qnol ogiuri gadasvl is rigiToba windawin unda iyos dadgenil i.

2.5. diagnostikis magaliTi

imisaTvis, rom CavataroT mowyobil obis diagnostika saWiroa pirvel rigSi vicodeT am mowyobil obis muSaobis principi. magaliTad nax. 2.9-ze mocemul ia samfaza el eqtroZravas magnituri gamSvebiT pirdapiri gaSvebis sqema. Zal ovani (nax. 2.9, a) sqema Seicavs samfaza kvebis wyaros (L1;L2;L3), mTavar mcvel ebs (F1), mTavar kontaktoresa (K1) da gadatvirTvisagan dacvis rel es (F2).

marTvis sqema (nax. 2.9, b) Sedgeba F2 gadatvirTvis rel es, SO gaCerebis Ril akis normal urad Caketili



nax. 2.9. asintronul i Zravis Zal ovani (a) da marTvis sqema (b)

(nC) da S1 gamSvi Ril akis normal urad Ria (nR) kontaktebisagan, roml ebic mimdevrobiT arian CarTul i K1 mTavar kontaktores koWasTan. wredis kveba xorciel deba F3 mcvel is gavli iT. mTavari K1 kontaktores koWa L1 fazaze CairTveba mxol od im SemTxvevaSi, roca marTvis wredis yvel a kontakti Caketili ia. Mmocemul SemTxvevaSi, roca TiTs davaWerT S1 Ril aks, marTvis wredi Caikebeba da mTavar kontaktores miwodeba kveba. am kontaktores nR kontaktebi paral el urad SeerTebul ia S1 Ril akTan. rogorc ki kontaktores CairTveba, maSinve misi K1 kontaktebi Caikebeba da dabl okavs S1 Ril aks, ris gamoc am Ril akze TiTis moSorebis Semdeg kontaktores darCeba CarTul i da el Zrava gaagrZel ebs muSaobas manam, sanam TiTs ar davaWerT SO gaCerebis Ril aks an gadatvirTvis rel e ar gamortavs F2 kontakts.

SesaZl o dazianebebi, roml ebic aRiZvreba el eqtroZravas gaSvebis an muSaobis procesSi:

I SemTxveva. S1 gaSvebis Ril akze daWeris dros el eqtroZrava gaiSvebs, magram am Ril akze TiTis aSvebisas el eqtroZrava Cerdeba.

movaxdinoT situaciis anal izi (CavTval oT rom wredis F1 mcvel ebi ar aris dazianebul i). radganac S1 gaSvebis Ril akze TiTis daWeriT el eqtroZrava iwyeb muSaobas, e.i. el eqtrokveba am Ril akiT Sekruli i wrediT miwodeba K1 mTavari kontaktores koWas. rogorc ki CairTveba mTavari kontaktores maSinve unda CairTos misi nR K1 kontaktebi, dabl okos S1 Ril aki da marTvis wredi, daiWiros CarTul mdgomareobaSi

manam, sanam TiTs ar davaWerT SO gaCerebis Ril aks an gadatvirTvis rel es nC kontaktebi ar gaixsneba.

imisaTvis rom vipovoT dazianeba saWiroa CavataroT Semowmeba Semdegi TanmimdevrobiT:

1. SevamowmoT marTvis wredis kveba, gavzomoT Zabva L1 sadensa da Nsadens Soris, Tu kontaktoris koWa gaTvl il ia 220 v Zabvaze, da L1 da L2 sadenebs Soris, Tu kontaktoris koWa gaTvl il ia 380 v Zabvaze.

2. mul timetris saSual ebiT SevamowmoT marTvis wredis F3 mcvel i, Tu igi gadamwvaria maSin Sevcval oT igi da gavuSvaT el eqtroZrava. Tu probl ema mxol od amaSia, maSin el eqtro Zrava normal urad daiwyebs muSaobas.

3. Tu marTvis wredis mcvel i wesrigSia, maSin SevamowmoT xom ar muSaobs gadatvirTvis rel e. es SeiZl eba Semowmdes mul timetriT. SevamowmoT Zabva neutral sa da gadatvirTis rel es gamosaval kontakts Soris, romel ic CarTul ia gaCerebis Ril akTan. Tu gadatvirTvis rel e ar muSaobs da mul timetri gviCvenebs normal ur Zabvas am or wertil s Soris, maSin gadavdivarT Semowmebis Semdeg punqtze

4. SevamowmoT Zabva gaCerebis Ril akis bol oebze. Tu Zabva arsebobs gadavideT Semdeg punqtze.

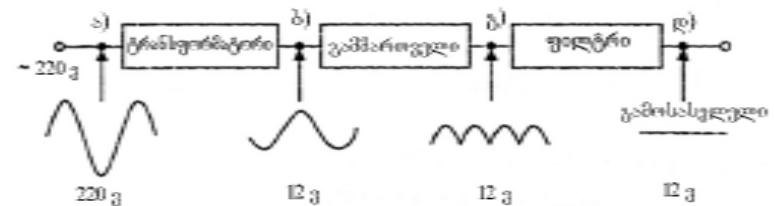
5. Tu el eqtroZrava muSaobs mxol od S1 Ril akze TiTis daWeriT, maSin SevamowmoT am Ril akis paral el urad CarTul i K1 kontaktoris K1 nR kontaktebi. Sesazl oa es kontaktebi dazianebul ia. amis Ddasamt-kicebl ad aviRoT izol irebul i sadenis naWeri da CavketoT K1 kontaktebi. Tu ekl eqtroZrava gaiSvebs,

maSin es kontaktebi sinamdvil eSi dazianebul ia da Sevcval oT mTavari kontaktebis sakontaqto j gufi.

II SemTxveva. el eqtroZrava iwyebs muSaobas magram gaSvebidan ori wuTis Semdeg Zrava Cerdeba. Aam SemTxvevaSi diagnostikisaTvis unda Sevasrul oT wina SemTxvevis pirvel i sami punqti da Tu yvel aferi wesrigSia, amis Semdeg vamowmebT gadatvirTvis rel es. Tu rel e amuSavda, maSin unda veZi oT mi zezi, ris gamoc SeiZl eba el eqtroZrava gadatvirTos.

2.6. dazianebis anal izi

Ddazianebis anal izi moiTxovs karg Teoriul codnas da anal izur azrovnebas. igi ar SeiZl eba viswavl oT wignebidan. igi unda aviTvisoT diagnostikis mudmivi mecadineobiTa da eqsperimentebis gziT. Aaseve arsebobs gansazRvrul i wesebi, romel sac unda daveqvemdebaroT diagnostikis procesSi. magal iTis saxiT moviyvanoT dazianebul i bogirul i gammarTveli i, roml is bl ok-sqema mocemul ia nax. 2.10-ze. igi Sedgeba transformatoris, gammarTvel isa da fil tris bl okebisagan. TiToeul sakontrol o wertil Si naCveneblia oscil ografiT gadaRebul i signal ebi.

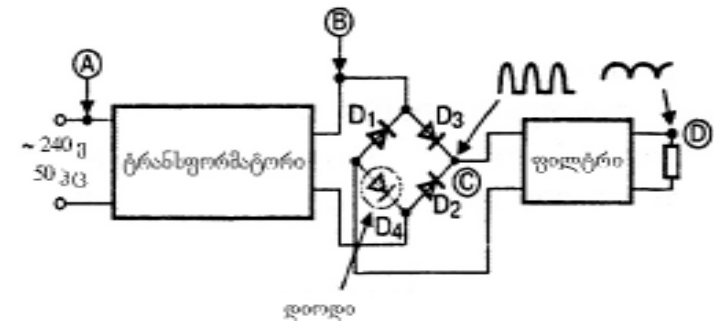


ნახ. 2.10. გამართველი ს ბლ ოკ-სკემა

rezistori gawyvets wreds da gamosasvl el ze Zabva nul is tol i gaxdeba. am winaRobis Secvl is win unda davrwundeT, rom kondesatori an gamosasvl el i ar aris mokl ed SerTul i.

garRveul ia diodi. garRveul i diodi SeiZl eba warmovidginoT rogorc zRudari, romel ic dens atarebs orive mimarTul ebiT. Nnax. 2.13-ze naCvene bia denis gza D_4 diodis garRvevis SemTxvevaSi deni dadebiTi naxevarperiodis ganmavl obaSi Cveul ebriv gaedineba D_3 da D_4 diodebis gavl iT, garRveul diodebs gaaCnia nul ovani winaRoba orive mimarTul ebiT, amitom dadebiTi naxevarperiodi C wertil Si normal uria. uaryofiTi naxevarperiodis ganmavl obaSi suraTi icvl eba: denis gza Seikvreba D_1 da D_4 diodebis gavl iT, radganac es diodebi SeerTebul ia mimdevrobiT da uzrunvel yofen mcire winaRobian gzas. transformatoris meoreul i gragnil i mokl ed SeirTveba da masSi gavl is didi deni. amitom D_1 diodi gadaxurebis gamo swrafad gamovides mwyobridan. transformatoris meoreul gragnil Si denis gazrda iwvevs denis gazrda pirvel ad gragnil Si. Tu pirvel adi gragnil is wredSi dayenebul ia Sesabamisi nominal is mcvel i, maSin es mcvel i unda gadaiwvas da daicvas transformatori da D_1 diodi daziane bisagan. Tu mcvel i ar gadaiwva maSin D_1 diodi gadaxurdeba (an gadaiwveba) da Zabva C wertil Si mi iRebs nax. 2.13 naCvene b formas.

Aanal ogiuri anal izi SeiZl eba CavataroT sxva diodebis garRvevis SemTxvevaSi.



nax. 2.14. diodis gawyvetis niSnebi

Diiodis gawyveta. davuSvaT nax. 2.13-ze mocemul wredSi gawyda igive D_4 diodi, maSin am diodis gavl iT deni arc erT mxares ar gavl is. uaryofiTi naxevarperiodis ganmavl obaSi es diodi ar axdens gavl enas gamosasvl el Zabvaze, xol o dadebiTi naxevarperiodis ganmavl obaSi denis gza gadaketil ia da gamosasvl el ze Zabva ar arsebobs. sxva si tyvebiT rom vTqvaT sqema muSaobs rogorc naxevarperiodiani gammarTvel i. Ees SeiZl eba ganvsazRvroT gamosasvl el i Zabvis didi pul saciebiT, amasTanave pul saciis sixSire 100 hc-is nacvl ad Seadgens 50 hc-s. es SemTxveva gamosaxul ia nax. 2.14-ze

transformatoris daziane ba. aseTi tipis daziane ba Zal ian xSirad ar gv xvdeba, magram Tu danarCeni sqema gamoiyureba wesivrul ad, maSin unda Semowmdes transformatori. transformatoris SesaZl o daziane bis saxeebia: pirvel adi an meoreul i gragnil ebi SeiZl eba iyos gawyvetil i an nawil obriv mokl ed SerTul i. Tu gawyvetil ia romel ime gragnil i, maSin mTel sqemaze Zabva ar arsebobs da amas

მივყავართ გამოსავლელზე ნულს ვაზვამდე. თუ ნაწილობრივ დამოკლდებით პირველია გრაფიკი, მაშინ იზრდება ტრანსფორმაციის კოეფიციენტი. ამ დროს იზრდება ზაბვა მეორეულ გრაფიკზე და შესაბამისად სემის გამოსავლელზეც. ნაწილობრივ დამოკლდებით მეორეული გრაფიკი ამცირებს ტრანსფორმაციის კოეფიციენტს და ზაბვა გამართვლზე მცირდება და შესაბამისად მცირდება გამოსავლელი ზაბვა.

მცველის გადავსა. როგორც აღვნიშნეთ, მცველის გადავსა ხდება დიოდის გარღვევის შემთხვევაში. ამიტომ სანამ მცველს შევცვლიდეთ საუროს ვინაშნაც შევამოთ დიოდები. ტრანსფორმაციის პირველია და მეორეული გრაფიკების ნაწილობრივ მოკლედ შეტვას მივყავართ დენის გაზრდასთან, რაც აგრეთვე შეიძლება იყოს მცველის გადავსის მიზეზი. ამიტომ მცველს შევცვლით და შევამოთ ტრანსფორმაცი.

2.7. ძვანიების ნისანი და მიზეზი

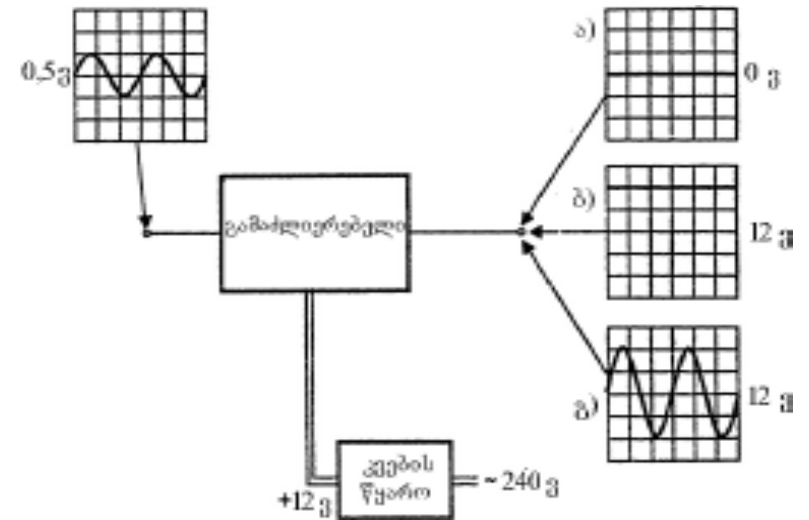
ელექტრული სემის დიაგნოსტიკა სრულდება სამ ეტაპად. პირველი ეტაპზე განისაზრვება სემის ძვანიება. მეორე ეტაპზე ხდება ძვანიების ანალიზი და ამ ძვანიების შესაძლო მიზეზების განსაზრვა. მესამე ეტაპზე ხდება ძვანიების არმოქვრა.

პირველი რიგის საუროს განისაზრვოს ძვანიება. ამისათვის საუროს გავრციოთ მისი ნისები. დვანიებად ითვლება ისეტი სემა, რომლის გამოსავლელი პარამტრები არაკორექტულია, მიუხედავად იმისა, რომ შესავალი პარამტრები შესრულია.

მაგალიტად, ნახ. 2.15-ზე გამოსახული გრაფიკები ის შესავალი სიგნალი კორექტულია, მაგრამ გრაფიკები

ბის გამოსავლელზე სიგნალი არ გვაქვს. ამ შემთხვევაში ძვანიების ნისად ითვლება გრაფიკები ის გამოსავლელზე ზაბვის არ არსებობა.

ეს კონკრეტული ნისანი იქნება საკმარის ინფორმაციას ძვანიების შესაძლო მიზეზებზე. დვანიება ერთსა და იგივე ნისანთან (გამოსავლელზე ნული ვაზვა) შეიძლება მიგვიყვანოს სემის სხვადასხვა კომპონენტების ძვანიებამ. სხვა შემთხვევაში ნისანი შეიძლება პირდაპირ მიგვითქვას განსაზრვულ არეზე, სადაც ძვანიების გამოვლენის აბათობა უფრო მეტია. მაგალიტად, გამოსავლელზე მუდმივი ზაბვა, რომელიც თლია კვების ზაბვისა გვიწვინებს, რომ ტრანზისტორი იმყოფება ვაკუუმის რეჟიმში (ნახ. 2.15, ბ). შევამოვს ვიწყებთ გამოსავლელთან მდებარე უახლოესი კასადი და ვმოზრაობთ უკუმართულებით. და შევამოთ ყველა ტრანზისტორი გა-



ნახ. 2.15. სემის ძვანიების ნისების განსაზრვა

dasasvl el is gawvyetaze, agreTve saWiroa SevamowmoT mirCil vis adgil ebi da emiterul i rezistorebis winaRobebi.

Tu gamaZl ierebel i gamarTul ad muSaobs, maSin gamosasvl el ze unda gamoCndes gaZl ierebul i signal i. gamosasvl el i signal is ampl ituda daaxl oebiT tol ia kvebis wyaros gamorTul i Zabvis mniSvnel o-bisa. Ggamosasvl el i signal is forma zustad unda iyos Sesaval i signal is formis yovel gvari damaxinj ebiis gareSe (nax 2.15.g.).

2.8. diagnostikaSi farTod gamoyenebul i xel sawyoebi

a) xel sawyo indikatorebi (Zabvis maCvenebl ebi).

Zabvis maCvenebl ebi gamoiyeneba Zabvis arsebobis Semowmebis aTvis marTvis, dacvis, avtomatikis, dabal i da maRal i Zabvis mowyobil obebis sxvadasxva wertil - Si. mrewvel obis mier Zabvis maCvenebl ebi mzaddeba sxvadasxva saxiT, rogorc dabal i, ise maRal i ZabvisTvis. nax. 2.8-ze mocemul ia sxvadasxva saxis dabal i da maRal i Zabvis maCvenebl ebi.

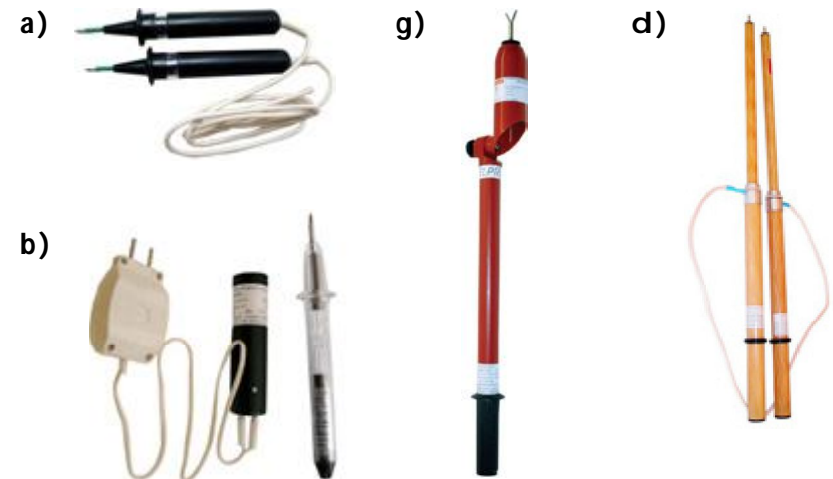
orpol usiani (nax. 2.8, a) Zabvis maCvenebl ebiT erTdroul ad exebian dengamtari nawil is orive SiSvel pol uss, riTac ikvreb a uSual od indikatoris el eqtrul i wredi da Zabvis arsebobis SemTxvevaSi ainTeba indikatorSi CamontaJebul i neonis naTura.

saxraxnisi-maCvenebl is gamoyenebis SemTxvevaSi Sesamowmebel dengamtar nawil Tan maCvenebl is sacecis Sexebis dros, Tu erTi xel iT SevexebiT maCvenebl is metal is dabol oebas, xol o meoreTi - Camiwebis

konstruqcias, maSin Seikvreb a el eqtrul i wredi maCvenebl is, adamianis winaRobas, maCvenebl Si CamontaJebul i kondensatorisa da miwis gavl iT. Sesamowmebel pol usze Zabvis arsebobis SemTxvevaSi ainTeba maCvenebl Si CamontaJebul i neonis naTura.

mudmivi Zabvis Semowmebis dros inTeba neonis naTuris an erTi an meore mxare da am dros cvl il ebiis xasiaTi gviCvenebs Sesamowmebel i Zabvis niSans.

maRal i Zabvis Sesamowmebl ad gamoiyeneba sxvadasxva tipis maCvenebl ebi. nax. 2.16, b-ze mocemul ia YBH 80 - 3M tipis maCvenebl ebi, roml is Semowmebis diapazonia $2,2 \div 10$ kv, anTebis zRurb l i 550 v. mas aqvs mkveTrad mocimcime sinaTl is indikacia, romel ic naTebas iwyebs Zabvis arsebobis dros.

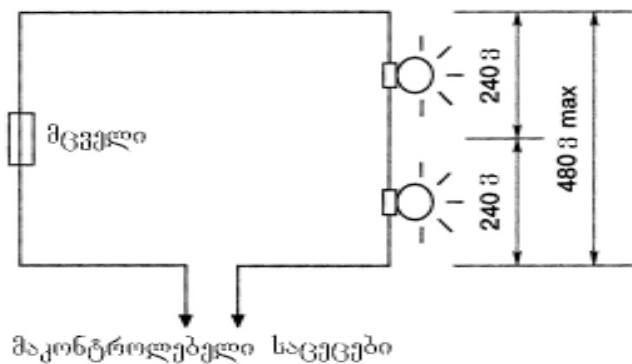


nax. 2.16. Zabvis maCvenebl ebi:

- a) orpol usiani YHM-1 tipis;
- b) saxraxnisi - maCvenebl i YH-453 tipis;
- g) maRal i Zabvis maCvenebl i YBH80 -3M tipis;
- d) Zabvis maCvenebl i fazirebisTvis YBHCTΦ-6 ÷ 10 tipis

xSirad saWiro xdeba $6 \div 10$ kv da 35 kv kabel ebis, sahaero xazebisa da transformatorebis fazireba, risTvisac gamoiyeneba nax. 2.16, d-ze naCvenebl orpol usiani maCvenebl ebi. Zabvis arseboba mowmdeba momatebul i sikaSkaSis Suqdiodebis daxmarebiT.

b) naTuriani indikatori inJiner-el eqtrikosis erT-erTi mTavari instrumentia diagnostikisaTvis da cnobil ia, rogorc Zabvis indikatori. igi Sesdgeba mimdevrobiT SeerTebul i ori naTurisagan TiToeuli nominal uri ZabviT 240v. am indikatoris (nax. 2.9) muSa wreds Seadgens ori mimdevrobiT SeerTebul i naTura, mcvel i da sacecebi. TiToeul i naTuris simZl avre unda iyos tol i da ara umetes 25 vatisa. ori naTuris aReba saWiroa imisaTvis, rom xandaxan es indikatori SeiZl eba CairTos 380 vol ti da meti Zabvis qsel Si, ris gamoc erTi naTura SeiZl eba gadaivvas da SecdomiT gviCvenos wredis gawyveta. meti saimedobisTvis aseTi indikatorebi gamoyenebis win da Semdeg unda Semowmdes wesier mdgomareobaSi myof wyaroze.



nax. 2.17. or naTuriani indikatoris sqema

12 an 36 v Zabvaze SemowmebisTvis SeiZl eba gamoye-
yoT erT naTuriani indikatori.

naTuriani indikatori SeiZl eba gamoyenebul i iq-
nas:

-Zabvis arsebobis gansazRvrisaTvis;

-kvebis wyaros pol arobis gansazRvrisTvis anu
aqtiuri da neutral uri wertil ebis, kvebisა da Cami-
wmebis kl emebis gansazRvrisaTvis;

-ori daparal el ebul i wyaros "fazirebisa- fa-
zebis Sesabamisobis Sesamowmebl ad;

-el eqtroZravas Camiwebis Sesamowmebl ad. indika-
toris erTi gamomyvani uerTdeba erTfaza kvebis wyaros
'fazis- kl emas, xol o meore - gragnil is kl emas. Tu
naTura ainTo, maSin gragnil i Camiwebul ia, winaaRm-
deg SemTxvevaSi - ara;

-samfaza wyaros Sesamowmebl ad. indikatoris ga-
momyvanebs CarTaven or fazas Soris. am dros Sesa-
Zl ebel ia samidan erTi SemTxveva:

-Tu kveba gamortul ia, maSin naTurebi ar ainTeba.

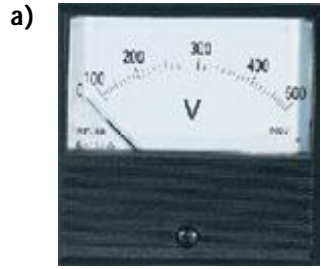
-Tu erT-erTi faza gaTisul ia, maSin naTurebi
ainTeba naxevari varvarebiT.

-Tu orive faza wesrigSia, maSin naTurebi ainTeba
mTel i varvarebiT.

**g) maRal impendansiani
testeri.** Zabvis indikatoris
erT-erTi saxeobaa. (nax. 2.18)
Zabvis arsebobis dros xel -
sawyo gamoscems vizual ur-
xmovan signal s



nax. 2.18. maRal impen-
dansiani testeri



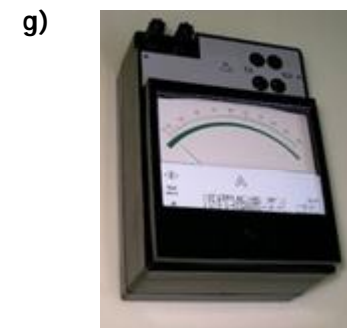
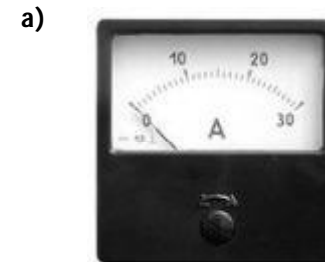
nax. 2.19. vol tmetrebi:
a) faris; b) isriani;
g) cifrul i; d) l aboratoriul i

d) vol tmetrebi. (nax. 2.19) or wertil s Soris Zabvis (potencial Ta sxvaobis) gasazomad gamoiyeneben xel sawyos, romel sac vol tmetri ewodeba. igi gamoiyeneba iseTi wredebis testirebis dros, roml ebic CarTul ni arian kvebis wyarosTan. vol tmetri gamoiyeneba rogorc mudmivi, aseve cvl adi Zabvis gasazomad did sazRvrebSi. vol tmetri yovel Tvis CairTveba sakontrol o wertil ebs Soris paral el urad.

gazomvis dawyebis win darwmunebul i unda viyoT Seesabameba Tu ara xel sawyoze arCeul i diapazoni gasazom Zabvas, radganac xel sawyo gaTvl il ia Zabvis gansazRvrul i mniSvnel obis gasazomad.

Tu moiTxoveba gazomvebi maRal i Zabvis wredebSi, maSin vol tmetris gazomvis zRvari unda gavafarTovoT., wredSi damwevi Zabvis transformatoris CarTviT (CarTvis sqema ganxil ul i iqneba SemdegSi). am SemTxvevaSi vol tmetris skal aze naCvenebi Zabvis mniSvnel o ba unda gavamravl oT Sesabamis koeficientze. nax.2.19.-ze mocemul ia faris, isriani cifrul i da l aboratoriul i vol tmetrebi.

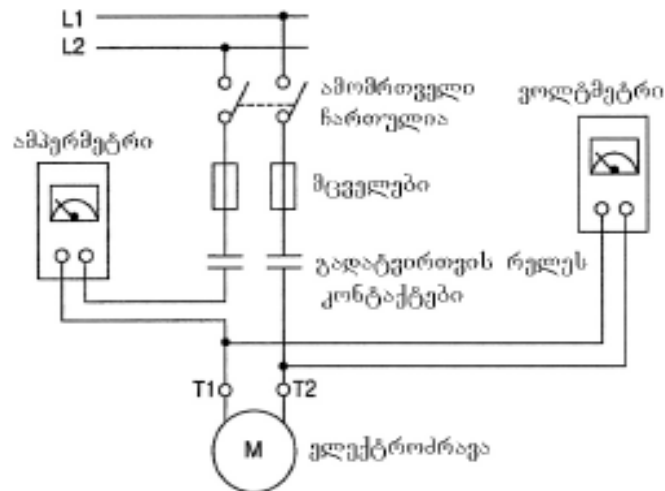
vol tmetrebi gamoiyeneba el eqtrul wredSi energiis gadacemis; erTfaza da samfaza kvebis; el ementebis (mag. rel e, taimetri da a.S.) vargisianobis; Camiwebis mTI ianobis Semowmebisatvis da a.S.



nax. 2.20. ampermetrebis saerTo xedi:
a) isriani; b) cifrul i; g) l aboratoriul i

e) **ampermetrebiT** sargebl oben dabal i Zabvis Caketil el eqtrul wredSi gamaval i donis gasazomad. igi gamoiyeneba Zabvis qveS myofi el eqtrul i wredebis dros da yovel Tvis wredSi irTveba mimdevrobiT. mimdevrobiT CarTul i ampermetri gviCvenebs datvirTvis mier moxmarebul dens. ampermetriT uSual od izomeba rogorc mudmivi, aseve cvl adi deni farTo sazRvrebSi dabal i Zabvis dros. ampermetrebi arsebobs sxvadasxva modifikaciis. nax. 2.20-ze moce mul ia faris, cifrul i da l laboratoriu l i ampermetrebi.

ampermetrebis gazomvis diapazonis zRvris gasadidebl ad, mas rTaven denis transformatoris gavli iT (roml is CarTvis sqema naCvenebi iqneba SemdegSi). am dros ampermetris Cveneba mravl deba denis transformaciis koeficientze.

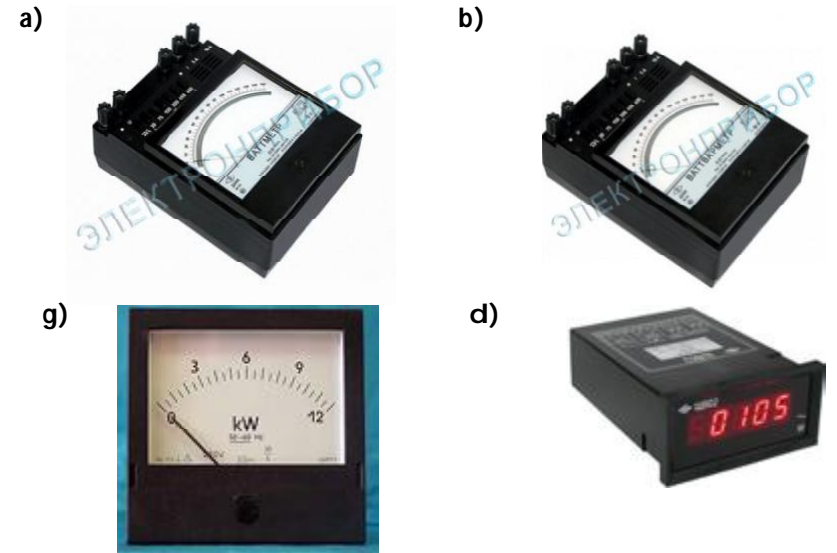


nax. 2.21. martiv wredSi ampermetrisa da vol tmetris CarTvis sqema

nax. 2.21-ze naCveneblia diagnostikisaTvis el eqtrul wredSi ampermetrisa da vol tmetris CarTvis sqema. rogorc am sqemidan Cans, ampermetri wredSi CarTul ia mimdevrobiT wredis ubanze, xol o vol tmetri – paral el urad sakontrol o wertil ebs Soris.

v) **vatmetrebi da varmetrebi**. cvl adi denis samfaza wredebSi aqtiuri simZl avreebis gasazomad gamoiyeneben vatmetrebs, xol o reaqtu l i simZl avris gasazomad – varmetrebs.

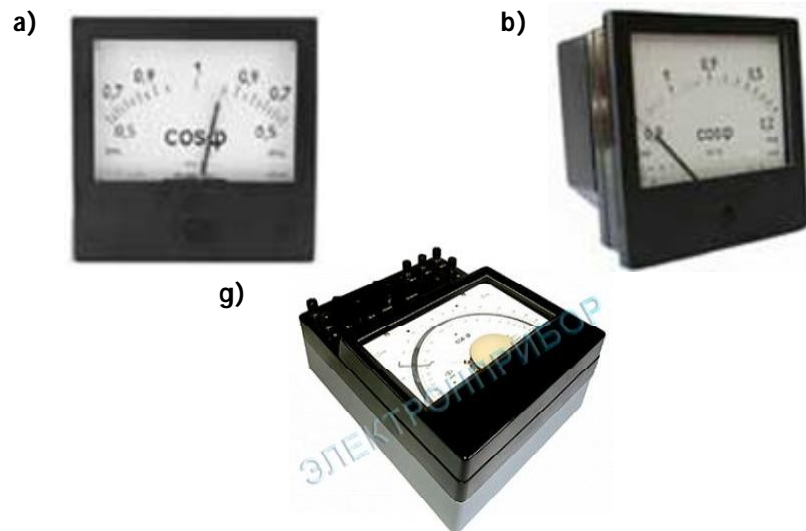
nax. 2.22, a-ze naCveneblia D5061 tipis vatmetri, romel ic gamoyenebul ia aqtiuri simZl avris gasazomad erT-faza cvl adi da mudmivi denis wredebSi; nax. 2.22, b-ze



nax. 2.22. vatmetrebi da varmetrebi:
a) - D5061 tipis vatmetri; b) - D5070 tipis vatvarmetri;E
g) - O301/1 tipis vatmetr-varmetri; d) - OA02Btipis vatmetr-varmetriE

moyvanil ia D5070 tipis vatvarmetri, romel ic gamoiyeneba aqtiuri simZl avris gasazomad. samfaza samsadenian cvl adi denis wredesi fazebis rogorc simetriul i, aseve arasimetriul i datvirTvis dros da reaqtul i simZl avris gasazomad samfaza samsadenian cvl adi denis wredesi simetriul i Zabvebis dros, roca fazebis datvirTvis arasimetriul oba ar aRemateba 5%-s; xol o nax. 2.22, g-ze mocemul ia faris O301/1 tipis vatmetr-varmetri, romel ic dagraduirebul ia kil ovatebSi (kil ovarebSi). nax.2.22, d-ze naCvenebia OA02 tipis cifrul i vatmetr-varmetri.

z) fazometrebi. rogorc erTfaza, ise samfaza cvl adi denis wredesi simZl avris koeficientis ($\cos\varphi$) gasazomad gamoiyeneba sxvadasxva tipis fazometrebi.



nax. 2.23. fazometrebi: a) – erTfaza wredisTvis C302M1 tipis; b) – samfaza wredisTvis C43205 tipis; g) – laboratoriu i D5782 tipis

nax. 2.23, a-ze moyvanil ia N30211 tipis fazometri, romel ic gamoiyeneba erTfaza cvl adi denis wredesi 0 _ 10000 herci sixSiris diapazonSi; nax. 2.23, b-ze moyvanil ia faris N42305 tipis fazometri, romel ic gamoiyeneba samfaza cvl adi denis 50 herci sixSiris wredesi; xol o nax. 2.23, g-ze naCvenebia D5782 tipis laboratoriu i fazometri.

T) vol tamperfazometri (vafi). diagnostikis sferoSi didi gamoyeneba aqvs universal ur xel sawyos – vol tamperfazometrs, romel ic arsebobs sxvadasxva modifikaciisa da Sesabamisad sxvadasxva tipis.



nax. 2.24. vol tamperfazometrebi (vafi): a) – IA?IA AAO-A-2 tipis; b) – AAO-11 tipis; g) – IA?IA AAO-A-2 tipis; d) – retometri

nax. 2.24, a-ze moyvani I IA?IA AAO-O-2 tipis vol tamperfazometri (ori marwuxiT), mTI ianad avtomatizirebul i universal uri xel sawyo, roml is daniSnul ebaa warmoebis mTavari energetikosis, avtomatikisa da sarel eo dacvis samsaxuris, energozedamxedvel obisa da energogasaRebis muSaobis uzrunvel yofa. mas SeuZI ia mudmivi Zabvis; samrewvel o sixSiris cvl adi denisa da Zabvis; Zabvasa da Zabvas; densa da dens; densa da Zabvas Soris Zvris kuTxisa da erTdroul ad wredis srul i simZI avris; sixSiris gazomva; samfaza sistemaSi fazaTa Tanmimdevrobis gansazRvra.

generatorebis, transformatorebis, denisa da Zabvis transformatorebis wredebSi dacvebis kompl eqsuri gamocdebi saTvis gamoiyeneba nax. 2.24, b-ze mocemul i AAO-I1 tipis xel sawyo. mas SeuZI ia agreTve rel euri dacvis fazomgrZnobiare sqemebis Semowmeba da gawyoba. igi gamoiyeneba agreTve samfaza el eqtrul i mricxvel ebis CarTvis sisworis Sesamowmebl ad.

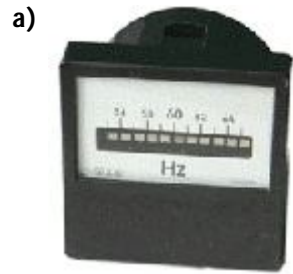
nax. 2.24, g-ze mocemul ia uaxl esi I4185RS tipis xel sawyo, roml is daniSnul ebaa orfaza da samfaza el eqtrul i denis wredebis parametrebis gazomva. mas gaaCnia gazomvis farTo diapazoni. kerZod, mas aqvs muSaobis Semdegi reJimebi: Zabvis; denis; sixSiris; Zabva-Zabva, deni-deni, Zabva-deni Soris Zvris kuTxis gazomva; aqtiuri, reaqtul i da srul i simZI avreebis gamoTvl a; drois arCeul periodSi yvel a parametr minimal uri, maqsimal uri da saSual o mniSvnel obis gaangariSeba; drois mocemul periodSi moxmarebul i energiisa da simZI avris koeficientis gamoTvl a;

denisa da Zabvis sazomi transformatorebis datvirTvis kontrol i.

mocemul i, gazomil i da gamoTvl il i mniSvnel obebi indicirdeba grafikul i displ eis ekranze. indicirebul i mniSvnel obebi Seinaxeba gare an Siga mexsierebaSi. am xel sawyos SeuZI ia imuSaos personal ur kompiuterTan erTad da uzrunvel yos drois mixedviT periodul i gazomvebi da miRebul i Sedegebis mixedviT Seadginos cxril ebi da grafikebi, agreTve gamosaxos ekranze drois real ur masStabSi qsel is muSaobis veqtorul i diagrama. saWiroebis SemTxvevaSi igi SeiZI eba gamoyenebul i iqnes informaciul i marTvis sistemebis Semadgenl obaSi.

misi kvebis ZiriTad wyaros warmoadgens akumul atoris batarea. garda amisa SesaZI ebel ia misi kveba 220v Zabvisa da avtomobil is qsel idan.

did interest iwvevs nax. 2.24, d-ze warmodgenil i xel sawyo retometri. igi axal i Taobis mraval funqciuri da mTI ianad avtomatizirebul i certificirebul ia xel sawyoa, romel ic Tavisi sizustiTa da woniTi gabaritul i maCvenebl ebiT bevrad uswrebs amJamad gamoSvebul vaf-ebis. xel sawyos Zal ian moxerxebul ia da martivia eqspl uataciaSi. mas SeuZI ia xangrZI ivi drois ganmavl obaSi imuSaos avtonomiur reJimSi CaSenebul i akumul atorebidan. igi saSual ebas gvaZI evs CavataroT gazomvebi l aboratoriul da savel e pirobebSi temperaturis cvl il ebis farTo diapazonSi da susti ganaTebis SemTxvevaSi. igi TavisufI ad Tavsdeba jibeSi.



nax. 2.25. sixSiris mzomebi:

a) - vibraciul i sistemis; b) - cifrul i

misi gansakuTrebul i ganmasxvavebel i SesaZI e-bl obebja: gazomvis mTI iani avtomatizacia; indikatoris mkveTrad ganaTebul i msxvil i simbol oebi saSual ebas iZI eva muSaoba vawarmooT bnel Senobeb-Si; SeuZI ia gazomos wredis el eqtrul i winaRoba da aqvs "garekvis~ ("I?icaiea ~) reJimi; Cal iTaSi Cakerebul i magnitebis daxmarebiT xdeba xel sawyos damagreba nebismer metal is zedapirze.



nax. 2.26. cifrul i densazomi marwuxebi:

a - dabal i Zabvis; b - maRal i Zabvis

i) **sixSiris mzomi.** sixSire el eqtrul i wredis erT-erTi umniSvel ovanesi parametria amitom mis gakontrol ebas gansakuTrebul i mniSvel oba eniWeb- ba. el eqtrul wredesi sixSiris gasazomad gamoy- enebul ia vibraciul i da cifrul i xel sawyoebi. nax. 2.25,oa-ze mocemul ia vibraviul i sistemis xel sawyo, romel ic gamoiyeneba sixSiris gasazomad cvl adi denis wredesi moZrav da stacional ur obieqtebeze, xol o nax. 2.25, b-ze naCvenebia mraVal i tipis cifrul i six- Sirmzomi dan erT-erTi, kerZod, Tanamedrove uaxl esi CN-90XL60ГГЦ tipis,

roml is sixSiris gazomvis diapazonia 0,001hc - 60ghc.

k) **densazomi marwuxi.** (nax. 2.26) es xel sawyo saSual ebas gvaZI evs maRal i sizustiTa da ukotaq- toT gavzomoT wredSi gamaval i denis Zal a, ise rom ar SevwyvitoT wredSi el energiis miwodeba momx- marebel ze. denis Zal is gazomvis dros marwuxis sace- cebi, romel Sic CamontaJebul ia feritis gul arebi, Semoexveva dengamtar sadens. sadenSi gamaval i deni aRZravs magnitur inducias, roml is mniSvel oba pirdapirproporciul ia sadenSi gamaval i denisa.

induciiis es mniSvel oba marwuxis denis gadam- wodebiT registrirdeba denis mniSvel obad, romel - ic gamonaTdeba marwuxis displ eize. densazom mar- wuxs aqvs unari, daimaxsovro an Seinaxos gazomil i sididis mniSvel oba. es xel sawyo SeiZI eba gamoy- enebul i iqnes vol tmetrad, ristvisac mas gaaCnia spe- cial uri sacecebi da maTi SeerTebis adgil i. amitom igi iTvl eba universal ur sazom xel sawyod. es xel -



nax. 2.27. 43800 tipis testeri

sawyo gamoiyeneba iseT adgil ebSi, sadac gvaqvs fazebis gancal kevebis SesaZl ebl oba da ar SeiZl eba gamoyenebul iqnes mraval ZarRva Zal ovan kabel ebSi, sadac erT kabel Si moTavsebul ia yvel a samive fazis sadeni. am xel sawyos gamoyenebis dros saWi roa yura-

dReba mivaqciOT imas, rom marwuxis sacecebi erTmaneTTan mWi drod unda iqnes moWeril i RreCos gareSe. winaaRmdeg SemTxvevaSi gazomvis mniSvnel oba iqneba mcdari. densazomi marwuxebi muSaoben rogorc mudmiv, ise cvl ad denze gasazomi sididis did diapazonSi.

l) testeri. farTod gamoiyeneba diagnostikis procesSi kombinirebul i el eqtrosazomi xel sawyo - testeri, romel ic arsebobs sxvadasxva modifikaci iT. erT-erTi modifikaciis testeri mocemul ia nax.2.27-ze.



nax. 2.28. mul timetrebi:

a) - O4342-11 tipis anal ogiuri mul timetri; b) - cifruli mul timetri

m) mul timetrebi. mul timetrebs didi gamoyeneba aqvT mudmivi da cvl adi denebisa da Zabvebis, wi naRobebis, sixSiris, wredis mTI ianobis, el ementebis wesivru- l obis Sesamowmebl ad. damazadebl ebis mier gamoSvebul ia aseTi xel sawyoebi sxvadasxvagvari funqvi ebi T. mul timetrebi arsebobs anal ogiuri (nax. 2.20, a) da cifruli (nax. 2.20, b).

Cveul ebriv mul timetrebi Seicavs ampermetrs, vol tmets da ommets. Sesabamisi funqciebis gadam- rTvel iT. ommetri arsebitad warmoadgens denis sa- zom xel sawyos, roml is skal a dagrauirebul ia omeb- Si. aseTi ampermetr-vol tmetr-ommetri ZiriTadi di- agnostikuri xel sawyoa. am xel sawyos sworad gamoy- eneba amaRl ebs ara mar to gazomvis sizustes, aramed axangrZl ivebs misi momsaxureobis vadasac.

mul timetris gamoyenebis procesSi unda davi- vaT sifrTxil is qvemOT moyvanil i zomebi:

-xel sawyos dazianebis Tavidan asacil ebl ad saWi roa Semowmeba daviwyoT gazomvis yvel aze maRa- l i zRvaridan da TandaTanobi T SevamciroT.

-ufro zusti Sedegis masaRebad gazomvis diapa- zoni unda SevarciOT ise, rom xel sawyos Cveneba iyos xel sawyos skal is zeda naxevarSi.

-gazomvis win (gansakuTrebi T mudmivi denisa da Zabvis SemTxvevaSi) ganvsazRvroT wredis pol ar oba.

-winaRobis gazomvis win es winaRoba unda gam- ovrToT kvebis wyarodan, winaaRmdeg SemTxvevaSi sa- zomi xel sawyo gamova mwyobridan.

-winaRobis gazomvis sizustis uzrunvel yofis mizniT mul timetrSi periodul ad unda Seicval os kvebis batarea.

-xel sawyo unda davicvaT mtvris, nestis, kvaml isa da maRal i temperaturisagan.

anal ogiur mul timetrTansDSedarebiT cifrul i mul timetri fl obs mTel rig dadebiT Tvissebebs, rac mas xdis mosaxerxebel da efeqtur xel sawyod. mas gaaCnia funqcional uri simartive, mraval funqcional oba (Zabvis, denis, winaRobis gazomvis reJimebi) gazomvis diapazonis avtomaturi arCevis Tvisseba, gazomvis Sedegis Senaxvis, diodebis, tranzistorebis, kondensatorebis da sxva parametrebis Semowmebis SesaZl ebl oba.

n) megometri. Cveul ebrivi mul timetrebi ver uzrunvel yofen gazomvis sizustis 10 megaomze meti winaRobis gazomvis dros, radgan maTSi gamoyenebul ia dabal i Zabvis kvebis wyaro. amitom 0 _ 1000 megaom diapazonSi winaRobis gazomvis gamoiyeneben megaommetrebs (Semokl ebiT megeri) anu izol aciis winaRobis sazomebs. Tavisi moqmedebis principiT isini wadmoadgenen ommetrebs, roml ebSic kvebisatvis gamoyenebul ia maRal i Zabvis wyaro. es xel sawyoebi ZiriTadad gamoiyeneba kabel is izol aciis, el eqtroZras an transformatoris xviebs Soris winaRobis gasazomad da a.S.

megaommetridan Sesamowmebel wredze moedeba maRal i Zabva da Tu wredSi arsebobs mcire el eqtru- l i gaJonvac ki, es Zabva iwvevs SesamCnev dens, rac am xel sawyos xdis izol aciis winaRobis gamzomad.

a)



b)



nax. 2.29. megaommetrebi:

a) - el eqtromeqanikuri generatoriT (YN 0202/1A);

b) - cifrul i (AM2002)

zogierT l laboratoriu l sazom xel sawyos gaaC- nia CaSenebul i maRal i Zabvis wyaro, romel ic saSu- al ebas gvaZl evs didi sizustiT gaizomos didi win- aRobebi. amastanave aseTi xel sawyoebi ar aris mobi- l i uri.

megaometri aris portatul i ommetri maRal vol- tiani kvebis wyaroTi. es kvebis wyaro SeiZl eba iyos el eqtromagnituri mudmivi denis generatori an ba- tarea. megaommetrSi, romel sac gaaCnia generatori gamoyenebul ia saxel uri generatoris Ruzis dasa- brunebl ad. generatori Tavisi model idan gamomdinare gamoimuSavebs 500, 1000 da 2500 vol t Zabvas. wadmoebis mier gamoSvebul ia sxvadasxva tipis megaometrebis didi raodenoba. magal iTisaTvis Cven ganvixil avT mxol od or maTgans.

nax. 2.29, a-ze naCvenebia YN 0202/1A tipis megaom- metri, romel ic cvl is dRemde arsebul M4100/1; M4100/2; M4100/3 da M4101 tipis megamommetrebs. igi



nax. 2.30. izol aciis winaRobis sazomebi:
a) - anal ogiuri (MA-2060); b) - cifrul i (4102MF)

ikvebeba masSi CamontaJebel i el eqtromeganikuri generatoriT, rac gamoricxavs misi wredSi CarTvis saWi roebas. misi gazomvis diapazoni 0 - 1000 momi-a. gamosacdel i Zabvebia 500, 1000 da 2500 vol ti.

nax 2.29, b-ze naCvenebia AM2002 tipis cifrul i megometri, romel ic uzrunvel yofs gazomvis maRal sisuztes (1-2%) 0,1-1000 m omi winaRobis diapazonSi. gamoimuSavebs 100, 250, 500 da 1000 v sacdel Zabvebvs. ikvebeba 9 v ZabviT. amitom es ukanasknel i didi popul arobiT sargebl obs inJiner-el eqtrikosebs Soris, radgan msubuqi da kompaqturia.

o) izol aciis winaRobis sazomi. Zal ian didi winaRobebis gasazomad gamoiyeneba izol aciis winaRobis sazomebi. nax. 2.30, a-ze naCvenebia MA-2060 tipis xel sawyo, roml is gazomvis zRvaria 500 komidan - 500 gomamde. es xel sawyo gamomuSavebs 500, 1000, 2000 da 5000 v Zabvebs. am xel sawyoTi SeiZl eba CavataroT danadgaris gamocda el eqtrul simtkiceze, radganac



nax. 2.31. 1151 IN - tipis mraVal funqciuri cifrul i avtotestteri



nax. 2.32. CA 6115-N tipis kompl eqsuri Semowmebis xel sawyo

SesaZl ebel ia sacdel i Zabvis SenarCuneba garkveul i drois ganmavl obaSi. xel sawyo uzrunvel yofil ia testirebis damTavrebis Semdeg avtomaturi ganmux-tvis mowyobil obiT.

nax. 2.30, b-ze naCvenebia 4102MF tipis cifrul i izol aciis winaRobis sazomi, romel sac SeuZl ia izol aciis winaRobis, wredis winaRobis, mudmivi da cvl adi Zabvis gazomva da mowyobil obaTa testireba. winaRobis gasazomad am xel sawyos testirebisaTvis gamoiyeneba mudmivi Zabvis sami mniSvnel oba: 250, 500 da 1000 v. xel sawyos gazomvis zRvaria 2 komidan - 8 gomamde. ikvebeba 12 v mudmivi ZabviT.

p) mraVal funqciuri testerebi. ukanasknel xanebSi did gamoyenebas poul obs agreTve mraVal - funqciuri 1151 IN tipis cifrul i avtotestirebi (nax. 2.31) da el eqtrodanadgarebis kompl eqsuri Semowmebis xel sawyo, romel ic mocemul ia nax. 2.32-ze. es



nax. 2.33. MI 2150 tipis el eqtrosadenis testirebis xel sawyo

xel sawyo efeqturad gamoiyeneba sayofacxovrebo, komerciul da samrewvel o seqtorSi. el eqtroteqniko-sebi mas iyeneben axal i mowyobil obis miRebis dros an mowyobil obis rekonstruqciis Semdeg Semowmebi-saTvis. xel sawyos daxmarebiT advil ad da riskis gareSe srul deba el eqtrodanadgarebis standartiT rekomendirebul i gazomvebi. xel sawyo Seesabameba saerTaSoriso standartebis. kompiuterul i programa CA 6115-N -NsaSual ebas iZl eva xel sawyos mexsierebidan miviRoT gazomvis Sedegebi cxril is saxiT. kompiuterul i programa saSual ebas iZl eva agreTve yvel a Sedegi amoibeWdos printerze A6 formatiT.

el eqtrosadenebis mTI ianobis, izol aciis winaRobis, Sexebis Zabvis, damiwebis sadenze Zabvis arseobis Semowmebisa da sadenis vargisianobis daskvni-saTvis gamoiyeneba nax. 2.33-ze mocemul i MI 2150 tipis portatul i xel sawyo.

el eqtroenergiis xarixxis Semowmebi saTvis gamoyenebul ia IEE-57 tipis kompl eqsuri kontrol is xe-



nax. 2.34. IEE-57 tipis mraval funqciuri xel sawyo



nax. 2.35. oscil ografi

Zl avris, simZl avris koeficientis, aqtiuri da reaqtiul i energiis, damcavi mowyobil obis, wredis srul i winaRobis, izol aciisa da Camiwebis winaRobis, gruntis gamtarobis mniSvnel obebi, fazaTa Tanmimdevroba, sixSiris gadaxra, Zabvisa da denis arasinu-soiduroba 49-e harmonikamde da sxva.

misi Sinagani mexsiereba Seadgens 2 megabai ts.

J) oscil ografebi. oscil ografi farTod gamoyenebul i xel sawyoa. sakvl evi signal i gamoisaxeba mis ekranze, roml is mixedviTac vmsj el obT mis sixSi reze, formaze da impul sebis xangrZl ivobaze. igi SeiZl eba gamoyenebul i iqnes rogorc mudmivi, aseve cvl adi Zabvis gasazomad.

ekranze gamosaxul i signal is mixedviT SeiZl eba gani sazRvros misi ampl ituda da periodi. nax. 2.35-ze mocemul ia GOS-7630 tipis orsxiviani oscil ografi.

orsxiviani oscil ografi saSual ebas iZl eva davinaxoT da erTmaneTs Seadarot or sxvadasxva arxSi gamaval i signal i. gadamrTvel ebis ori j gufi iZl eva Sesazl ebl obas Seadarot maTi periodebi, ampl i-

tudebi, formebi. damamaxsovrebeli oscilografIT SeiZl eba SevinaxoT signalis forma mis Semdgoni anal izis Catarebis mizniT.

yvel a zemoTmoyvanil i xel sawyos gamoyenebis dros unda visargebl oT xel sawyoze TandarTul i instruqci iT.

2.9. el eqtroteqniki gazomvebi diagnostikis dros

a) erTeul Ta sistemebi. Nnebi smieri mecnerebis dargs gaaCnia Tavisi sakuTari unikal uri ena da am mxriv el eqtroteqnika gamonakl iss ar warmoadgens.

izomeba yvel aferi, yvel gan da yovel Tvis; gazomvis aucil ebl obas moiTxovs nebi smieri teqnologiuri procesis mimdinareobis gakontrol eba, manqana-danadgarebis muSaobis reJimebis Seswavl a, gamomuSavebul da daxarj ul energiebs Soris fardobis dadgena, usafrTxoebis pirobebis dacva, marTvis avtomaturi reJimebis Sesazl ebl oba da mraval i sxva.

meti sicxadisa da moxerxebul obisaTvis saerTaSoriso SeTanxmebiT miRebul ia, rom erTi fizikuri sididis aRniSvna yvel gan iyos erTnairi, yvel gan izomebodes erTnair erTeul ebSi da dacul i iyos am erTeul is standarti. am mizniT SemoRebul ia erTeul - Ta sistemebi, romel Tagan yvel aze gavrcel ebul ia e.w. SI (System International) sistema, SedarebiT nakl ebad _ CGSE sistema.

cxril i 2.1-Si naCvenebia zogierTi fizikuri sididis saerTaSoriso aRniSvna da erTeul i am sistemaSi.

cxril i 2.1

sidide	sididis aRniSvna	sazomi erTeul i	erTel is aRniSvna
Ddenis Zal a	I	Aamperi	Aa
Zabva	V	vol ti	v
Mmuxti,el eqtrobis raodenoba	Q	Kkul oni	Kkl
Energia	W	j oul i.vati.sT	j .vt.sT
simZl avre aqtiuri	P	vati	vt
simZl avre reaqtul i	Q	vol tamperreaqtul i	var
simZl avre srul i	S	vol tamperi	va
winaRoba	R	omi	omi
kuTri winaRoba	ρ	0omi.metri	0omi .m
reaqtul i winaRoba	X	0omi	0omi
srul i winaRoba	Z	omi	0omi
Ggamtaroba aqtiuri	G	simensi	sim
Ggamtaroba reaqtul i	B	simensi	sim
Ggamtaroba srul i	Y	simensi	sim
induqciuroba	L	Hhenri	hn
tevadoba	C	Ffardi	Ff
sixSire	f	Hherci	hc
kuTxuri sixSire	??	radi ani /wami	rad/wm
dro	t	wami	wm

b) el eqtromzomi xel sawyoebis kl asifikacia

sxvadasxva saxis gazomvebi waroadgenen diagnostikuri samuSaoebis arsebiT nawil s. gamzomi xel sawyoebisa da gazomvis meTodis swor arCevazea damokidebul i el eqtromowyobil obis mdgomareobis Sefasebis xarisxi.

sazomi teqniki sxva saxeebTan SedarebiT el eqtruli i gazomvebi gamoirCeva didi sizustiT, simartiviT da saimedoobiT. amis gamo el eqtromzomi xel sawyoebis meqanizmebi ixmareba ara mar to uSual od el eqtruli i sidideebis gasazomad, aramed sxva, bevri arael eqtrul i sididis gasazomadac. gasazomi sidideebis nairgvarobis gamo gamzomi meqanizmebic nairgvaria da maTi kl asifikacia xdeba mTel i rigi faqtorebiT. ase magal iTad: gasazomi sididis mixedviT arsebobs denis, Zabvis, simZl avris daxarj ul i energiis, sixSiris, Zvris kuTxis da simZl avris koeficientis sazomi xel sawyoebi; gasazomi denis saxis mixedviT el eqtromzomi xel sawyoebia: mudmivi denis, erTfaza cvl adi denis da samfaza denis; gasazomi sizustis mixedviT isriani mzomi xel sawyoebi dayofil ia rva kl asad: 0,05; 0,1; 0,2; 1,0; 1,5; 2,5 da 4,0 kl asis nomeri da dsaSvebi cdomil ebis mniSvnel oba amotanilia xel sawyos skal is panel ze. 1,5 kl asis xel sawyoebis cdomil ebis dasaSvebi mniSvnel obaa 1,5% da a.S. xel sawyoebi ,romel Ta cdomil eba 4%-s aRemateba kl asebiT kl asifikacias ar eqvemdebareba, esenia, umetesad faris xel sawyoebi, romel Ta mTavar daniSnul ebad gasazomi sididis indikacia iTvl eba. 0,05 _ 0,5 fasis xel sawyoebis daniSnul ebaa gazomvis didi sizuste da gam-

oiyeneba rogorc sxva mzomi xel sawyoebis makontrol ebel i xel sawyoebi da l laboratoriu l i kvl evebis dros. gazomvis zRvris gazrdis mizniT standartis mixedviT gamoiyeneba 0,02; 0,05; 0,1 0,2 0,5 da 1,0 kl asis Suntebi da damatebiTi winaRobebi.

praqtikaSi diagnostikuri samuSaoebis Sesrul ebis dros yvel aze xSirad gamoiyeneba gazomvis uSual o Sefasebis meTodi winaswar dagrauirebul i xel sawyos saSual ebiT (denis gazomva ampermetriT, Zabvis _ vol tmetriT, simZl avris _ vol tmetriT da a.S.). magram sakmaod xSirad gamoiyeneba agreTve Sedarebis meTodebi (winaRobis gazomva bogiriT, Zabvis _ poten-

cxrili 2.2

mamravli	dasaxel eba	qarTuli aRni Svna	saerTaSoriso aRni Svna
10 ¹⁸	eqsa	e	E
10 ¹⁵	peta	p	П
10 ¹²	tera	t	T
10 ⁹	giga	g	G
10 ⁶	mega	mg	M
10 ³	kilo	k	K
10 ²	heqto	h	h
10 ¹	deka	dk	da
10 ⁻¹	deci	dc	d
10 ⁻²	santi	s	c
10 ⁻³	milli	m	m
10 ⁻⁶	mikro	mk	mk(μ)
10 ⁻⁹	nano	n	n
10 ⁻¹²	piko	p	p
10 ⁻¹⁵	fento	f	f
10 ⁻¹⁸	ato	a	a

ciometriT). orive meTodi miekuTvneba pirdapiri gazomvis meTods.


garda amisa, gamoiyeneba agreTve gazomvis iribi meTodebi, roml is drosac CvenTvis sainteresosidide ganisazRvneba angariSis gziT (simZl avris gazomva ampermetrisa da vol tmetris CvenebiT). ufro zust meTodad miCneul ia pirdapiri gazomvis meTodi da pirvel rigSi Sedarebis meTodi.

g) j eradi erTeul ebi _ gazomvis Sedegebis Caweris gamartivebisa da moxerxebul obis mizniT SemoRebul ia fizikur sidideTa j eradi erTeul ebi. xSir SemTxvevaSi es j eradoba gamoisaxeba 10-is xarisxebiT

cxrili #2.3

gasazomi sidide	xel sawyos dasaxel .	pirobiTi aRniSvna
deni	ampermetri miliampermetri mikroampermetri	A mA μA
Zabva	vol tmetri milivol tmetri kilovol tmetri	V mV kV
simZal vre	vatmetri kilovatmetri	W kW
energia	mricxveli	kWh
Zvris kuTxe da simZ. koef. sixSire	fazometri sixSirmzomi	φ $\cos \varphi$ Hz
winaRoba	ommetri megaommetri	Ω $M\Omega$

cxrili #2.4

xel sawyos sistema	aRniSvna
magnitoel eqtruli el eqtromagnituri logometri el eqtrodinamiuri, induqciuri	

cxrili #2.5

aRniSvna	denis saxeebi
1	mudmivi deni
10^2	mudmivi da cvl adi
10^3	erTfaza cvl adi
10^4	samfaza cvl adi
$1,5$	sizustis klasi
	izolaciis xarisxi 7kv -ze

Semdegi dasaxel ebebiT: mil ionj ermeti _ mega, aTasj ermeti _ kilo, aTasj er naklebi _ mili, mil ionj er naklebi _ mikro da a.S. cxrili #2.2-Si mocemulia mamravlebi, maTi dasaxel ebebi da saerTasoris aRniSvnebi.

d) skalaze datanili aRniSvnebi _ el eqtromozomi xel sawyoebis skal is upirvel esi daniSnul ebaa ciferbl atze isris mdgomareobiT wavikiTxoT gasazomi sididis raodenobrivi mniSvneloba. xSirad

isris qveS datanil ia sarke, roml is daniSnul ebaa gazardos aTvl is sizuste. amisaTvis skal as davxevadavT zemodan im kuTxiT, rom isris mdgomareoba daemTxves mis sarkul anarekl s. dakvirvebis am kuTxiT waikiTxeba isris zusti Cvenebe.

garda amisa el eqtromzomi xel sawyoebis arCevis mizniT mis skal aze gamotanil ia mTel i rigi aRniSvnebi, romel ic miuTitebs gasazom sidides, mis zeda zRvars da xasiaTs, xel sawyos sistemas, kl ass da a.S.

es aRniSvnebi moyvanil ia #2.4 da #2.5 cxril ebis saxiT.

e) danayofis fasis dadgena isrian xel sawyoebze

xSir SemTxvevaSi el eqtromzomi xel sawyoebi gamodis gasazomi sididis sxvadasxva mniSvnel obis zeda zRvariT. zRvaris arCeva xdeba damatebiTi momWeriT, kl aviSiT, Stefsel uri tipis Rrmul iT da sxva.

skal a dagrauirebul ia garkveul diapazonSi, magal iTad $0 \leq 150$; $0 \leq 100$ da sxva diapazonebSi.

gasazomi sididis zeda zRvaris arCevis Semdeg danayofis fasi SeiZl eba ganisazRvros proporciidan, aRvniSnoT: isris maqsimal uri gadaxra (a) _ gazomvis zeda zRvari (b); isris gadaxra gazomvis procesSi (c) anu gazomil i danayofebis ricxvi _ gasazomi sidide (x). a -s Seesabameba b ; c -s x .

$$\frac{a}{c} = \frac{b}{x} \quad \text{sai danac} \quad x = \frac{c \cdot b}{a} \quad \text{danayofis fasia} \quad \frac{b}{a}.$$

ganvixil oT magal iTi: vTqvaT vol tmetris panel ze amotanil ia kl aviSebi gazomvis zeda zRvrebis CvenebiT, 150v, 300v, 600v.

skal a dagrauirebul ia $(0 \leq 150)$ diapazonSi. vol tmetris gazomvis wredSi CarTvis Semdeg Tu

$$\text{avirCevT kl aviSs } 150v, \text{ danayofis fasi iqneba } \frac{150}{150} = 1.$$

e.i. isris gadaxra pirdapir uCvenebs gasazomi Zabvis sidides. Tu avirCevT kl aviSs 300v, maSin danayofis

$$\text{fasi iqneba } \frac{300}{150} = 2, \text{ anu isris Cvenebe unda gavamrav-}$$

l oT 2-ze da a.S. gazomvis sizustis gazrdis mizniT sasurvel ia gazomvis zeda zRvari xel sawyoze avirCioT iseTi, rom meti iyos gasazomi sididis mniSvnel obaze, magram rac SeiZl eba masTan miaxl oebul i. magal iTad, Tu zemoT moyvanil magal iTSi gasazomia daaxl oebiT 100v rigis Zabva, umj obesia avirCioT zeda zRvari 150v da ara 300 da miTumetes 600.

v) cneba gazomvis cdomil ebis Sesaxeb.

arcerTi gazomvis Sedegi ar aris ideal urad zusti. gazomvis Sedegebi yovel Tvis met-nakl ebi sizustiT uaxl ovdeba gasazomi sididis namdvil mniSvnel obas da im mizniT, rom ganvsazRvroT ramdenia maT Soris sxvaoba, Semogvaqvs cneba gazomvis cdomil ebis Sesaxeb.

gazomil i (A) da gasazomi sididis namdvil mniSvnel obas (A_0) Soris sxvaobas absol uturi cdomil eba ewodeba.

$$\Delta A = A - A_0.$$

absol uturi cdomil ebiT ver vimsj el ebT gazomvis cdomil ebaze, ramdenadac igi gasazomi sididis diapazonzea damoki debul i. ase magal iTad, Tu izomeba deni, roml is sidide 1 amperis rigisaa da absol uturi cdomil eba 0,3 amperia, im denebis gazomvisa, roml is rigi 1000 amperia da absol uturi cdomil eba 5 amperia, gazomvebi ufro zustria, vidre wina SeTxvevaSi.

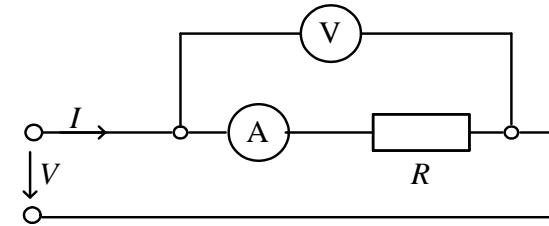
amitom gazomvis cdomil eba fasdeba fardobiTi erTeul ebiT da gamoisaxeba procentebiT.

$$\text{gazomvis fardobiTi cdomil eba } \gamma = \frac{\Delta A}{A_0} \cdot 100\%.$$

§2.8-Si moyvanil ia diagnostikis dros gamoyenebuli i farTod gavrcel ebel i xel sawyoebi, maTi maxasiatebi ebi. qvemoT dawvril ebiT SevexebiT el eqtruli sidideebis gazomvis sqemebs, processa da gazomvis Taviseburebbs.

z) denisa da Zabvis gazomva. denisa da Zabvis gasazomad mudmivi denis wredebSi ZiriTadad gamoiyeneba magnitoel eqtrul i sistemis ampermetrebi da vol tmetrebi, roml ebic xasiaTdebian maRal i sizustiT, mgrZnobi arobiTa da gadatvirTvis unarianobiT. Tanamedrove pirobepSi didi gamoyeneba aqvT agreTve wina paragrafsi dasaxel ebul cifrul sazom xel sawyoebbs. cal keul SemTxvevebSi gamoiyeneba agreTve el eqtromagnituri sistemis xel sawyoebi.

cvl adi denis wredebSi denebisa da Zabvebis gasazomad gamoiyeneba el eqtromagnituri, el eqtrodinamiuri da cifrul i sistemis xel sawyoebi. am uka-



nax. 2.36 denisa da Zabvis gazomvis sqema

nasknel T didi gamoyeneba aqvT maRal sixSirul gazomvebSi.

xel sawyos arCevis dros ama Tu im gazomvis Casatarebl ad mxedvel obaSi unda miViRoT Semdegi: gazomvebisatvis, roml ebic ar moiTxoven did sizustes SeiZl eba gamoyenebul i iqnes 1-1,5 sizustis kl asis xel sawyoebi, xol o didi sizustis SemTxvevaSi 0,2-0,5 kl asis xel sawyoebi. sarel eo dacvis gawyobisatvis gamoiyeneba 0,5 kl asis xel sawyoebi da a.S.

denisa da Zabvis erTdroul i gazomvis dros xel sawyoTa stacional urad damagrebis SemTxvevaSi arCeul i unda iyos xel sawyoTa ganl agebis adgil i sqemaSi. Tu vol tmetris Sinagani winaRoba Tanazomadia ampermetris Sinagani winaRobisa, maSin ar SeiZl eba ampermetri dadges vol tmetramde, radgan vol tmetrisi gamaval i deni ar Sevides gazomvaSi da xel sawyoebi unda CairTos Semdegi sqemiT (nax. 2.36). amave dros ampermetris Sinagani winaRoba unda iyos rac SeiZl eba dabal i, radgan masSi Zabvis vardnam gavl ena ar iqonios gazomvis Sedegze.

Tu denisa da Zabvis gasazomi mniSvnel oba aRemateba xel sawyos gazomvis zRvars, maSin pirvel SemTxvevaSi gamoiyeneba denis mzomi transformatorebi (cvl adi

denisaTvis) da gareSe Suntebi (mudmivi denisaTvis), xol o meore SemTxvevaSi Zabvis mzomi transformatorebi (cvl adi denisaTvis) da damatebiTi winaRobebi (mudmivi da cvl adi denis SemTxvevaSi). denisan Zabvis transformorebis gamoyenebis SemTxvevaSi denisa da Zabvis gazomil i mniSvnel obebi ganisazRvrebian formul ebiT:

$$I_{gaz} = I_{xel\ s.} \cdot K_I;$$

$$V_{gaz} = V_{xel\ s.} \cdot K_V,$$

sadac - K_I da K_V — Sesabamisad denisa da Zabvis transformorebis transformaciis koeficientebia.

Suntebis gamoyenebis dros denis gazomil i mniSvnel oba ganisazRvrebamil ivol tmetris CvenebiT

$$I_{gaz} = \frac{V_{xel\ s.}}{\Delta V_{S.n.}} \cdot I_{S.n.},$$

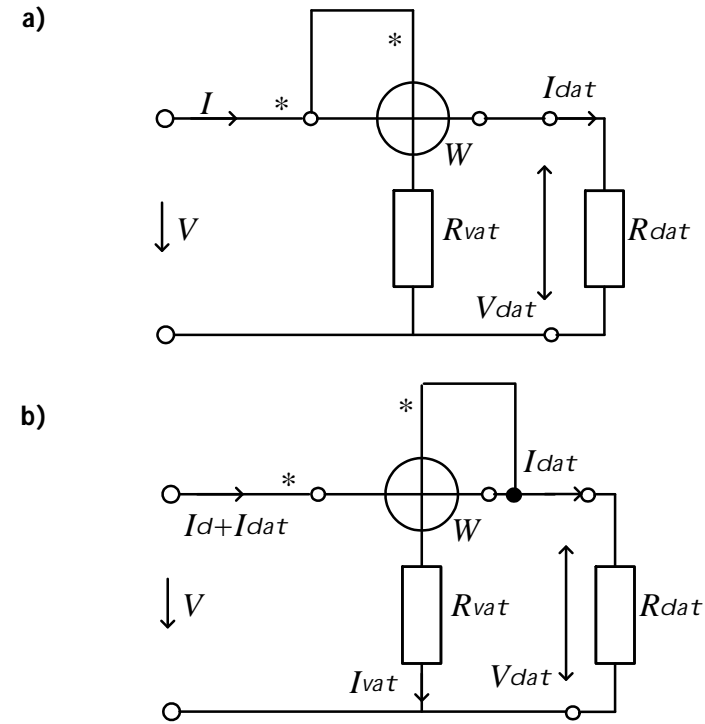
sadac $V_{xel\ s.}$ — mil ivol tmetris Cvenebaa, $\Delta V_{S.n.}$ — Zabvis vardna Suntze $I_{S.n.}$ denis dros.

damatebiTi winaRobis gamoyenebis dros Zabvis gazomil i mniSvnel oba ganisazRvreba formul iT:

$$V_{gaz} = V_{xel\ s.} \cdot \frac{R_S + R_{cm}}{R_S},$$

sadac, R_S da R_{cm} - Sesabamisad xel sawyos (vol tmetris) Sinagani da damatebiTi winaRobebia.

T) simZI avris gazomva. cvl adi denis wredebSi simZI avris gasazomad gamoiyeneba el eqtrodinamiuri da ferdinamiuri sistemis xel sawyoebi 0,2-0,5 sizus-



nax. 2.37 simZI avris gazomva vatmetrit mudmivi denis wredebSi

tis kl asiT da induqciuri sistemis xel sawyoebi, moZravi diskoTi sizustis kl asiT 1,5-2,5.

am xel sawyoebis sqemebis CarTva xorciel deba gragnil ebis pol arobis dacvit. el eqtrodinamiuri vatmetrit sargebl obis dros mxedvel obaSi unda miviRoT am xel sawyos Cvenebis ZI ieri damokidebul eba datvirTvis simZI avris koeficientze $\cos\varphi$. xel sawyos Cveneba SeiZl eba iyos zusti im SemTxvevaSi, Tu datvirTvis $\cos\varphi$ axl oa xel sawyos $\cos\varphi$ -sTan. dabal i $\cos\varphi$ -s SemTxvevaSi sargebl oben special uri

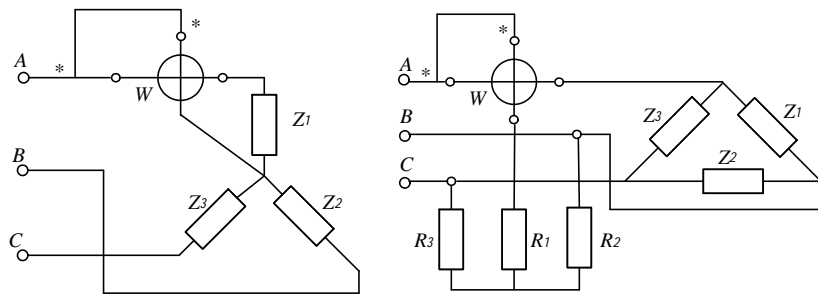
vatmetrebiT, roml ebic iZl evian swor Sedegebs $\cos\varphi=0,1\div 0,3$ fargl ebSi. mudmivi denis wredesi simZl avres gansazRvaven magnitoel eqtrul i sistemis ampermetrisa da vol tmetris Cvenebis safuZvel ze, formul iT:

$$P = V \cdot I.$$

umetes SemTxvevaSi mudmivi denis wredesi simZl avris gasazomad gamoiyeneben el eqtrodinamiuri an magnitoel eqtrul i sistemis vatmetrebs. am SemTxvevaSi isini wredesi CairTvebian qvemoT moyvanil i sqemebis mixedviT.

nax. 2.37 a-ze moyvanil i sqema gamoiyeneba im SemTxvevaSi, roca SeiZl eba ugul vebel vyoT danakargebi vatmetris gragnil ebSi. am SemTxvevaSi simZl avris gasazomi mniSvel oba tolia:

$$P_{gas} = V \cdot I = R_{dat} (V_{d.g.} + V_{dat.}) = I_{dat.} \cdot V_{d.g.} + P_{dat.},$$



nax. 2.38. erTfaza vatmetris CarTvis sqemebi

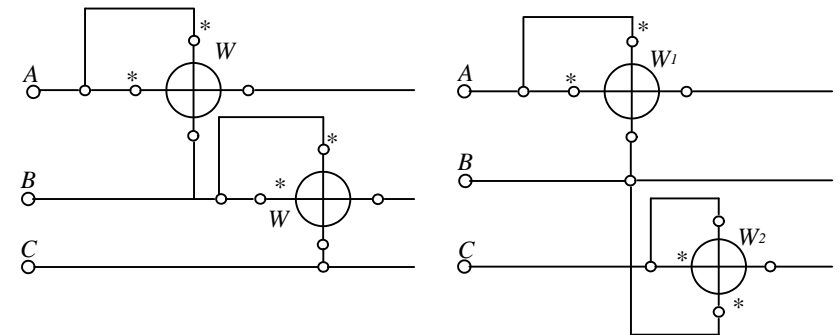
sadac, $V_{d.g.}$ — aris Zabvis vardna vatmetris denis gragnil ebSi; $V_{dat.}$ — Zabvaa datvirTvaze; $I_{dat.}$ — datvirTvavSi gamaval i deni; $P_{dat.}$ — datvirTvis simZl avre.

nax. 2.37, b-ze moyvanil i sqema gamoiyeneba im SemTxvevaSi, roca saWiroa simZl avris zusti gazomva, radganac vatmetris gragnil Si danakargebis Sesworeba am SemTxvevaSi ufro martivad xdeba, amis garda es Sesworeba ucvl el i rCeba denis nebi smieri mniSvel oba gansazRvreb formuliT:

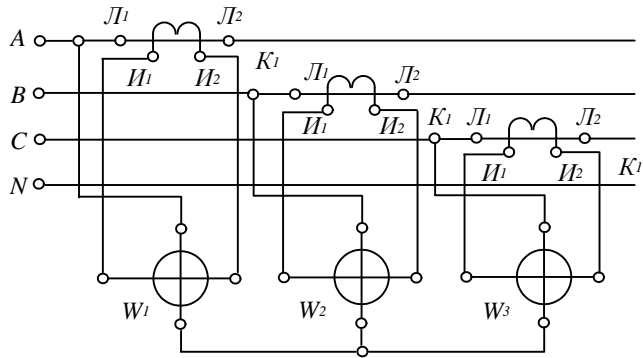
$$P_{gas} = V (I_{dat} + I_{vat}) = P_{dat} + \frac{V^2}{P_{vat}},$$

sadac, I_{dat} — vatmetris Zabvis gragnil Si gamaval i denia; P_{vat} — vatmetris Zabvis wredis winaRobaa.

samfaza wredesi aqtiuri simZl avris gasazomad diagnostikuri samuSaoebis praqtikaSi gamoiyeneba



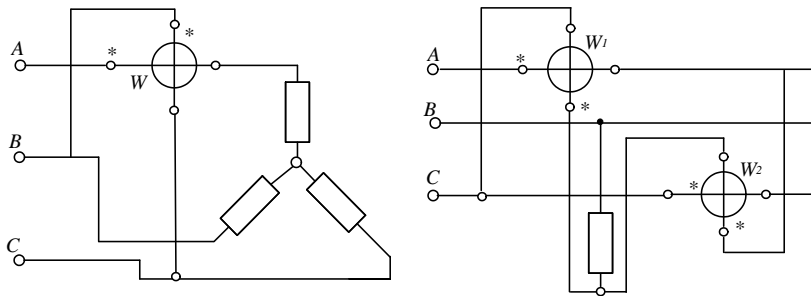
a) b)
nax. 2.39. vatmetrebis samfaza wredesi CarTvis sqemebi



nax. 2.40. samfaza oTx sadenian sistemaSi denis transformatorebiT simZI avris gazomvis sqema

erTfaza vatmetrebi, roml ebic wredabis konfiguraciis mixedviT SeiZl eba CairTos sxvadasxva sqemiT. nax. 2.38-ze naCvenebia vatmetris CarTvis sqema samsadenian simetriul i datvirTvis wredSi

orive SemTxvevaSi vatmetri zomavs erTi fazis simZI avres, magram radganac datvirTva simetriul ia (Tanabaria), amitom jamuri simZI avre gamoiTvl eba formul iT:



a)

b)

nax. 2.41. reaqtul i simZI avris gazomvis sqemebi samfaza sistemis simetriul i (a) da arasimetriul i (b) datvirTvis SemTxvevaSi

$$P = 3P_f = 3V_f I_f \cos \varphi.$$

nax. 2.39-ze naCvenebia vatmetris CarTvis ufro gavrcel ebul i sqemebi:

samfaza wredis jamuri simZI avre ganisazRvrebakorive vatmetris Cvenebis jamiT

$$P = P_{W1} + P_{W2}.$$

nax. 2.40-ze naCvenebia sami erTfaza vatmetris oTxgamtarian sistemaSi CarTvis sqema, sadac gazomvis zRvaris gasadidebl ad gamoyenebul ia denis transformatorebi. am sqemis mixedviT samfaza wredis jamuri simZI avre tol ia

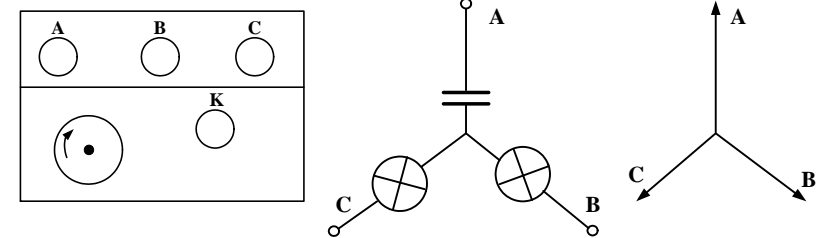
$$P = (P_{W1} + P_{W2} + P_{W3}) \cdot K_f,$$

sadac, K_f — denis transformatoris koeficientia.

reaqtul i simZI avre samfaza sistemaSi SeiZl eba gaizomos, nax. 2.41, a-ze moyvanil i sqemebiT.

nax. 2.41, a-ze moyvanil i sqemiT reaqtul i simZI avre ganisazRvrebafomul iT:

$$Q = \sqrt{3}P,$$



nax. 2.42. U517 tipis fazamaCvnebl is xedi

nax. 2.43. fazTa Tanmimdevrobis ganmsazRvrul i wredi damisi vektorul i diagrama

xol o nax. 2.41 b-ze moyvanil i sqemisaTvis, formul iT:

$$Q = \sqrt{3}(P_{W1} + P_{W2}).$$

ukanasknel SemTxvevaSi wredSi CarTul i winaRoba tol i unda iyos vatmetris Zabvis gragnil is winaRobisa.

i) fazaTa Tanmimdevrobis gansazRvra. el eqt-romowyobil obis swori CarTvis, eqspl oataciis, sare l eo dacvisa da avtomatikis muSaobis uzrunvel y-ofis mizniT, dadgenil ia dengamtari nawil ebis SeRebva gamanawil ebel mowyobil obebSi, sadac mxedvel o-baSi mi iReba fazaTa Tanmimdevroba. wesis mixedviT A faza SeRebil ia yviTI ad, B -mwwaned da C -wiTI ad. fazaTa aseTi, anu pirdapiri Tanmimdevroba ganisazRvrebazemoT moyvanil i $BA\Phi$ tipis xel sawyoebiT. am xel sawyoebis arqonis SemTxvevaSi fazaTa Tanmimdevroba martivad mowmdeba $U517$ tipis fazamaCvenebl iT (nax. 2.42). Sesamowmebel i sistemis Zabvebi mierTdeba fazamaCvenebl is Sesabamisi markirebis momWerebTan. pirdapiri Tanmimdevrobis ($A-B-C$) dros K Ril akze TiTis daWeriT disko iwyebis brunvas isriT naCvenebl mimarTul ebiT, xol o ukuTanmimdevrobis SemTxvevaSi _ sawinaaRmdego mxares. Ril akis daWeris xangrZl ivoba ar unda aRematebodes 3 mm-s.

kidev ufro martivad fazaTa Tanmimdevroba SeiZl eba ganisazRvros nax. 2.43. a-ze mocemul i arasimetriul i datvirTvis varskvl avad SeerTebul i wrediT, sadac naTurebis simZl avre erTnairia da kondensatoris winaRoba ($1/\omega C$) naTuris winaRobis tol ia.

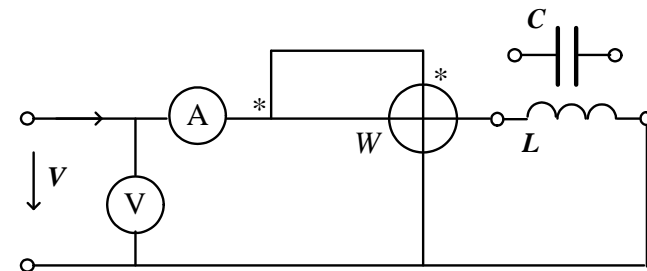


nax. 2.44. RLC-s sazomi xel sawyo

wredis veqtorul i anal iziT (nax. 2.43, b) SeiZl eba davadginoT, rom nax. 2.43, a-ze naCvenebl CarTvis dros B fazaSi CarTul i naTura metad kaSkaSebs, vidre C fazaSi CarTul i. naTurebi da kondensatori gaTvli l i unda iyos samfaza wredis fazur Zabvebze.

v) tevadobisa da induqciurobis gazomva. manqanebisa da transformatorebis gragnil ebis tevadobis gasazomad gamoiyeneba sxvadasxa tipis xel sawyoebi. Cvens SemTxvevaSi warmodgenil ia $AKM-6101$ — tipis (nax. 2.44) xel sawyo, roml is ZiriTadi maxasiaTebli ebia:

- _ srul i da aqtiuri winaRoba gazomva _ 1 gomamde;
- _ tevadobis gazomva _ 10 mF-mde;
- _ induqciebis gazomva _ 10 khn-mde;



nax. 2.45. tevadobisa da induqciurobis sazomi sqema

- _ vargi sobis gazomva _ 0,0001 _ 9999;
- _ danakargebis kuTxis tangensi _ 0,0001 _ 9999;
- _ bazuri cdomil eba _ 0,3%;
- _ gazomvis siCqare 3 gazomva/wm.

tevadobisa da induqciurobis gazomva SeiZl eba ampermetr-vol tmetris meTodiT cvl ad denze. kondensatoris tevadoba am SemTxvevaSi ganisazRvreba formul iT:

$$C_x = \frac{I}{V2\pi f}.$$

amave meTodiT SeiZl eba ganisazRvros induqciuroba:

$$L_x = \frac{V}{2\pi fI}.$$

tevadobisa da induqciurobis ufro zusti gazomvisaTvis SeiZl eba gamoyenebul i iqnes Semdegi sqema (nax. 2.45).

am SemTxvevaSi pirvel rigSi ganisazRvreba wre-dis srul i winaRoba:

$$Z = \frac{V}{I} \text{ da aqtiuri winaRoba } R = \frac{P}{I^2} = \frac{V^2}{P};$$

amis Semdeg ganisazRvreba reaqtul i winaRoba

$$X = \sqrt{Z^2 - R^2}.$$

reaqtul i winaRobis gansazRvris Semdeg ganisazRvreba tevadoba da induqciuroba, Sesabamisad:

$$C_x = \frac{1}{2\pi f X}; L_x = \frac{X}{2\pi f},$$

sadac f sixSirea.

z) izol aciis mdgomareobis Semowmeba. el eqtrul manqanebsa da aparatebSi gamoyenebul i nebismieri izol acia (diel eqtriki) arsebiTad war-moadgens kondensators, roml is Semanafenebis erT mxares war-moadgens aparatis konstruqciis el ementebi (korpusi, gul ara), xol o meore mxares dengamtari nawil ebi (kabel is ZarRvebi, sadenebi, sal teebi). maT Soris moTavsebul ia saizol acio masal ebi, romel Ta struqtura ganisazRvreba ara mar-to gamoyenebul i masal ebiT (qarsi, qaRal di, satransformatoro zeTi, boWko), aramed misi mdgomarebiTac _ defeqtebis, sax-el dobr, danestiane-bis arsebobiT. izol aciaSi mim-dinare fizikuri procesebi masze modebul i Zabvis dros anal ogiuria kondesatorSi mimdinare fizikuri procesebisa. izol aciis mdgomareobis SemowmebaSi mTavari adgil i uWiravs izol aciis winaRobisa da absorbciiis koeficientis gazomvas.

T) izol aciis winaRoba (R_{iz}) Eel eqtromowyobil obis izol aciis mdgomareobis ZiriTadi maxasi-aTebel ia, radganac el mowyobil obis garegani da Si-nagani defeqtebi (daziane-ba, danestiane-ba, zedapiris gaWuWyiane-ba) amci-rebs winaRobas. Aamitom izol aciis Semowmebis yvel a etapze xdeba izol aciis winaRobis gazomva. izol aciis winaRoba rogorc wina paragrafSi avRniSneT izomeba megaommetriT.

megaommetris tipis arCeva xdeba obieqtis nomi-nal uri winaRobis (Zal ovani kabel ebi 1-1000; sakomu-tacio aparatebi 1000-5000; Zal ovani transformator-ebi 10-20000; el manqanebi 0.2-1000; faifuris izol atorebi

100-10000 momi), misi parametrebisa da Zabvis mixedviT. rogorc wesi mowyobil obis izol aciis winaRobis gazomad 1000v Zabvamde (meoradi komutaciis wredebi, el eqtroZravebi da sxva) gamoiyeneba megaommetrebi 100, 250,500 da 1000 v nominal uri ZabviT, xol o 1000 v-ze meti Zabvis danadgarebSi -1000 da 2500 v ZabviT megaommetriT winaRobis gazomvisaTvis rekomendirebul ia operaciebis Semdegi Tanmimdevroba:

1. gavzomoT megaommetriT gamosacdel aparatTan misaerTebel i sadenebis izol aciis winaRoba, romel is mniSvnel oba ar unda iyos megaommetris gazomvis zeda zRvarze nakl ebi.

2. Mmegaommetris gamoyenebis win unda CavataroT misi sakontrol o Semowmeba, rac gamoixateba skal is CvenebiT gaxsnil i da mokl ed SerTul i sadenebis dros. pirvel SemTxvevaSi isari unda iyos skal is niSanTan " ∞ ", xol o meore SemTxvevaSi - "0".

3. davrwundeT rom Sesamowmebel i obieqti ar aris Zabvis qveS.

4. gamovrToT da davamokl oT yvel a detali, romel sac gaaCnia dabal i izol aciaan dabal i gamosacdel i Zabva (kondesatorebi, naxevargamtarul i xel sawyoebi da sxva)

5. xel sawyos CarTvis dros davamiwoT Sesamowmebel i wredi.

6. xel sawyoze davaWiroT xel i Ril aks "maRal i Zabva" Tu xel sawyo ikvebeba qsel idan, an vabrunoT megaommetris induqciuri generatoris saxel uri daaxil oebiT 120 br/wT siCqarIT da 60 mm-is Semdeg davafiqsiroT xel sawyos skal aze winaRobis mniSvnel oba.

7. Ddidi tevadobis mqone obieqtebis izol aciis winaRobis gazomvis dros xel sawyos Cveneba aviRoT isris mTI iani dawynarebis Semdeg.

8. Ggazomvis damTavrebis Semdeg, gansakuTrebiT didi tevadobis mqone mowyobil obebSi (mag. didi sigrZis kabel ebSi, sanam gamovrTavT xel sawyos bol oebis, saWiroa movxsnaT dagrovil i muxti Camiwebis dadebis gziT.

izol aciis winaRobis gazomvis Sedegi Sesazl ebel ia damaxinj ebul i iyos zedapirul i gaJonvis denebiT (mag. danadgaris izol irebul i nawil is danestianebis Sedegad.), maSin obieqtis izol aciaze adeben denamrTmev el eqtrods, romel ic SeerTebul i unda iyos megaommetris u"Э" (экран) momWerTan.

Mmiwisgan izol irebul i kabel is izol aciis winaRobis Semowmebias u momWeri unda mierTdes kabel is metal ur garsacmTan. Eel eqtrul i manqanebis gragnil ebs Soris izol aciis gazomvisas u momWeri mierTebul i unda iyos gamomyvani izol aciis kal TasTan.

Zal ovani da ganaTebis sadenebis izol aciis winaRobis gazomva, unda vawarmooT CarTul i amomrTvel ebis, moxsnil i mcvel ebis, gamorTul i el eqtromimRebebis, aparatebis, moxsnil i naTurebis dros.

Kkategoriuil ad akrZal ul ia gaizomos izol aciis winaRoba xazze, Tu misi mcire ubanic ki gadis Zabvis qveS myofi xazis siaxl oves da sahaero xazebze Weqa-quxil is dros.

i)Aabsorbciis koeficienti aris Zabvis modebidan 60 mm-is gavl is Semdeg izol aciis winaRobis

fardoba (R_{60}) 15 wamis gavl is Semdeg arsebul i

izol aciis winaRobasTan (R_{15}) anu $K_{abs} = \frac{R_{60}}{R_{15}}$.

Tu izol acia mSral ia, maSin absorbciiis koeficienti mniSvnel ovnad aRemateba erTeul s, xol o nestiani izol aciis SemTxvevaSi axl oa erTTan. Ees gamowveul ia imiT, rom mSral i izol aciis SemTxvevaSi dro didia, damuxtv is deni icvl eba nel a da 15 da 60 wamis Semdeg gazomil i winaRobebi erTmanTisgan Zl ier gansxvavdebian. Nnestiani izol aciis SemTxvevaSi damuxtv is deni swrafad icvl eba da 15 wamis gavl is Semdeg aRwevs damyarebul mdgomareobas, amitom 25 da 60 mm-is gavl is Semdeg gazomil i winaRobebi erTmaneTisgan TiTqos ar gansxvavdebian.

Aabsorbciiis koeficienti aris manqanebisa da transformatorebis izol aciis mdgomareobis meore Zir iTadi maCvenebel i. R_{iz} da R_{abs} Zal ian aris damokidebul i temperaturaze. am sidideebis gazomva xdeba $+10^{\circ}\text{C}$ -ze meti temperaturis dros, radganac nakl eb temperaturaze nestis arsebobis dros gazomvis Sedegebi arastabil uria.

izol aciis absorbciiis koeficientis gasazomad gamoiyeneba megaometri. zusti gazomvis Casatarebl ad saWiroa winaswar uzrunvel yoT megaometrze normal uri Zabva da mere swrafad davadoT "sacecebi" gasazomi obieqtis winaswar gasuFTavebul dengamtar nawil s da daviwoT drois aTvl a. xel sawyos pirveli i Cveneba davafiqsiroT 15 mm-is gavl is Semdeg, xol o meore 60 mm -is gavl is Semdeg. maTi fardoba iqneba

gazomvis Sedegi. Am gazomvis dros mkacrad unda davicvaT sifrTxil e da usafrTxoebis wesebi, radgan megaometris Zabva saSi Sia adami anis sicocxl isaTvis. Ggazomvis Semdeg saWiroa ganvmuxtoT gazomvis obieqti.

k) diel eqtrikul i danakargis kuTxis tangensi da misi gazomva

el eqtromowyobil obis izol aciis mdgomareobis gansazRvris gavr cel ebul meTods warmoadgens diel eqtrikul i danakargebis kuTxis tangensi ($tg\delta$) igi warmoadgens izol aciaSi gamaval i denis aqtiuri mdgenel is (I_a) fardobis reaqt iul mdgenel Tan (I_c) masze modebul i cvl adi Zabvis dros. $Ftg\delta = I_a/I_c$ Aaqtiuri mdgenel i ganpirobebul ia gaxurebiT da ionizaciaze danakargebiT, xol o reaqt iul i- Zabvis cvl il ebis TiToeul periodSi kondesatoris damuxtva-ganmuxtviT.

$tg\delta$ damokidebul ia tenianobaze, mowyobil obis zomaze, temperaturaze, Zabvaze. tenianobis gazrda zrdis denis aqtiur mdgenel s; temperaturis gazrda amcirebs izol aciis winaRobas da zrdis denis aqtiur mdgenel s da Sesabamisad danakargebs; Zabvis gazrda zrdis ionizaciis xarisxs.

amis gamo $tg\delta$ -s gazomva farTod gamoiyeneba transformatorebisa da maRal i Zabvis Semyvanebis izol aciis mdgomareobis Sesafasebl ad. Ggazomva unda vawarmooT $10-40^{\circ}\text{C}$ temperaturis diapazonSi.

diel eqtrikul i danakargebis kuTxis gasazomad gamoiyeneba Tanamedrove cvl adi denis bogirebi

rogorc Cveul ebrivi P5026M, Вектор-2.0M, Вектор-C, aseve programul i uzrunvel yofiT Тангенс-2000, МЭП-4CA maRal i Zabvis bogirebi.

Tavi 3 el eqtrul i wredebisa da el eqtronikis el ementebis diagnostika

3.1. el eqtrul wredebSi yvel aze xSirad Semxvedri dazianebebi

Eel eqtrul wredebSi yvel aze xSirad gv xvdeba Semdegi saxis dazianebebi:

1. wredis gawyveta, rodesac el eqtrul i wredis winaRoba usasrul od didia;
2. winaRobis mniSvnel ovani gazrda;
3. winaRobis mniSvnel ovani Semcireba;
4. mokl ed SerTva, rodesac el eqtrul i wredis winaRoba nul is tol ia an nul Tan axl osaa.

wredis gawyveta xdeba wredis el ementebis daZvel ebiT, didi denebis gavl iT, dartymebiT, vibraciiTa da koroziiT.

winaRobis mniSvnel ovani gazrda nominal ur mniSvnel obasTan SedarebiT gamowveul ia el ementebis daZvel ebiT kontaqtetisa da sakontaqto SeerTebis gauaresebiT, cal keul i el ementebis parametrebis gadaxriT.

winaRobis mniSvnel ovani Semcireba nominal ur mniSvnel obasTan SedarebiT gamowveul ia el ementebis daZvel ebiTa da zedapirul i gaJonvebis gazrdiT.

mokl ed SerTva gamowveul ia izol aciis garReviT, araizol irebul i gamtarebisa da el ementebis SexebiT korpusTan da erTmaneTTan (sxvadasxva polarobisa da fazebis dros).

Ddazianebis moZebnis dros unda vicodeT da unda SegveZI os gamoviyenoT ama Tu im el eqtromowyobi-

I obis gamarTul i muSaobis niSnebi. Ees niSnebi iyo-
fa or jgufad: aqtiuri da pasiuri anu meoreul i.

aqtiuri niSnebia xmovani signal ebisa da sig-
nal izatorebis, sasignal o naTurebis Cvenebebi; dacvis
mowyobil obis amuSaveba; agreTve xel sawyoebiT ga-
zomvis dros gamomJRavnebul i niSnebi.

pasiuri niSnebi mJRavndeba el eqtromowyobil o-
bis gare daTval ierebis dros.

xmovani signal ebi, signal izatorebi, sasignal o
naTurebi saSual ebas gvaZl even Tval yuri vadevnoT
el eqtromowyobil obis mdgomareobas.

Ddacvis saSual ebebi (mcvel ebi, maqsimal uri an
minimal uri rel eebi, avtomaturi amomrTvel ebi da
sxva) el eqtrul wreds amomrTaven kvebis wyarodan
gaJonvis, gadatvirTvis denebisa da mokl ed SerTvis
arsebobis dros.

wredis gawyvetis SemTxvevaSi dacva Cveul ebriv
ar amuSavdeba, magram misi normal uri mdgomareoba
el eqtrul wredSi dazianebebis arsebobis dros irib-
ad imis maniSnebel ia, rom dazianebas aqvs gawyvetis
xasiaTi.

Ddazianebebis Zieba swarmoebs el eqtrul i wredis
el ementebis parametrebis gazomviT gadasatani xel -
sawyoebisa da sazomi kompl eqtebis gamoyenebiT.

Eel eqtrul sqemebSi (mag. I ogikur, Zravas da a.S.)
cal keul i el ementebis parametrebis (winaRoba, Zabva,
deni) gazomvis dros saWiroa visargebl oT am el mow-
yobil obis cal keul i el ementebisa da bl okebis ga-
mosasvl el ze instruqciaSi moyvani i winaRobis, Zab-
vis, denis rukebiT.

dazianebebis moZebnis kerZo xerxebs miekuTvne-
ba Sual eduri gazomvebis Catareba, romel ic iZl eva
SesaZl ebl obas Tanmimdevrul ad gavyveT signal is gav-
l as sistemis sxvadasxva arxebSi; gamoricxvebi, romel -
ic saSual ebas iZl eva gazomvis Sedegad gamovricxoT
Sesamowmebel i sqemebis dauzanebel i nawil i da gam-
ovyot dazianebul i el ementi; im bl okebis (detal eb-
is) Secvl a, romel Sic aRmoCenil ia dazianebeba, imave
tipis vargisi bl okiT. dazianebul i sqemis gamocdis
Sedegebis Sedareba imave tipis vargisi sqemebis gamoc-
dis monacemebTan.

**el eqtrul i el ementebis dazianebebis ZiriTa-
di mizezebia:** deniT gadatvirTva; gadaZabva; garemo
temperaturis aweva; dauSvebel i vibracia da dartye-
bi.

obieqtis (sistemis, mowyobil obis, bl okis, modu-
l is el eqtronul i firfita) dazianebebis dros da-
zianebul i el eqtronikis el ementebis Zieba rekomen-
direbul ia daviwyoT el ementebis: sasignal o naTure-
bis, mcvel ebis, amomrTvel ebisa da komutaciis sxva
saSual ebebis; dacvis mowyobil obebis vargisianobis
winaswari Semowmebis Semdeg.

kvebis bl okebisa da kvanZebis Sesasvl el sa da
gamosasvl el ze unda Semowmdes Zabvebi, Semowmebul i
unda iqnas gare mowyobil obebi: gadamwodebi, signal i-
zatorebi, sabol oo amomrTvel ebi, monitorebi, kinesko-
pebi da a.S.

amis Semdeg unda Semowmdes Zabvisa da impul sebis
parametrebis mniSvnel obebi instruqciaSi mocemul
sakontrol o wertil ebSi.

dazianebul i el ementis Semdgomi Zieba rekomendirebul ia Sesrul des Semdegi miTiTebebis gaTval - iswinebiT: unda Seswavl il i iqnes dazianebul i obieqtis moqmedebis principi. Tavdapirvel ad moiZebneba ufro rTul i dazianebul i obieqti, xol o Semdgom - ufro martivi (pricipiT sistema-bl oki-kvanZi-el ementi)

anal izi gaukeTdeba dazianebis niSnebs, gamoiTqmeba dazianebis savaraudo mizezebi da airCeva Semowmebis meTodi. Aamis Semdeg swarmoebs im ubnebis da el ementebis arCeviTi Semowmeba, romel Ta dazianebis al baToba ufro didia, xol o maTi Semowmeba ikavebs mcire dros.

Tu arCeviTi SemowmebiT dazianebul i el ementi ver aRmoacines, maSin gadadian gamoricxvis meTodze obieqtis Sesasvl el idan gamosasvl el isaken moZraobiT an Semdgomi Semowmebis win obieqts hyofen Sromatevadobis mixedviT or tol nawil ad. Tu dazianeba obieqtisaTvis damaxasiaTebel i ar aris, maSin pirdapir gadadian gamoricxvis meTodze.

obieqtis garegani daTval ierebis dros sqemis gamoTvisTanave yuradReba unda mieqces: izol acis mdgomareobas: mis fers; simuqes; napral ebis arsebobs; damagrebebis, sakontaqto zedapirebis, SeerTebebis, mirCil vis adgil ebis wesivrobas; korpusebis, tranzistorebis, rezistorebis, diodebis, mikrosqemebis el eqtrol ituri kondesatorebis temperaturas.

pirvel rigSi Semowmebas eqvemdebareba is el ementebi, romel Tac gaaCniaT nakl i. saWiro monacemebis arsebobs dros Zieba SeiZl eba gagrZel des garkveul

ubneze gamarTul da dazianebul el ementebze Zabvebis Sedarebis gziT.

dazianebul i el ementis aRmoCenis Semdeg mis Secvli amde anal izi unda gaukeTdes dazianebis mizezebs da misi dadgenis Semdeg unda SeiCval os el ementi.

3.2. el eqtronikis el ementebis dazianebis ZiriTadi saxeebi, maTi aRmoCenis xerxebi da diagnostika

a) rezistorebis diagnostika. rezistoris muSaunarianobis dakargva SeiZl eba gamowveul i iyos Semdegi mizezebiT: 1. gamomyvanebis gawyvetiT an gada-wviT; 2. cvl adi winaRobis rezistoris dengamtar fenasa da moZrav kvanZs Soris kontaqtis darRveviT; 3. dasaSvebze metad winaRobis cvl il ebiT; 4. Ffoto-rezistorebis atvis mgrZnobi arobis SemcirebiT an dakargviT.

mudmivi da cvl adi denis mavTul iani da umavTul i o rezistorebis Sesamowmebl ad saWiroa gakeTdes Semdegi: Catardes garegani daTval iereba; Semowmdes cvl adi rezistoris moZravi meqanizmis muSaoba da misi nawil ebis mdgomareoba; markirebiTa da zomebis mixedviT ganvsazRvroT winaRobis nominal uri mniSvnel oba, gabnevis dasaSvebi simZl avre da sizustis kl asi; ommetriT gavzomoT winaRobis namdvil i mniSvnel oba da ganvsazRvroT misi gadaxra nominal ur mniSvnel obidan. cvl ad rezistorebSi damatebiT gavzomoT cocias moZraobis dros winaRobis cvl il ebis simdovre. rezistori wesrigSia, Tu mas ar gaaCnia meqanikuri dazianebebi, misi winaRobis sidide imyo-

feba mocemul sizustis kl asis dasaSveb sazRvrebSi, xol o cocias kontakti dengamtar fenasTan mudmivi da saimedoa.

b) induqciuri koWebis diagnostika. induqciuri koWis dazianebebi SeiZl eba gamowveul i iyos: xviis gawyvetiT; izol aciis daZvel ebiT; xviebis damokl ebiT; gamomyvanebis CawyvetiT.

inducqciuri koWebis Semowmeba iwyeba misi gar-egani daTval ierebiT, roml is drosac vrwundebiT karkasis, ekranis, gamomyvanebis wesrigSi yofniT; koWis yvel a detal is erTmaneTs Soris SeerTebis sisworeSi da saimedoobaSi; sadenebis xil ul i gawyvetis, mokl ed SerTvis, izol aciis dazianebebis ar arsebobaSi. gansakuTrebul i yuradReba unda mieqces im adgil ebs, sadac izol acia da karkasi danaxSirebul i, gaSavebul i an gamdnaria.

gawyvetaze Semowmeba xorciel deba indikatoriT. winaRobis gazrda miuTitebs erTi an ramdenime ZarRvis gawyvetaze an cud kontakqtze, xol o winaRobis Semcireba uCvenebs xviaTa Soris mokl ed SerTvas. Ggamomyvanebis mokl ed SerTvis dros winaRoba nul is tol ia.

koWis vargisianobaze ufro zusti warmodgenisaTvis saWiroa gai zomos koWis induqciuroba. rekomendirebul ia agreTve koWis muSaunarianobis Semowmeba iseTive aparatze, roml isTvisac is aris gaTval - iswinebul i.

g) kondensatorebis diagnostika. Kkondensatorebis el eqtrul dazianebas miekuTvneba: kondensatorebis garRveva; SigniT firfitebis mokl ed SerT-

va; diel eqtrikis daZvel ebis gamo dasaSvebze metad nominal uri tevadobis cvl il eba; masSi sinestis moxvedra; gadaxureba; deformacia; izol aciis gauaresebis gamo gaJonvis denebis gazrda; el eqtrol itis gaSrobis Sedegad el eqtrol ituri kondensatorebis tevadobis nawil obrivi an mTI iani dakargva.

kondensatorebis vargisianobis Semowmebis umartives xerxs warmoadgens gare daTval iereba, roml is drosac SeiZl eba aRmoVaCinoT meqanikuri dazianebebi. Tu meqanikuri dazianebebi ar aRmoCnda, maSin iwyeben el eqtrul Semowmebas, romel ic moicavs Semowmebas: mokl ed SerTvaze, garRvevaze, gamomyvanebis mTI ianobaze, gaJonvis denze (izol aciis winaRobaze) da tevadobis gazomvas.

Semowmebis meTodika SemdgomSi mdgomareobs:

1. kondensatoris erTi gamomyvani unda gancal kevdes danarCeni sqemebisagan;

2. sazomi xel sawyo aiwyoba aTeul da aseul i kil oomis an megaomis diapazonSi;

3. kondensatoris gamomyvanebze miuerTdeba xel - sawyos sacecebi: am dros didi tevadobis kondensatorebis aTvis (ramdenime aTeul idan ramdenime aseul mikrofaradis fargl ebSi) damaxasiaTebel ia pirvel sawyis momentSi sazomi xel sawyos (ommetris) isris gadaxra nul isaken (damuxtvvis maqsimal uri denis gavl is momentSi), xol o Semdgom isari TandaTanobiT gadaxreba "∞" ni Snul ze

4. kondensatoris diel eqtrikis damakmayofil ebel mdgomareobad iTvl eba, Tu ommetris Cveneba aris aranakl eb 100 komi

5. Tu didi tevadobis kondensatorSi (10-100mkf) adgil i aqvs gawvyetas, maSin xel sawyos isari myisve dadgeba niSnul ze " ∞ ".

6. saSual o tevadobis kondensatorebs (500hf-1 mkf) amowmeben kondensatorebis gamomyvanebTan mimdevrobiT SeerTebul i denis wyarosa da tel efonis daxmarebiT. vargisi kondensatoris SemTxvevaSi wredis CarTvis momentSi tel efonSi gaismis wkapuni.

7. mcire tevadobis (500hf-mde) kondensatorebs amowmeben maRal i sixSiris wredSi. Kkondensators rTaven antenasa da mimRebs Soris, Tu miRebis xmamaRl oba ar Semcirda maSin gamomyvanebis gawyveta ar gvaqvs.


8. mcire tevadobis kondensatorebisatvis ommetriT gawvyetis gansazRvra SeuZl ebel ia, radgan xel sawyo gviCvenebs an mokl ed SerTvas, Tu moxda izol aciis garRveva, an usasrul od did winaRobas, Tu kondensatori vargisia an aris gamomyvanis gawyveta. kondensatoris SigniT gawyveta gani sazRvrebaba uSual od sqemis gazomviT, romel ic Sesdgebra mimdevrobiT SeerTebul i kondensatoris, cvl adi denis ampermetrisa da denis SemzRudavi rezistorisagan.

sqema CairTveba cvl adi denis wyaroSi, romel zec modebul i Zabva ar unda aRematebodes kondensatoris nominal uri Zabvis 20 %-s. wredSi ampermetris nul ovani Cveneba uCvenebs kondesatoris gawvyetas.

gaJonvis denis gazrda (izol aciis Semcireba) gani sazRvrebaba kondensatoris gamomyvanebTan ommetris ganmeorebiTi CarTviT.

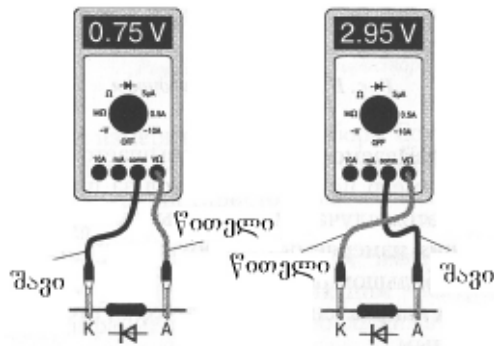
pirvel CarTvaze xel sawyos isari gadaxreba damuxtvis denis gamo, xol o Semdeg brundeba sawyis mdgomareobaSi. Tu Semdgomi CarTvebisas, romel ic meordeba ramdenime wamis interval iT, isris gadaxra meordeba, es niSnavs, rom kondensators aqvs gaJonvis momatebul i deni.

d) diodi. Diodi warmoadgens naxevargamtar el ements, romel ic dens atarebs mxol od erTi mimarTul ebiT. sxva si tyvebiT rom vTqvaT, diods gaaCnia Zal ian mcire winaRoba erTi mimarTul ebis denisaTvis da Zal ian didi winaRoba meore mimarTul ebis denisaTvis. winaRobis gazomvisas gasazom el ementTan CarTaven ommetrs, romel sac gaaCnia sakuTari kvebis wyaro (batarea). Oommetris kl emebze Zabva Seadgens 1,5 an 3 vol ts. Ppirdapiri wanacvl ebisaTvis diodi moiTxovs 0,7v Zabvas. amitom Tu ommetrs dadebiT sacecs mivuerTebT diodis anods (A), xol o uaryofiTs - kaTods (K), maSin adgil ebis Secvl is Semdeg wesi vrul mdgomareobaSi myofi diodis winaRoba unda iyos Zal ian didi. Aangvarad diodis Semowmebisatvis SeiZl eba visargebl oT Cveul ebrivi ommetriT.

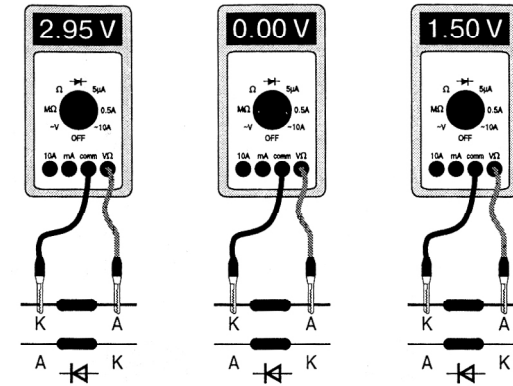
mraVal cifrul mul timetrs gaaCnia diodis Semowmebis funqcia. xel sawyos zRvrebis gadamrTvel ze es funqcia aRniSnul ia diodis simbol uri gamosaxul ebiT () mul timetrs gaaCnia Zabvis sakuTari wyaro, romel ic sakmarisia diodis orive mxaris Sesamowmebl ad. Nnax. 3.1-ze il ustrirebul ia diodis Semowmebis procesi. Mmul timetris dadebiTi saceci (wiTel i feris) CarTul ia diodis anodTan.

Oxol o uaryofiT*i* (Savi feris) –kaTodTan. Tu diodi vargisia, maSin mul timetrma unda gviCvenos Zabvis mniSvel oba 0.5 dan 0.9 vol tis fargl ebSi (Cveul ebriv 0.7v). Semdeg sacecebs ucvl ian adgil ebs da am SemTxvevaSi diodi mul timetrisaTvis warmoadgens gawvyetil wreds da mis displ eize aisaxeba praqtiku- l ad sakuTari Zabva, romel ic Cveul ebriv imyofeba 2,5 -3,5 vol tis fargl ebSi.

uvargisi diodi warmoadgens gawvyetil an orive mxridan Caketil wreds. Yvel aze xSirad gvxdeba pirvel i SemTxveva, rac gamowveul ia p-n gadasasvl el - is gadaxurebiT. Aam dros diods gaaCnia Zal ian maRal i winaRoba, rogorc pirdapiri ise ukumimarTul ebiT. Mmeore SemTxvevaSi, roca diodi garRveul ia mul timetri gviCvenebs orive mimarTul ebiT Zabvis nul o- van mniSvel obas. zogierT SemTxvevaSi garRveul ma diodma SeiZl eba arc gviCvenos mTl iani Caketil i wredi, magram gaaCndes orive mimarTul ebiT winaRo- bis erTi da igive mniSvel oba. (magal iTad mul time-



ნახ.3.1. vargisi diodi



ნახ. 3.2. uvargisi diodi

tri gviCvenebs 1.5 vol ts). Ees SemTxvevebi mocemul ia nax. 3.2-ze

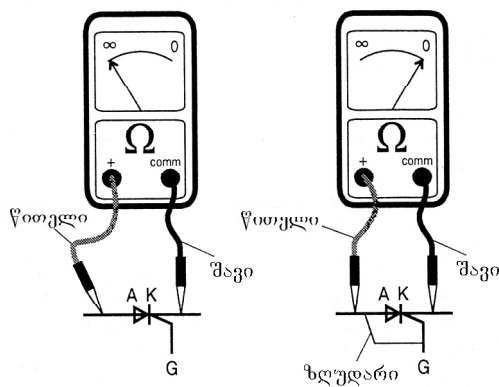
Tu mul timetrს ar gaaCnia diodის Semowmebis funqcia, maSin diodi SeiZl eba SevamowmoT misi orive mxridan winaRobის gazomviT. xel sawyos gadamrTve- l i davayenoT “OM”(“Ω”) mdgomareobaSi.Ddiodის “pirdapiri wanacvl ebis” dros xel sawyo gviCvenebs ramdeni aseul i omidan ramdenime aTaseul omamde. Ddiodის real uri winaRoba Cveul ebriv ar aRwevs 100 omamdec ki, magram umetesi mzomi xel sawyoebis Sinagani Zabva ar aris sakmarisi p-n gadasasvl el is mTl iani wanacvl ebisaTvis. Aam mizeziT naCvenebs mniSvel oba momatebul ia. Ddiodის “ukuwanacvl ebis” dros mul - timeri gviCvenebs diapazonის sazRvrebidan gamosvl - as, radganac winaRoba am dros Zal ian maRal ia ga- zomvisaTvis.

Ggasazomi winaRobის mniSvel obebi arsebiTi ar aris. MmTavaria davrwundeT imaSi, rom diodის pirda- piri da ukumimarTul ebiT winaRobebs Soris gansx-

vaveba Zal ian didia. Ffaqtiurad es sakmarisia imisaTvis rom diodi CavTval oT vargisad.

e) tiristori. tiristori warmoadgens diods damatebiTi marTvis el eqtrodiT (G). tiristori denis gatarebas iwyebs maSin, roca „wanacvl ebul ia pirdapiri mimarTul ebiT“. Aam dros marTvis el eqtrodze miwodeba gamRebi impul si. Aamitom tiristori SeiZl eba SevamowmoT iseTnairad, rogorc mowmdeba Cveuli ebrivi diodi. sazomi xel sawyos dadebiTi (wiTel i) saceci CairTveba tiristoris anodTan (nax.3.3), xol o uaryofiTi (Savi) -kaTodTan. vargisi tiristoris SemTxvevaSi xel sawyom unda uCvenos usasruli od didi winaRoba.

tiristoris gaxsnisaTvis gamoiyeneben zRudars, (“ПЕРЕМЫЧКА”), roml iTac tiristoris marTvis el eqtrods SearTeben dadebiT sacectan; am dros ar unda gamoirtos sazomi xel sawyo. sazom xel sawyoze tiristoris winaRobis Cveneba mkveTrad unda daeces.



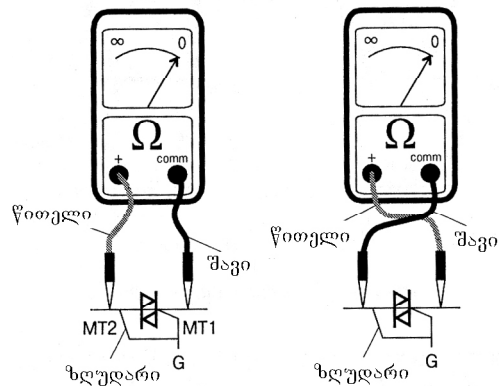
nax.3.3. tiristoris Semowmeba

zRudaris gamorTvis Semdeg tiristori SeiZl eba darCes gaxsnil mdgomareobaSi an daubrundes Caketil mdgomareobas. Ees damokidebul ia tiristorisa da sazomi xel sawyos Tvisebebze. Tu tiristors gaaCnia daWeris mcire deni, maSin ommetrs SeuZl ia daiWiros igi gaxsnil mdgomareobaSi. Tu tiristoris daWeris deni didia, maSin zRudis gamorTvisas tiristori CaikeTeba.

zoghierT mZl avr tiristors SeiZl eba hqondes Sinagani rezistori, romel ic CarTul ia kaTodsა da marTvis el eqtrods Soris. Ees rezistori gaaRebs tiristors mcire dabrkol ebiT. inJinerm a Tu ar icis am rezistoris arsebobis Sesaxeb, SeiZl eba SecdomiT miRos igi kaTodsა da marTvis el eqtrods Soris gaJonvad. Aam winaRobis gazomva SeiZl eba ommetriT.

v) semistorebi. semistori konstruqciul ad Sedgeba ori tiristorisagan, roml ebic erTmaneTTan CarTul ia paral erurad da sapirispiro mimarTul ebiT. Aamitom semistorebis Semowmebis procesi Zal ian waagavs tiristorebis Semowmebis process. sazomi xel sawyos dadebiTi saceci CairTveba MT2 gamomyvanTan, xol o uaryofiTi - MT1 gamomyvanTan.

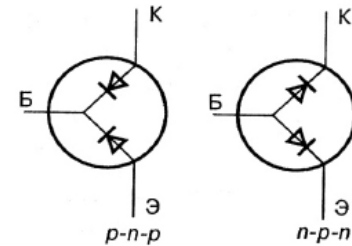
gamorTul i marTvis el eqtrodis SemTxvevaSi ommetрма unda uCvenos usasruli od didi winaRoba, Semdeg iseve rogorc tiristorebis Semowmebisas marTvis el eqtrods zRudariT SearTeben MT2 gamomyvanTan (miwodeba dadebiTi gamRebi impul si). xel sawyoze naCvenebi semistoris winaRobis mniSvnel oba mkveTrad unda daeces. Ees niSnavs rom tiristorebis am wyvil idan erTi tiristori vargisia.



ნახ. 3.4. სემისტორების შემოწმება

სემდეგ ომეტრის საცეხს შეუცვლიან ადგილს. ისევე, თუ მართვის ელექტროდი გამოერთია, ომეტრმა უნდა გვიჩვენოს უსასრულოდ დიდი წინაობა. ამის შემდეგ მართვის ელექტროდს ზრდართან შეერთებენ MT2 გამოყვანთან, (მიუხედავად იმისა, რომ იმპულსი). სემისტორის წინაობა მცირდება, ეს ნიშნავს მეორე ტერმინალის ვარგისიანობას. ეს პროცესი ნაწვენებია ნახ. 3.4-ზე.

ზ) ბიპოლარული ტრანზისტორები. ბიპოლარული ტრანზისტორები სდებათ ნახევარგამტარული მასალის სამი ფენიდან და შეიძლება იყოს p-n-p ან n-p-n ტიპის. თითოეული ტრანზისტორი შეიძლება წარმოადგინოს ორი დიოდის სახით, რომლებიც ერთმანეთთან ერთად არიან სემიკონდუქტორული სტრუქტურის, რომელთა შერთების ერთი დასამოწმებელია გამოყვანილია გამოყვანილი, რაც ნაწვენებია ნახ. 3.5-ზე. p-n-p ტიპის ტრანზისტორის ბაზის ეკვივალენტი (Б) ერთმანეთთან შეერთებულია ორი დიოდის კათოდები, ხოლო n-p-n ტიპის ტრანზისტორის ბაზის ეკვივალენტი ერთმანეთ-



ნახ. 3.5. ორი დიოდის წარმოშობა ტრანზისტორში

თან შეერთებულია ორი დიოდის ანოდიები. დიოდების დარღვევის შემთხვევაში ორი გამოყვანილია ემისერს (E) და კოლექტორს (K). ტრანზისტორის p-n-ორივე გადასვლას ამოწმებენ ცალ-ცალკე, როგორც ორი დამოუკიდებელი დიოდი. თუ ორივე

დიოდი ვარგისია, მაშინ ტრანზისტორიც ვარგისია. დიოდების შემოწმებისას ტრანზისტორის ფუნქცია შეიძლება გამოვიყენოთ ტრანზისტორის შემოწმებისას. ავიროთ შემოწმებისას p-n-p ტიპის ტრანზისტორი. მულტიმეტრის "უარყოფითი საცეხი" (Savi) დავაძლიერებთ ემისერს, ხოლო სემდეგ კოლექტორს. მულტიმეტრმა ორივე შემთხვევაში უნდა გვიჩვენოს მცირე წინაობა. სემდეგ "სავი საცეხის" ადგილზე შევაერთოთ ბაზასთან "ვითელი საცეხი" და გავიმეოროთ პროცედურა. ამ შემთხვევაში მულტიმეტრმა უნდა გვიჩვენოს ორივე შემთხვევაში დიდი წინაობა.

გ p-n-p ტიპის ტრანზისტორების შემოწმების პროცედურა იგივეა. გგანსხვავდება მხოლოდ იმას, რომ როცა ბაზასთან მიერთებულია "სავი საცეხი", მაშინ მულტიმეტრი გვიჩვენებს დიდი წინაობას, ხოლო როცა "ვითელი" - მცირე წინაობას.

თუ მულტიმეტრს არ გაცნია დიოდების შემოწმების რეჟიმი, მაშინ ტრანზისტორი მოწმდება წინაობის გაზომვის "ომ" ("Ω") რეჟიმში ისევე როგორც დიოდი. ისევე ავრნიშნავთ, რომ ხელსაწყოს ვენება რამდენიმე ასული ომი-

dan ramdenime aTaseul omamde pirdapiri mima-
 rTul ebiT ar niSnavs tranzistoris aucil ebel uvar-
 gisobas. es SeiZl eba niSnavdes mxol od imas, rom sa-
 zomi xel sawyoebis Sinagani kvebis wyaro ar yofnis
 p-n gadasvl is mTI iani wanacvl ebisaTvis. ukumima-
 rTul ebiT winaRobis usasrul o mniSvnel oba imave
 tranzistorisaTvis cxadad gviCvenebs tranzistoris
 vargisobas. aq mxedvel obaSi unda miViRoT mxol od
 ori Cvenebs sxvaoba da ara maTi moqmedi mniSvnel o-
 bani.

tranzistori uvargisia, Tu orive p-n gadasasvl el s
 gaaCniaT orive mimaTul ebiT erTnairi winaRobebi.

**T) bipolarul tranzistorze momuSave sqe-
 mebis Semowmeba.**

zogj er tranzistori vargisia, magram gareSe wred-
 Si arsebul i dazianebebis gamo SeiZl eba imuSaos
 arasworad. Mmagal iTad, civi rCil vis Sedegad tran-
 zistoris baza danarCen sqemebTan ar aris SeerTebu-
 l i. maSin wanacvl ebis Zabva tranzistorze nul is
 tol ia, rasac miVyavarT mis CaketvasTan. aseTi tran-
 zistoris Semowmebis dros nabeWd firfitaze igi
 gviCvenebs rom vargisia, xol o gamosasvl el ze signa-
 l i ar gvaqvs.

imisaTvis rom ukeTasad gavigoT rogor Cavatar-
 oT diagnostireba bipolarul tranzistorze, ma-
 gal iTisaTvis ganvixil oT nax. 3.6-ze warmodgenil i
 gamaZl ierebel i kaskadi. kaskadi akrefil ia 2N3946
 tipis tranzistorze, sacnobaro monacemebidan cno-
 bil ia, rom am tranzistoris h_{FE} aris 50-150 diapazonSi

davuSvaT am tranzistoris $h_{FE} = 100$. wanacvl ebis
 Zabvas bazaze da kol eqtorze virCevT Sesabamisad
 $V_{BB} = 3v$ da $V_{CC} = 9v$. Sevasrul oT gaangariSeba da gan-
 vsazRvroT:

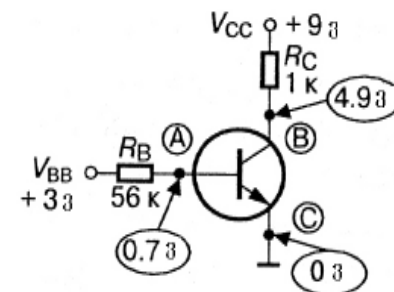
$$I_B = \frac{V_{BB} - V_{BE}}{R_B} = \frac{3 - 0,7}{56} = 41,4 \text{ mka,}$$

$$I_C = h_{FF} \cdot I_B = 100 \cdot 41,4 = 4,1 \text{ ma,}$$

$$V_C = V_{CC} - I_C \cdot R_C = 9 - 4,1 = 4,9 \text{ v.}$$

nax. 3.6-ze naCvenebia Zabvebi da komponentebis parame-
 trebi. Yyvel a gazomil i Zabva warmodgenil ia miwis
 mimaT. Tu sqema sworad muSaobs, maSin unda gvqondes
 Semdegi Zabvebi: Awertil Si - 0,7 v; B-Si - 4,9 v da C-
 Si - 0 v. dasawyisSi unda Semowmdes tranzistori. Tu
 is vargisia, maSin unda davaTval ieroT nabeWdi fir-
 fita, xom ar aris masze meqanikuri dazianebebi, gada-
 mwvari komponentebi an cudi mirCil vis adgil ebi.
 Bbol os izomeba Zabva tranzistoris gamomyvanebze.

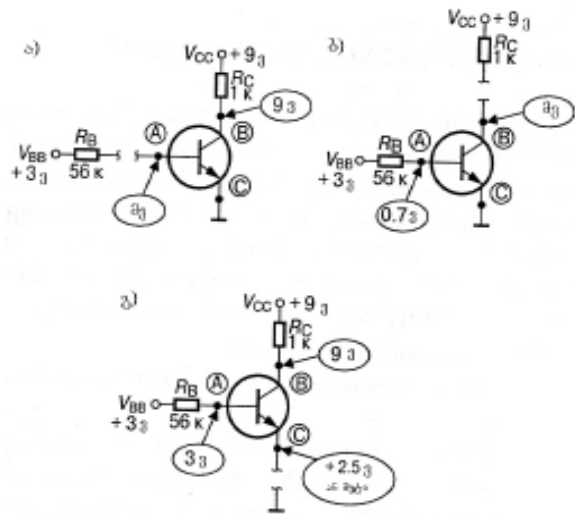
gare wredis dazianebebis gamo SeiZl eba aRiZvras
 araswori muSaobis sami reJimi. Ees reJimebi naCvenebia



**nax. 3.6. gamaZl ierebl is
 erTi kaskadis diagnostika**

nax. 3.7-ze. gavzomavT ra
 Zabvas tranzistoris ga-
 momyvanebze SeiZl eba uf-
 ro efeqturad ganvsazRv-
 roT es uwesivrobebi.

Tu Zabva Awertil Si
 normal uri 0,7. v-is magi-
 er Seadgens ramdenime mi-
 krovolt ts, es niSnavs, rom



Nmax.3.7 bipol arul tranzistorze momuSave sqemis araswori muSaobis reJimebi: a) bazis gawyveta; b) kol eqtoris gawyveta; g) emiteris gawyveta

gawyvetil ia bazis wredi (nax. 3.7, a). unda Semowmdes tranzistoris bazisa da R_B winaRobis mirCil va. SeiZl eba agreTve gaizomos R_B rezistoris winaRoba. saWiroa agreTve Semowmdes tranzistoris bazasTan mimaval i yvel a wredi, savaraudod sadRac aris cudi mirCil va an araSesabamisi maxasiaTebI is mqone komponentebi.

Tu mul timetri gviCvenebs kol eqtorze ramdenime mil vol t Zabvas (nax. 3.7, b), es ni Snavs, rom kol eqtori CarTul i ar aris wredis danarCen nawil Tan. Zabva bazaze amave dros unda iyos 0,7 v radgan gadasvl a Zabva-emiteri wanacvl ebul ia pirdapiri mimarTul ebiT. Aam dros unda Semowmdes kol eqtorisa da R_C rezis-

toris mirCil va agreTve gaizomos R_C rezistoris winaRoba. Ggarda amisa saWiroa Semowmdes kol eqtoris wredSi rezistorTan CarTul i yvel a komponenti.

miwasTan SeerTebis gawyvetic niSnebi Semdegia: +3 v bazis gamomyvanze da +9 v kol eqtoris gamomyvanze, radgan ar aris kol eqtorisa da emiteris deni (nax.3.7, g). Zabva emiterze Seadgens +2,5 v-da zeviT. is gamowveul ia deniT, romel ic gadis Semdegi gziT: $V_{BB} - R_B$ -baza-emiteris gadasasvl el i- sazomi xel sawyos sakuTari winaRoba-mi wa.

Aamtom vol tmetri aregistrirebs Zabvis vardnas p-n gadasasvl el ze. Uunda Semowmdes emiteris mirCil va da masTan CarTul i yvel a wredi.

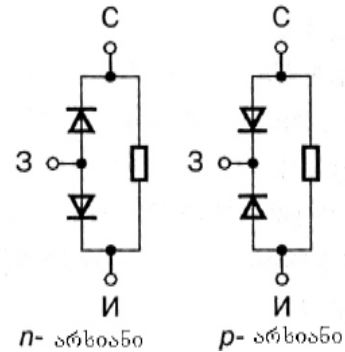
k) savel e tranzistorebi. savel e tranzistorebis Semowmeba ufro rTul ia vidre bipol arul is. am tipis tranzistorebis Semowmebis win unda dadgindes es tranzistori aris gadasasvl el iT p-n, Tu aris МОП (МОП - металл - оксид - полупроводник) tranzistori, roml is ZiriTadi maxasiaTebI ebi sxva tranzistorebTan SedarebiT aris maRal i Sesaval i winaRoba. amis Semdeg unda dadgindes tranzistori p-arxiania Tu n-arxiani.

savel e tranzistori p-n gadasasvl el iT SeiZl eba Semowmdes Cveul ebrivi ommetriT.

savel e tranzistoris eqval enturi Canacvl ebis sqema mocemul ia nax. 3.8-ze.

is warmoadgens Casadinarsa da saTaves Soris mimdevrobiT SeerTebul or diods. Ddiodebis pol aroba urTierTsawinaaRmdegoa. maTi Sua wertil idan gamoyvanil ia saketi. n arxiani tranzistorebisaTvis sake-

ti CarTul ia diodebis anodebTan, xol o parxianisaTvis- kaTodebTan. sil iciumis oqsidis maizol irebel i fena warmoadgens maRal omian rezistors, romel ic CarTul ia Casadinarisa da saTaves Soris diodebis paral el urad.



ამგვარად ტრანზისტორი **ნახ.3.8. სავლე ტრანზისტორი p-n გდასავლე ის მარტივია** Seizl eba SevawmoT omme- tris daxmarebiT. gavzomoT p-n gadasavl el is winaroba saketsa da Casadinars da saketsa da saTaves Soris. Tu ტრანზისტორი varგისია, მაSin orive gadasavl el is parametrebi unda iyos diodis parametrebis anal ogiuri: erTi mimarTul ebiT unda hqondes didi winaroba, xol o meore mimarTul ebiT- mcire. Semdeg zomaven winarobas Casadinarsa da saTaves Soris. Oommetrma unda გვიცენოს ტრანზისტორის parametrze damokidebul i raRac winaroba.

МОП ტრანზისტორის Semowmeba ommetriT Zal zed rTul i amocanaa. Ees dakavSirebul ia imasTan, rom saketi izol irebul ia arxidან sil iciumis oqsidis Zal zed Txel i feniT. amIT ganpirobebul ia МОП ტრანზისტორის Zal zed maRal i Sesaval i winaroba, rac mas xdis advil ad dazianeбads mcire statikuri daZabul obis drosac ki.

ფატიურად МОП ტრანზისტორები advil ad Seizl eba gamoviyvanoT mwyobridan msubuqi SexebiTac. Aam mizeziT МОП?- ტრანზისტორები SefuTul ia iseTnair-

ad, rom misi yvel a gadamyvanebi el eqtrul ad aris SeerTebul i. rac Tavidan acil ebs el eqtrodebs Soris statikur daZabul obas.

МОП?- ტრანზისტორები unda Semowmdes dabal vol- tiani ommetriT gansakuTrebul i sifrTxil iT. Dday- enebul i unda iqnes gazomvis udides zRvarze. varგისი МОП?- ტრანზისტორს Casenebul i arxiT gaaCnia saT- avesa Casadinars Soris raRac gamtaroba. amasTanave saketsa da saTaves, saketsa da Casadinars Soris win- aRoba maRal ia. varგის МОП- ტრანზისტორსი induqci- uri arxiT gamomyvanebs Soris el gamtaroba praqtiku- l ad ar arsebobs.

1) მმარTველი p-n გდასავლე იტ სავლე ტრან- zისტორებიანი sqemebis diagnostika. sqemebSi, sadac gamoyenebul ia სავლე ტრანზისტორები, მაTi gamor- Ciლ va sqemi dan rekomendirebul in ar aris. vizual uri daTval ierebis Semdeg, romel sac vatarebT daziane- bul i komponentebis an cudi mirCil vis gamosayene- bl ad, vZomavT Zabvas Casadinarze da saTaveze miwis mimarT.

dazianebis tipiuri ნისანია, Tu Zabva saTaveze daax- l oebiT tol ia kvebis wyaros Zabvisa. es xdeba მაSin, roca saTaveSi gamaval i deni nul is tol ia da amitom ar arsebobs Zabva R_D winarobaze (ნახ.3.9, a). amis mizezi aris erT-erTi qvemoT CamoTvl il i uwesivroba.

- ar aris mirCil ul i R_S winaroba (R_S wredis gawyveta);

uvargisia R_S rezistori an misi winaroba gamo- dis dasaSvebi zRvridan;

- ar aris mirCil ul i R_D winaRoba (R_D wredis gawyveta);

- uvargisia R_D rezistori an misi winaRoba gamodis dasaSveb zRvridan;

- ar aris mirCil ul i saTavis gamomyvani;

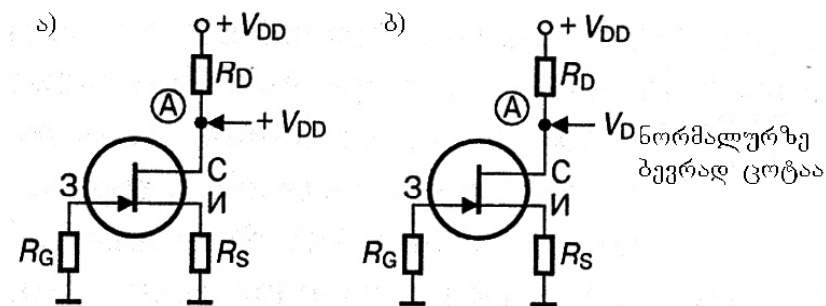
- ar aris mirCil ul i Casadinaris gamomyvani;

- tranzistorebs SigniT Casadinarsa da saTaves Soris aris wyveta.

Ddazianebs tipiuri meore niSania saTaveze Zabvis normal ur mniSvnel obaze mcire mniSvnel oba. (nax.3.9, b) es xdeba maSin, roca saTavis deni aRemateba normal ur mniSvnel obas.Aam dros R_D winaRobaze adgil i aqvs Zabvis did vardnas. Ees SeiZl eba gamowveuli iqnes Semdegi uwesivrobebiT:

- ar aris mirCil ul i R_G winaRoba (gawyvetil ia R_G wredi);

- uvargisia R_G winaRoba an misi mniSvnel oba gamodis dasaSvebi zRvridan;



nax. 3.9. p-n gadasavl el is marTviT savel e tranzistorebze momuSave sqemebis tipiuri araswori muSao-bis reJimi

- ar aris mirCil ul i saketis gamomyvani;

- SigniT tranzistorSi Cawyvetil ia saketis gamomyvani.

zogierTi dazianeba Znel ia gamovavl inoT. magal iTad SeiZl eba moviyvanoT МОП - tranzistori nulovani wanacvl ebiT. Mmis SigniT saketis gawyvetis dros Zabva saket-Casadinoze rCeba igive (0 v). amis gamo saTavis deni ar icvl eba da wanacvl eba normal urad gamoiyureba.

zemoTqmul idan gamomdinare savel e tranzistorebis diagnostika Znel i amocanaa da moiTxovs ufro met gamocdil ebas vidre bipolar arul i tranzistorebi.

m) operaciul i gamaZl ierebl ebis diagnostika. Operaciul i gamaZl ierebl ebi warmoadgenen rTul mowyobil obas, romel sac eqspl uataciis procesSi uCndebaT Sinagani dazianebebi. amasTanave, rogorc aseTi, operaciul i gamaZl ierebl ebi ar eqvemdebarebian Semowmebas. Aamitom Tu operaciul i gamaZl ierebel i gamovi da mwyobridan igi aucil ebl ad unda Seicval os.

Operaciul gamaZl ierebl ian sqemaSi Cveul ebriv monawil eobs ramdenime gareSe komponenti. tipiuri sqema Seicavs Sesaval winaRobas, ukukavSiris rezistors da potenciometrs wanacvl ebis Zabvis kompensacisaTvis. Tu sqema gaiTisa, maSin pirvel rigSi unda Semowmdes gareSe komponentebi. SeiZl eba iyos miurCil avi adgil ebi, gadamwvari komponentebi an komponentebi, romel Ta parametrebi gamosul ia dasaSvebi zRvridan. Tu yvel aferi wesrigSia, maSin unda Semowmdes TviT operaciul i gamaZl ierebl is kontaqtobi.

Bbol os Tu yvel a gasinj ul i el emeti muSaunari-
ania da sqema ar muSaobs, maSin uvargisia TviT oper-
aciul i gamaZI ierebel i da igi unda Seicval os.

qvemoT moyvanil ia operaciul i gamaZI ierebl is
mqone sqemebSi ramdenime tipiuri uwesivroba:

1) kvebis wyaros Zabva. Ees aris pirvel i, saidan-
ac unda daiwyos Semowmeba. Uunda uzrunvel yofil i
iyos kvebis wyaros Sesabamisi ZabviTa da CamiwebiT.
Uunda gvaxsovdes, rom mraival i integral uri sqemebi-
saTvis kvebis Zabvis sidide kritikul ia

2) ukukavSiris wredis gawyveta. Aam dazianebas
mivyavarT gamosaval i signal is ampl itudis SezRud-
vamde, radganac operatiul i gamaZI ierebel i muSaobs
Zabvis gaZI ierebis maqsimal uri koeficientiT (anu
sqema warmoadgens gamaZI ierebel s ukukavSiris gareSe)

3) Caketil i ukukavSiri. Aam SemTxvevaSi signa-
l i gamosasvl el ze imeorebs signal s Sesasvl el ze.

4) Sesaval i rezistoris wredis gawyveta.
Mmainventirebel gamaZI ierebel Si gamosasvl el ze
signal i ar gveqneba, radgan signal i ar gvaqvs Sesas-
vl el ze. Aanu gamaZI ierebel i gamodis Zabvis gamame-
orebl is rol Si. gamaZI ierebel Si gamaZI ierebl is
koeficienti 1-is tol ia da signal i gamosasvl el ze
imeorebs signal s Sesasvl el ze.

**5) potenciometriT arasworad aris daregu-
l irebul i.** Aamas mivyavarT signal is SezRudvamde
an mxol od zevidan, an mxol od qvevidan.

3.3. el eqtrul i wredebis Semowmeba gamorTul i Zabvis dros

el samontaJo samuSaoebis damTavrebiS Semdeg Ses-
amowmebel el eqtrul wredebSi xSirad Tavs iCens
iseTi defeqtebi, rogoricaa SecdomiT (araswori)
SeerTebesi, roml ebmac SeiZI eba gamoiwvios el mowy-
obil obis mwyobridan gamosvl a an momsaxure per-
sonal is dazianeba el eqtrul i deniT, agreTve arasa-
survel i movl enebi. amitom axal i damontaJebul i an
garemontebul i el eqtro danadgari gansakuTrebul i
yuradRebiT unda iqnes Semowmebul i da araviTar
SemTxvevaSi ar unda moxdes Seumowmebel el eqtro dan-
adgarze Zabvis miwodeba.

Eel eqtrowredebis SeiZI eba Semowmdes teqno-
l ogiuri aRWurvil obisa da maT gareSe. Semowmeba
teqno l ogiuri aRWurvil obis gareSe xorciel deba
vizual uri daTval ierebiT. Aamowmeben el eqtromon-
taJis Sesrul ebis Sesabamisobas dokumentaciasTan;
kontaqturi SeerTebis gare mdgomareobas; koroziiisa
da Tburi zemoqmedebis kval s; sal teebis CarTvis sis-
wores el eqtrogamanawil ebel farebSi; kabel ebisa da
sadenebis Cal agebas. Mmagram el eqtrul i wredebis
uxil avi ubnebis Semowmeba vizual uri daTval iereb-
is gziT SeuZI ebel ia.

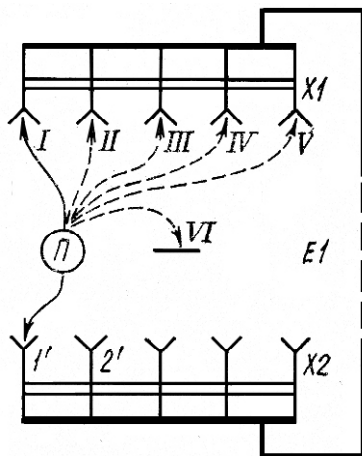
Eel eqtrul i wredebis Semowmeba teqno l ogiuri
saSual ebebis gamoyenebiT SeiZI eba ganxorciel des
uSual o da **Camiwebis** xerxebiT.

uSual o Semowmebas gamoiyeneben im SemTxvevaSi,
roca el eqtrul i wredebis sawyisebi da bol oebi

mdebareoben erTmaneTTan ise axl os, rom erTdrou-
l ad SeiZl eba miuerTdes sasinj is sacecebi.

ganvixil iT magal iTi. davuSvaT saWiroa Semowm-
des el eqtrul i wredis mTI ianoba kabel Si an Cal iCiS
("жггт"), roml is bol oebi ganmxol oebul ia X1 da X2
SemaerTebL ebze (nax. 3.10)

am dros SeerTebis siswore mowmdeba SemaerTeb-
l is kontaktebTan datanil i aRniSvnebiT. sasinj is П
erTi saceci CairTveba kabel is (Cal iCiS) X2 Semaer-
rTebL is 1' kontakTtan, xol o sasinj is meore sal te-
Ti kabel is (Cal iCiS) meore mxares X1 SemaerTebel ze
eZeben Sesabamis I kontakts. Secdomis Tavidan ac-
il ebis mizniT saWiroa sasinj is meore saceci ri-
grigobiT miuverToT X1 SemaerTebL is yvel a kon-
taqts, SemaerTebL is korpusa da E1 kabel is (Cal i-
CiS) ekrans.



nax. 3.10 el eqtrul i
wredibis uSual od
Semowmebis xerxi

aRniSnul i Semowmeba
keTdeba im SemTxvevaSiC ki,
Tu saZebni el eqtrul i
wredi moZebnil i iqna piv-
el cdi danve. Aamgvaradve
eZeben meore, mesame da aS
wredebs.

Camiwebis xerxi gam-
oiyeneba im el eqtrul i
wredibis Sesamowmebl ad,
romel Ta sawyisebi da bo-
l oebi mdebareoben erT-
maneTisagan sakmaod Sors
an sxvadasxva SenobebSi. Aam

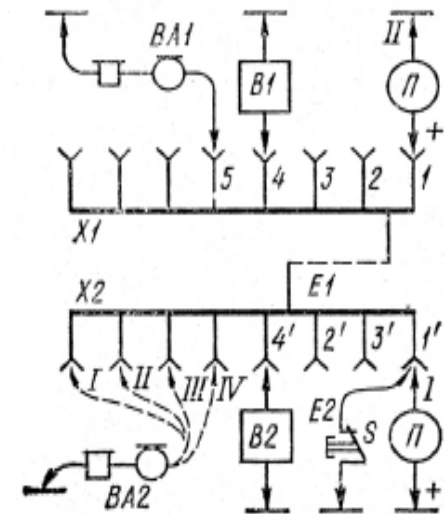
dros Sesamowmebel wredebTan erTad sargebl oben
damxmare wredibiT: Camamiwebel sadenebs, nebi smieri
kabel is ZarRvebs, special urad Cadebul sadenebsa da
Camiwebis sal tebs.

magal iTi: saWiroa Semowmdes kabel is ZarRvebze
datanil i aRniSvnebis siswore (nax. 3.11). am SemTxveva-
Si Semowmebas axorciel ebs ori adamiani, romel Ta
Soris winaswar damyarebul ia satel efono kavSiri.
sal aparako mowyobil oba B1 da B2 CarTul i an Sesam-
owmebel i E1 kabel is ZarRvebiT an cal ke Cadebul i
sadenebiT.

Semowmeba iwyeba droebiTi zRudaris E2 dayenebiT
kabel is erT-erTi mxaris nebi smier erT ZarRvTan.

sasinj is (П) erTi sa-
ceciT exebian kabe-
l is Camiwebul
ZarRvs. amowmeben
damxmare wredis: mi-
wa-Ril aki S-ZarRvi
1' mTI ianobas. Aamas-
Tanave unda Semowm-
des E2 zRudaris
dayenebis siswore
amisaTvis S2 Ril aki
T unda gavwyvi toT
misi wredi da Tva-
l yuri vadevnoT sas-
inj is Cvenebas.

zRudaris E2 da-
yenebis Semdeg kabe-



nax. 3.11. el eqtrul i wredis
Semowmeba Camiwebis
xerxiT

I is meore mxareze iwyeben Camiwebul i ZarRvis Ziebas sasinj is saceciT. Camiwebul i ZarRvis povnis Semdeg an CavrToT da gamovrToT S RiI aki an gamovxsnaT da ise mi vaerToT E2 zRudari raTa davrwmundeT sasinj is Cvenebis sisworeSi da damatebiTi E2 zRudareb- is ar arsebobasi. winaaRmdeg SemTxvevaSi SeiZl eba aRmoCndes, rom sasinj is Cveneba gamowveul ia kabel is romel ime ZarRvis CamiwebiT E2 zRudar isagan damoukidebl ad.

Ppirvel i wredis Semowmebis Semdeg E2 zRudars daayeneben meore wredze da gaimeoreben aRweril moqmedebas.

3.4. el eqtrul i wredibus Semowmeba Zabvis qveS

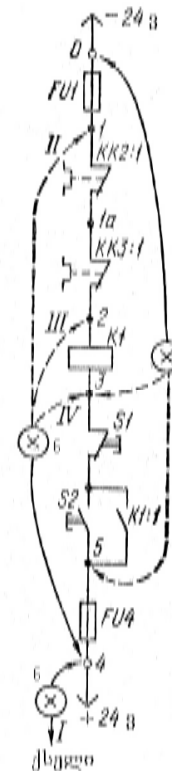
Eel eqtrul i wredi SeiZl eba Semowmdes masze muSa an sakontrol o Zabvis miwodebiT. Nnebis mier SemTxvevaSi gamoyenebul unda iqnes teqniki aRWurvi- l obis saSual ebebi: Zabvis maCvenebl ebi, mul timetre- bi, marwuxebi da sxva. Zabvis maCvenebl ad SeiZl eba gamoyenebul i iqnes varvarebis naTura, roml is var- gisoba winaswar Semowmebul i unda iqnes Zabvis qveS myof dengamtar nawil ebze. naTura moTavsebul i unda iqnes armaturaSi, radgan Semowmebis dros SeiZl eba gaskdes da momsaxure personal ma mi iRos travma.

ganvixil oT magal iTi. saWiroa Semowmdes wre- di nax. 3.12-ze mocemul sqemaSi, romel zec montaJis dasrul ebis Semdeg ar miwodeba Zabva. am SemTxvevaSi dasawyisSi unda Semowmdes sqemebis kvebis wredi maT- Si mokl ed SerTvis ar arsebobaze. amisaTvis kvebis

miwodebis win saWiroa erTi pol usis mimdevrobiT CavrToT Zabvis maCvenebl i ("n"), xol o Zabvis maCvenebl is meore bol o SevaerToT qsel Tan.

Tu aRniSnul i xerxiT sqemis Semowmebisas kvebis wyaros wredSi ar aris mokl ed SerTva, maSin obi eqtze Zabvis miwodebisas masTan mimdevrobiT SeerTebul i "n" naTura ainTeba arasrul i varvarebiT da am SemTx- vevaSi sqemas uSual od SeiZl eba miwawodoT Zabva. Mmok-

I ed SerTvis arsebobis SemTx- vevaSi naTura ainTeba srul i sikaSkaSiT da am SemTxvevaSi ar SeiZl eba sqemaze Zabvis miwode- ba da unda veZeboT mokl ed SerTvis mizezi. Tu el eqtru- l i wredibus Semowmebis win sqema muSaobda datvirTvisa da mokl ed SerTvis gareSe, maSin SeiZl eba Zabva miwawodoT wre- dis naTuris CaurTvel ad. Kkve- bis wredSi naTuris mimdevro- biT CarTvas aqvs Tavisi dadeb- iTi Tvi seba, kerZod wredSi gam- aval i deni SezRudul ia naTur- is wi naRobi T. Uunda aRini Snos, rom Zabvis qveS wredibus Semow- mebis dros gamoyenebul i unda iqnes mxol od varvara naTura, radganac I uminescenciuri naTuris naTebis intensivoba mokl ed SerTvis dros da mis



nax. 3.12. el eqtru- l i wredibus Semow- meba Zabvis qveS

gareSe vizual urad erTmaneTisgan ar gansxvavdeba.

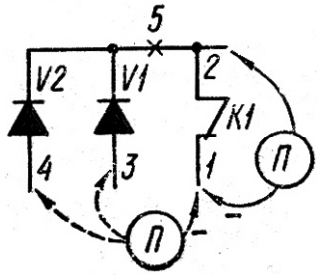
SevamowmoT wredis darCenil i. nawil i Zabvis qveS wredebis Semowmebis dros gamoiyeneba wredis el ementis iseTi Tviseba, rogoricaa el ementze Zabvis vardnis damokidebul eba mis winaRobaze. kontaktebze, mcvel ebze da maTgvar el ementebze Zabvis vardna praqtikul ad nul is tol ia. Yyovel SemTxvevaSi ori, sami rigiT nakl ebia Zabvis vardnaze iseT el ementebze rogoricaa: rel esa da kontaktoris koWebi, rezistorebi, naTurebi da datvirTvis sxva el ementebi.

aqedan gamomdinare SevamowmoT nax. 3.12-ze moyvanil i wredis el ementebi. Ppirvel rigSi vamowmebT wredis mTI ianobas: 0 wertil i-mcvel i F1-kontaqti KK2:1-kontaqti KK3:1 wertil i2. amisaTvis indikatoris erT sacecs mivuerTebY wertil s 4, xol o meore sacecs wertil Tan1. (pozicia II). vargisi F1 mcvel is SemTxvevaSi naTura ainTeba mTI iani varvarebiT. naTuris varvareba mowmobs 1 da 4 sakontrol o wertil ebs Soris Zabvis arsebobs. Aamis Semdeg indikatoris saceci 1 mdgomareobidan gadmovitanoT 1a mdgomareobaSi, xol o Semdeg 2 mdgomareobaSi. (pozicia III). amiT vamowmebT KK2:1 da KK3:1 kontaktebis wesivrobas. Mmcvel s SevamowmebT anal ogiurad. DdavrwmundiT ra Semowmebul i wredis vargisobaSi gadavdivarT Semdeg wredze: wertil i 4-mcvel i F4-kontaqti K1:1- masTan paral el urad CarTul i Ril aki S2-Ril aki S1-wertil i 3. am SemTxvevaSi indikatoris erTi saceci unda CavrToT 0 wertil Tan. Tu meore saceciT SevexebiT wertil s 5, maSin 0-5 wertil ebs Soris Zabvis arsebobiT vamowmebT F4 vargisobas. Tu S2 Ril akze

TiTis davaWerT da Sesamowmebel wredSi yvel a el ementi wesrigSia, wertil Si 3 wertil i 0-is mimarT unda iyos Zabva da unda CairTos K1 kontakti, roml is CarTva gamoiwvevs K1:1 bl ok kontaktis CarTvas da S2 Ril akze TiTis aRebis Semdeg K1 kontakti darCeba CarTul i. Aamgvarad or sxvadasxa wertil s Soris CarTul i naTuriani Zabvis indikatoris saSual ebiT Semowmebul i iqna mTel i wredis wesivrul oba.

3.5. Secdomebi el eqtrul i wredis Semowmebisas

Eel eqtrodanadgarebis el eqtrul i sqemebis Semowmeba zogjer garTul ebul ia imiT, rom ama Tu im el eqtrul i wredis Sesaxeb informacia SeiZl eba damaxinj des. zogjer Tvl ian, rom damaxinj eba gamowveul ia el eqtrul i sqemebis Semowmebis xerxebis SecdomiT arCeviT (uSual o CamiwebiT). magal iTad Tvl ian, rom momij nave qvesadgurebSi Camiwebis magistral ebis potencial ebis gansxvavebul obis gamo Camiwebis xerxebis gamoyeneba dauSvebel ia. aseTi azri mcdaria, radgan Tu Sesamowmebel i wredi ar imyofeba Zabvis qveS, maSin masSi ar gadis sxva deni garda sasinj is wyaros mier Seqmnil i denisa da Sesamowmebel i wredis bol oebze ar aRizvrebapotencial Ta sxvaoba. aseT pirobebSi TviT gasinj vis xerxebis ar SeuZl iaT daamaxinj os el eqtrul i wredebis mdgomareobis Sesaxeb informacia. Aamitom Secdomis mizezi SeiZl eba iyos an Sesamowmebel i wredis Suntireba sxva wredebis mier an damatebiTi el eqtrul i wredebis warmoqmna.



nax. 3.13 wredis warmomna diodebis gavli iT

sqemis fragmenti moyvanil ia nax. 3.13-ze

CavrToT sasinj i Π, ise rogorc naCvenebia nax. 3.13-ze SevaxebT ra sasinj is sacecs 2 sxva danarCen gamomyvanebs, davinaxavT rom yvel a samive SemTxvevaSi sasinj is Cveneba erTnairia. Ees miuTitebs imaze, rom an arsebobs defeqti TviTon sqemaSi, an Cveni araswori moqmedebiT SevitaneT Secdoma. (vTvl iT, rom sasinj is vargisoba winaswar iqna Semowmebul i).

ra unda gavakeToT imisaTvis rom ganvsazRvroT sasinj is erTnairi Cvenebis mizezi.

CavTval oT rom sqema vargisia, maSin defeqti gamowveul ia Cveni araswori moqmedebiT, amitom mis mosazebnad ganvixil oT wredi, romel ic warmoiqmna sasinj is CarTvis dros.

sasinj is CarTvisas 1-3 gamomyvanebs Soris ikvreba wredi: sasinj is (-) saceci- wertil i1-kontaqti K- wertil i2-diodi1-wertil i3-saceci (+).

sasinj i gviCvenebis, rom wredi 1-3 Caketil ia da Sesabamisad gamomyvanebi 1 da 3 ar SeiZl eba erTmaneTisagan gansxvavdebodnen. yuradReba mi vaqci oT imas,

magal iTi 1. damatebiTi wredis warmomna diodis winaRobis gavli iT Ppirdapiri mimaRTul ebiT.

davuSvaT saWiroa iseTi el eqtrodanadgaris gamomyvanebis numeraciis gansazRvra, romel ic Seicavs naxevargamtarul diodebs.

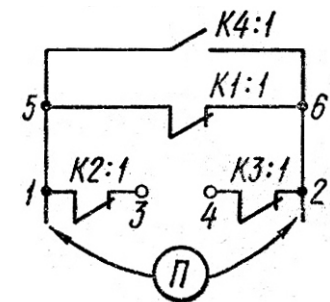
rom wredSi CarTul i diodi, roml is gamtaroba damokidebul ia masze modebul i Zabvis pol arobaze. gada vaadgil oT sasinj is sacecebi ise, rom gamomyvanebTan 1 CarTul i iyos (-) saceci. Aam SemTxvevaSi sasinj is Cveneba nul is tol ia, rac Seesabameba gaTiSul wreds. Aamitom gamomyvanebi 1-3 SeiZl eba ganvasxvavoT erTmaneTisgan. wredis 1-3 gamomyvanebze naTqvami SeiZl eba mi vakuTvnoT wredis 1-4 gamomyvanebs.

zemoTqmul idan gamomdinareobs, rom naxevargamtarul i diodebiani wredobis Semowmebis dros yuradReba unda mi vaqci oT sasinj is sacecebis pol arobas.

magal iTi 2. wredis warmomna gamomRTvel i kontaqtis gavli iT.

davuSvaT, rel ur-kontaqturi sqemis CarTvis win saWiroa SevmoT 1-2 wertil ebs Soris CarTul i paral el uri wredi (nax. 3.14), romel Ta Soris aris ori gamomRTvel i kontaqtis Semcvel i wredi. saxel - dobr wredi 5-6; gamomyvani1-kontaqti K1:1-gamomyvani-2 wredi 1-2 gamomyvani 1- kontaqti K2:1-kontaqti K3:1-gamomyvani 2.

movxsnaT Zabva sqemi dan da sasinj i CavrToT 1-2 gamomyvanebTan. sasinj i gviCvenebis rom am gamomyvanebs Soris wredi Caketil ia da gamarTul mdgomareobaSi. CavrTavT danadgaris muSaobaSi. Aam dros gamomJRavndeba defeqti, romel ic mdgomare-



nax. 3.14. wredis Suntireba gamomRTvel i kontaqt iT

obs imaSi, rom erT-erT reJimSi 1 da 2 wertil ebs Soris wredi ar irTveba, miuxedavad imisa, rom swori muSaobisaTvis igi Caketil i unda iyos. Tu davukvirdebiT sqemebs SeiZl eba davinaxoT, rom wredis Caketva xdeba kontaktebiT K2 da K3. Aamitom vamowmebT maT wesivrobas. Mmoxsnil i Zabvis dros CavrTavT sasinj s uSual od K2:1 kontakts 1-3 gamomyvanebTan da K3:1 kontakts 4-2 gamomyvanebTan. sasinj is Cveneba gveubneba, rom kontaktebi wesrigSia, magram wredi 1 da 2 gamomyvanebs Soris ar ikvreba. raSia mizezi?

radganac wredis K2 da K3 kontaktebi wesrigSia, amitom vamowmebT 1 da 2 wertil ebs Soris arsebobs Tu ara danadgaris muSaobis dros wredi, ristvisac 3 da 4 wertil ebs Soris vrTavT sasinj s, romel ic gvatyobinebs wredis gawyvetis Sesaxeb. AamasTanave Tu SevamowmebT wreds 3 da 4 wertil ebs Soris gamortul i Zabvis dros, maSin sasinj i gviCvenebs Caketil wreds. aseTi movl enis asaxsnel ad mivmarToT nax. 3.14-s

1 da 2 gamomyvanebTan mierTebul ia sami paral el uri wredi, romel Tagan ori warmoqmnil ia gamTisvel i kontaktebiT da roml ebic rel es udeno mdgomareobaSi yofnis dros Caketil ia. radganac 1-2 da 5-6 wredebi CarTul ia paral el urad, amitom sakmarisia Caketil i iyos erTi maTgani, rom 1-2 gamomyvanebTan mierTebisas sasinj ma gviCvenos, rom maT Soris wredi Caketil ia. sasinj is 3-4 gamomyvanebTan mierTeba ar izl eva saSual ebas vipovoT wredis gawyveta. radgan am dros iqmneba Caketil i wredi: sasinj is saceci_gamomyvani3-kontaqti K2-kontaqti K1-gamomyvani2-kontaqti3-sasinj is saceci. Aamgvarad, aRmoCnda, rom

Catarebul i Semowmeba ar gvaZl evs saSual ebas gavakeToT daskvna yvel a paral el uri wredis wesivrobis Sesaxeb da saWiroa SevamowmoT es wredebi cal -cal ke. Aamitom saWiroa 1-2 wertil ebs Soris wredi SevamowmoT orjer. Ppirvel ad gavTisoT K1 kontakti, maSin sasinj i gvaZl evs saSual ebas SevamowmoT mxol od is wredi, romel Sic Sedian K2 da K3 kontaktebi. Mmeore SemTxvevaSi gavTisoT K2 kontakti (an K3) am SemTxvevaSi mowmdeba wredi 1 wertil idan 2 wertil amde K1 kontakts gavliT.

aRniSnul i xerxiT warmoebul i Semowmeba gviCvenebs, rom wreds, romel Sic Sedian K2 da K3 kontaktebi gawyvetil ia.

aqedan gamomdinareobs, rom zogierT SemTxvevaSi el eqtrul i wredibus Semowmebias saWiroa Sesamowmebel i wredis maSuntirebel i kontaktebis izul ebiTi gamortva an gaTiSva.

3.6. meoradi komutaciis sqemebis Semowmeba Zabvis qveS

ganvixil oT operatiul i wredibus (marTvis, dacvis, avtomatikis, signal izaciis, bl okirebis) Semowmebis sakiTxebi Zabvis qveS.

Zabvis qveS sqemebis Semowmeba swarmoebs gamortul i Zal ovani wredis dros el eqtrul i wredibus montajis sisworis Semowmebis, aparaturis gawyobisa da izolaciis gamocdis Semdeg. winaswar Semowmebul i unda iyos yvel a sakontaqto SeerTebebi kl emebsa da aparatebze. agreTve mowodebul i Zabvis pol aroba.

operatiul i Zabvis pirvel i mowodebis dros unda davrwundeT, rom sqemaSi ar aris mokl ed SerTva. amisaTvis yendeba mxol od erTi mcvel i, xol o meores adgil ze CairTveba sakontrol o naTura. Tu wredSi mokl ed SerTva ar aris naTura ar ainTeba an ainTeba arasrul i varvarebiT. naTuras unda gaaCndes mcire Sinagani winaRoba (simZI avre unda iyos 150-200vt)

mcire winaRobis rel es koWaze didi winaRobis naTuris gavl iT Zabvis miwodebis dros naTuris varvareba srul i varvarebisgan mcired gansxvavdeba. Operatiul i Zabvis miwodebis Semdeg mowmdeba amuSavebis mkafioba rel esa da sqemis sxva el ementebis cal keul i kontaktebis muSaobis mimdevroba wredis muSaobis yvel a reJimSi.

dacvis, signal izaciis, avtomatikis sqemebis muSaoba mowmdeba mowyobil obis avariul i da aranormal uri reJimebis imitaci iT dacvis rel eebis, teqno logiuri gadamwodebisa da sxvaTa kontaktebis xel iT Caketvis gziT.

Zabvis qveS sqemis Semowmebis dros SesaZI ebel ia sqemis cal keul i el ementebisa da kvanZis muSaobaSi mtyunebis SemTxvevebi, Mmiuxedavad imisa rom dazianebebi da darRvevebi sqemaSi mraval gvaria. isini SeiZI eba mivakuTvnoT dazianebis Sedeg saxeebs: a) wredis gawyveta; b) mokl ed SerTva; g) miwasTan SeerTeba; d) Semovl iTi wredis arseboba; e) sqemaSi Semaval i cal keul i parametrebis uwesivroba an parametrebis Seusabamoba sqemis moTxovnebTan.

yvel a es defeqti maSinve ar SeimCneva da SeiZI eba hqondes sqemis Tvi sebebi dan gamomdinare sxvadasxvag-

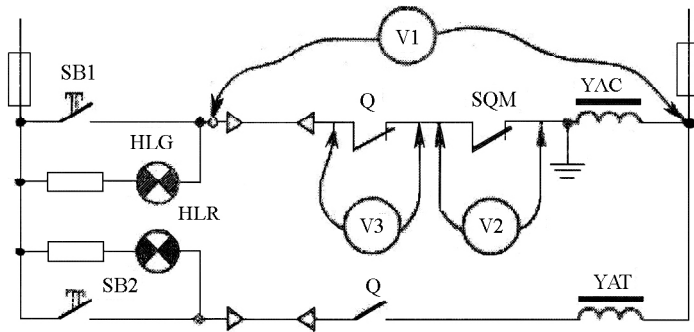
vari gareSe gamovl inebani. Mmxol od sqemis dawvril ebiTi analizi, Semowmebis mofiqrebul i gegma iZI eva saSual ebas swrafad da efeqturad gamovavlinoT da aRmovfxvraT dazianebebi. radganac sqemaSi TiToeul i dazianeba moITxovs special ur analizs, dazianebul i el ementis gansazRvris meTodika ar SeiZI eba warmovidginoT saerTo saxel mZRvanel os saxiT, romel ic gamosayenebel i iqneboda yvel a SesaZl o SemTxvevebisatvis.

Nnax. 3.15-ze moyvanil ia zambariani amZravis mqone zeTiani amomrTvel is marTvis principul i sqema.

magal iTis saxiT ganvixil oT umartivesi dazianebebis SemTxveva: darRveul ia Q amomrTvel is bl ok-kontaktis wredi. Ddazianebis gareSe niSania-ar inTeba HLG naTura. Ddazianebis gamosavl enad saWiroa:

1. SevamowmoT mcvel is vargisianoba;
2. SevamowmoT Zabva HLG naTuraze 3 (Tu naTuraze da damatebiT winaRobaze ar aris, maSin savaraudod gawyvetil ia amomrTvel is wredi);
3. SevamowmoT sasignal o naTuris Zafi;
4. SevamowmoT wredis mTl ianoba Q da SQM kontaktebze maTze paral el urad vol tmetris rig-rigobit CarTviT. Tu V_2 vol tmetris Cveneba nul is tolia, maSin SQM kontaktebi Caketil ia.

SQM da Q kontaktebTan paral el urad CarTul i V_1 vol tmetris Cveneba mowmobs wredis gawyvetas am kontaktebze operatiul i wredebis Semowmebis dros unda visargebl oT maRal omiani vol tmetrit, radganac dabal omianma vol tmetrma SeiZI eba migviyanos sqemis aparat is mcdar amuSavebasTan.



nax. 3.15. zambariani zeTiani amomrTvel is marTvis principul i sqema

ganxil ul sqemaSi (CarTvis wredis wesivrobis dros) vol tmetris magier sakontrol o naTuris damatebiT winaRobiani sasignal o HLG naTurasTan paral e- l urad CarTvam SeiZl eba gamoiwvios YAS CamrTvel i koWis amuSaveba da amomrTvel is TviTneburad CarTva. varvaris naTurebi SeiZl eba gamoviyoT mxol od im SemTxvevaSi, rodesac mowmdeba mcvel ebis mTl ianoba da wredis mokl ed SerTva.

Tavi IV. Eel eqtrul i aparatebi da maTi diagnostika

Eel eqtrul i aparati warmoadgens mowyobil obas, romel ic gamoiyeneba el eqtro momxmarebl ebis, kvebis wyaroebisa da arael eqtrul i procesebis el eqtro energiit marTvisaTvis.

zogadi sawarmoo daniSnul ebis el eqtrul i aparatebi, el eqtro-sayofacxovrebo aparatebi da mowyobil obebi gamoSvebul ia 1 kv. Zabvamde, xol o maRal i Zabvisa-1kv. zemoT. 1kv-mde Zabvis aparatebi iyofian: xel is, distanciur, dacvis aparatebad da gadamwodebad.

4.1. el eqtrul i aparatebis kl asifikacia

el eqtrul i aparatebis kl asifikacia xdeba sxvadasxva niSnis mixedviT: 1. daniSnul ebis(aparatis ZiriTadi Sesasrul ebel i funqcia); 2. moqmedebis principis; 3. samuSao xasiaTis; 4. Ddenis saxeobis (mudmivi da cvl adi); 5. denis sididis; 6. Zabvis sididis (1 kv-mde da 1 kv zeviT); 7. Sesrul ebis; 8.Ddacvis xarisxis; 9. konstruqciis.

Tavis mxriv ZiriTadi Sesasrul ebel i funqciis mixedviT el eqtrul i aparatebi iyofa: marTvis, dacvisa da makontrol ebel aparatebad.

1. marTvis aparatebis daniSnul ebaa el eqtrul i manqanebis, Carxebis, meqanizmebis gaSveba, reversireba, damuxruWeba, siCqaris, denisa da Zabvis regulireba, el eqtromomargebis sistemebSi el eqtroenergiis momxmarebl is gaSveba da parametrebis regulireba. am aparatebis ZiriTad funqcias miekuTvneba

agretve el eqtroamZravebisa da el eqtroenergiis sxva momxmarebl ebi marTva, gansakuTrebiT xSiri CarTva-gamorTvis dros. marTvis aparatebs miekuTvneba **xel iT marTvis aparatebi** - Camrazebi, universal uri gadamrTvel ebi, kontrol erebi, komandokontrol erebi, paketuri amomrTvel ebi da gadamrTvel ebi, reostatebi da sxva. **distanciuri marTvis aparatebi** - el eqtromagnituri rel eebi, magnituri gamSvebebi kontaktoerebi da sxva.

2. dacvis aparatebi gamoiyeneba el eqtrul i wredebis komutaciis, el eqtrowredebisa da el eqtromowyobil obebis gadatvirTvis, pikuri da mokl ed SerTvis denebisagan dasacavad.

Ddacvis aparatebs miekuTvneba dnobadi mcvel ebi, Tburi da denis rel eebi, avtomaturi amomrTvel ebi da sxva.

3. makontrol ebel i aparatebis daniSnul ebaa mocemul i el eqtrul i an arael eqtrul i aparatebis kontrol i. aparatebis am j gufs miekuTvneba gadamwodebi. **gadamwodebi** el eqtrul an arael eqtrul sidides gardaqmnian da gamoscemen informacias el eqtrul i signal is saxiT. Aam saxis aparatebs miekuTvneba: denis, wnevis, temperaturis, mdgomareobis, donis da foto gadamwodebi; agreTve denis, Zabvis, drois, sicqaris rel eebi.

4. moqmedebis principis mixedviT el eqtrul i aparatebi iyofa maTze moqmedi impul sebis xasiaTis mixedviT, gamomdinare im fizikuri movl enebidan romel zec dafuznebul ia maTi moqmedebis principi. yvel aze ufro gavrcel ebul ia Semdegi kategoriebi:

a) sakomutacio el eqtrul i aparatebi. Ggamoiyeneba kontaktebis saSual ebiT el eqtrul i wredebis CarTva-gamorTvis, erTi kontaktidan meore kontakqtze denis gadasvl isa da el eqtrul i wredebis gawyvetisaTvis (denmkveTebi, gadamrTvel ebi);

b) el eqtromagnituri el eqtrul aparatebi. maTi moqmedebis principi dafuznebul ia aparatis muSaobis dros arZrul el eqtromagnitur Zal aze (kontaktoerebi, rel eebi);

g) induqciuri el eqtrul i aparatebi, romel - Ta moqmedebis principi dafuznebul ia denis da magnituri vel is urTierTqmedebaze (inducyuri rel e);

d) induqciurobis koWebi (reaqtorebi, gaj erebis drosel ebi);

muSaobis xasiaTis mixedviT el eqtroaparetebs ganasxvaveben im wredis reJimi dan gamomdinare romel - Sic igi aris dayenebul i: 1.xangrZl ivad momuSave aparatebi; 2. muSaobis xanmokl e reJimSi momuSave; 3. datvirTvis xanmokl e ganmeorebiT reJimSi momuSave.

saerTo moTxovnebi romel sac unda akmayofil ebdes el eqtroaparetebi aris: maTi mowyobil obisa da mom-saxureobis simartive, ekonomiuropa (mci re gabaritebi da wona), ZviradRirebul i masal ebi Semcvel obis minimal uri raodenoba. Tanamedrove el eqtroteqnikuri mowyobil obebis sqemebSi el eqtro aparatebs unda gaaCndeT maRal i mgrZnobiaroba, swrafqmedeba da universal oba, maRal i meqanikuri da el eqtrul i cveTamedegoba, dengamtari el ementebis temperaturam ar unda gadaaWarbos dasaSveb zRvars, izol acia gaangariSebul i unda iqnes SesaZl o gadaZabvebze.

Eel eqroteqnikuri mowyobil obebis muSaobis reJimebi iyofa: nominal ur, normal ur da avariul reJimebad.

Nnominal uri reJimis dros el eqtrul i wre-dis el ementi muSaobs teqnikur pasportSi denis, Zab-visa da simZl avris naCvenebi mniSvnel obis dros, rac ekonomiuobisa da saimedobis Tval sazrisiT Seesabameba muSaobis ufro momgebian pirobebs.

Nnormal uri reJimis dros aparatis eqspl uata-cia xdeba nominal urTan SedarebiT mcired gansx-vavebul parametrebiT

Aavariul i reJimi iseTi reJimia, roca denis, Zab-vis, simZl avris mniSvnel obebi nominal urs aRemateba orjer da metjer. Aam SemTxvevaSi obieqti unda iyos gaTisuli. Aavariul reJims miekuTvneba mokled SerTvisa da gadatvirTvis denebis gavl a wredSi, agreTve qsel Si Zabvis daweva

imediano - es aris eqspl uataciis mTel i drois ganmavl obaSi aparatis Seufferxebeli muSaoba.

4.2. xel iT marTvis aparatebi

a) Camrazebi warmoadgenen xel iT marTvis umar-tives aparatebs, roml ebic gamoiyeneba cvl adi denis 660 v da mudmivi denis 440 v Zabvamde el eqtrodanad-garebis CarTva-gamortvisaTvis.

Ppol usebis mixedviT Camrazebi iyofa erT,or da sam pol usianad,marTvis mixedviT: central uri da gverdiTi saxel uriT,xol o SeerTebis mixedviT: pan-el ze wina da ukana SeerTebiT. central ur saxel uri-ani Camrazebi gamoiyeneba udeno el eqtrul wredebis



nax. 4.1. Camrazebi

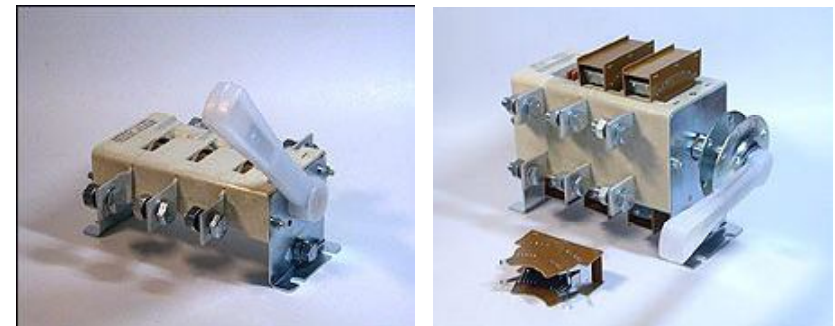
gasaTisad,xol o gverdiT saxel uriani Camrazebi - datvirTvis qveS myofi wredebis gasaTisad.

zogierTi saxis Camrazi naCvenebia nax. 4.1-ze.

central ur saxel uriani Camrazebi gamoSvebu- l ia rkal mqrobi mowyobil obis gareSe, bol o gver- diT saxel uriani-rkal mqrobi mowyobil obiT.

gamortvis dros danebis gadnobis Tavidan ac- il ebis mizniT Camrazebi mzaddeba naperwkal da rkal m- qrobi kontaktebiT. naperwkal mqrobi kontaktebi, rom- l iTac arWurvil ia danebi gamortvis dros tuCebidan gamodian zambarebis moqmedebiT

nax. 4.2-ze naCvenebia amomrTvel -ganmamxol oebli ebi.



nax. 4.2. amomrTvel -ganmamxol oebli ebi

zogierT SemTxvevaSi Camrazebi SeTavsebul ia mcvel ebTan da es mcvel ebi gamoyenebul ia danebad. aseTi konstrukcia saSual ebas iZl eva Camrazma Seasrul os dacvisa da komutaciis funqcia.

b) Ppaketuri amomrTvel ebi da gadamrTvel ebi. Ppaketuri amomrTvel ebi gamoiyeneba cvl adi 380 v Zabvamde da 60 a denamde da mudmivi 220v Zabvamde da 100 a denamde. Ppaketuri amomrTvel ebi da gadamrTvel ebi CamrazebTan SedarebiT ufro kompaqturia isini montaJdeba iseTnairad rom panel ze gamodis mxol od saxel uri, rac uzrunvel yofs momsaxure personal is usafrTxoebas. Ppaketuri gadamrTvel i naCveneblia nax. 4.3-ze.

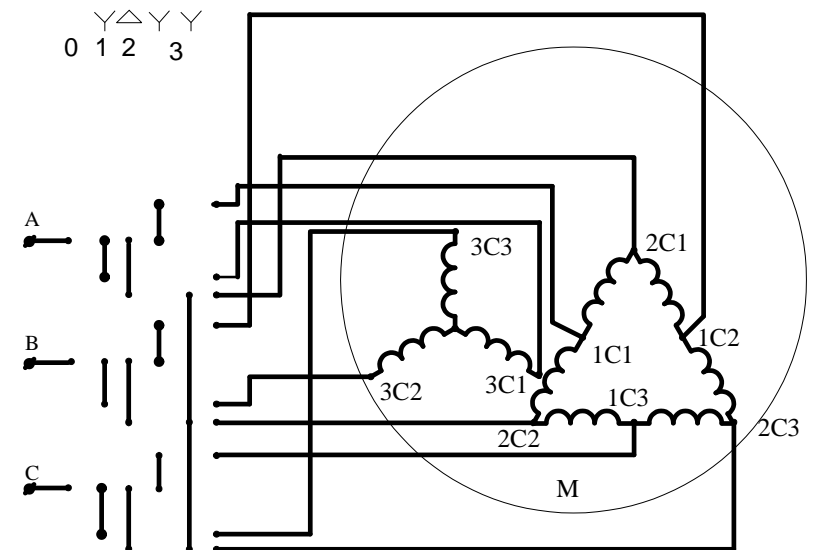
Ppaketuri gadamrTvel is saxel uris 90° iT Semo-brunebisas SegviZl ia CavrToT an gamovrToT el .danadgari. saxel uris 4 mdgomareobidan ori Seesabameba CarTul da ori gamorTul mdgomareobas.



nax. 4.3. paketuri amomrTvel i

Ppaketur gadamrTvel Si mxol od erTi mdebareoba Seesabameba el eqtro danadgariis gamorTul mdgomareobas, xol o danarCeni sami -sxvadasxva wesiT CarTul s. Nnax. 4.4-ze naCveneblia sam siCqariani Zravas paketuri gadamrTvel iT CarTvis sqema. oTx pozician paketur gadamrTvel s aqvs eqvsi uZravi kontakტი. erTi pozicia (0) Seesabameba Zravis gamorTul mdgomareobas. Zravis statorSi Cal agebul ia ori gragnil i. erTi gragnil i SeerTebul ia varskvl avad, xol o meore SeuZl ia gadairTos samkuTxedi dan ormag varskvl avze.

sqemis mixedviT saxel uris 1 mdgomareobaSi Zrava SeerTebul ia qsel is kl emebTan 3C1, 3C2 da 3C3 –



nax. 4.4. sam siCqariani el eqtro Zravas paketuri gadamrTvel iT CarTvis sqema

Tan.Zravas statorSi iqmneba mbrunavi magnituri vel i sami wyvil i pol usiT (2P=3). am dros Zravis sin-qronul i brunvis siCqare

$$n = \frac{60f}{2p} = \frac{60 \cdot 50}{3} = 1000 \text{ br /wT,}$$

sadac $f = 50$ hc qsel is sixSirea

gadamrTvel is marj vena kl emebis marcxenasTan SeerTebas ucveneben wertil ebi xazebiT, romel Ta vertikal ze naCvenebia gadamrTvel is saxel uris mdgomareobis Sesabamisi cifrebi.

gadamrTvel is saxel uris 1 mdgomareobaSi marcxena zeda kl ema SeerTebul ia Zravas 3C1 kl emasTan, marcxena Sua kl ema - 3C2- Tan, xol o marcxena qveda kl ema -3C3 kl emasTan saxel uris 3 mdgomareobaSi gadamrTvel is marcxena kl emebis Zravas 1C1, 1C2 da 1C3 kl emasTan SeerTebiT xdeba 2C1, 2C2 da 2C3 kl emebis erTmaneTTan SeerTeba. amiT ganpirobepul ia Zravas gragnil ebis SeerTeba ormag varskvl avad da warmoiqmneba pol usebis erTi (2p=1) wyvil i, ris gamoc Zravas siCqare $n=3000$ br/wT.

saxel uris 2 mdgomareobaSi marcxena zeda kl ema uerTdeba Zravas 2C1 kl emas, Sua marcxena kl ema- 2C2-s, xol o qveda marcxena- kl ema= 2C3-s. am dros Zrava CairTveba samkuTxedad da iqneba pol usebi ori wyvil i (2p=2) da Zravas siCqare $n=1500$ br/wT.

samfaza paketuri gadamrTvel ebi Camrazebisagan gansxvavdebi an imiT, rom moZrav kontaktebs (danebs) aqvT ara erTi aramed ori Caketil i mdgomareoba. Ddanebi SeiZl eba CairTos sami marj vena da sami marcx-

ena uZravi kontaktebiT. aseTi gadamrTvel ebi gamoiyeneba samfaza Zravas CairTvisa da brunvis mimarTul ebis Secvl isaTvis (reversirebisaTvis).

g) Ril akebi. Ril akebis daniSnul ebaa 660 v Zabvamde da 50 hc cvl adi denis el eqtrul wredebSi



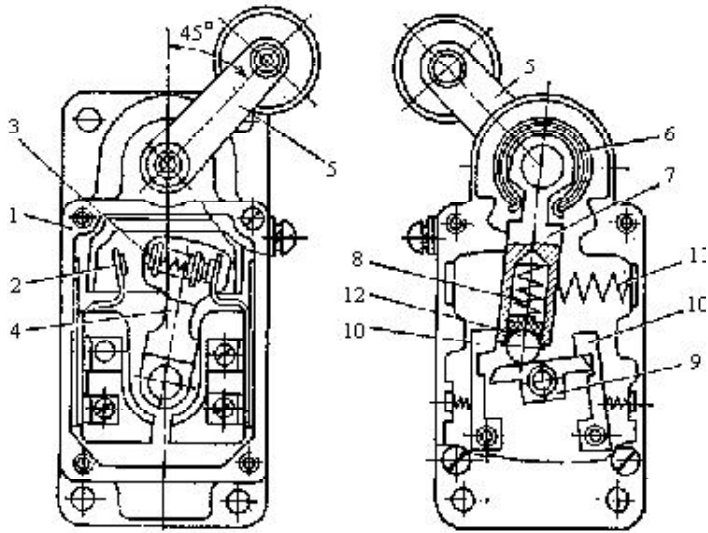
nax. 4.5. Ril akebi

magnituri gamSvebebis, kontaktoresisa da avtomatikis rel eebis operatiul i marTva.

nax. 4.5-ze mocemul ia sxvadasxva saxis Ril akebi.

mocemul i Ril akebi gamoiyeneba amwe-meqanizmebis marTvis wredebSi. Ril akebis ZiriTad dazianebad iTvl eba meqanikuri dazianeba, gacveTil i kontaktebi da cudi kontakti sadenebis mierTebis adgil ebSi.

d) sagzao da sabol oo amomrTvel ebi gamoiyeneba meqanizmebis zusti gaCerebis uzrunvel yofis mizniT, radganac zusti gaCereba miirweva el eqtroZravas dabal i brunvis siCqareze gadayvaniT, ami tom sabol oo amomrTvel is arCevis dros upiratesoba eniWebakontaktebis momental uri gaTisvis unaris mqone amomrTvel ebs. Nnax. 4.6-ze Wril Si moyvanil ia sabol oo amomrTvel ebi kontaktebis momental uri gaTisvit (BK-200Г da BK-300Г)



nax. 4.6. BK-200Г da BK-300Г tipis sabol oo amomrTvel is Wrili

korpusze damagrebul ia uZravi kontaktebi 2, xol o moZravi kontaktebi damagrebul ia berketze 4. Kkontaktebis gadarTva xorciel deba amZravi berketis 5 mobrunebiT, romel ic zambaris 6 saSual ebiT SeerTebul ia samarTTan 7. amZravi berketebis mobrunebis dros zambaras 8 moqmedebis Zal a gadaecema burTuli as 12 da Tamasis 9, romel ic xistad dakavSirebul ia berketTan 4 myisierad mobrundeba da ganTavisufli ebs saketela 10. Aam dros gamomrTvel is kontaktebi gadi iTveba. Ggarda zemoT moyvanil i amomrTvel ebisa nax 4.7-ze mocemul ia sxva saxis amomrTvel ebi.

ВПК-2110 tipis amomrTvel i xasiaTdeba sawyis mdgomareobaSi TviTdabrunebiT.



a) ВПК-15К21; b) ВПК-2110; 2111; 2112; g) ВП-19М21

zemoT aRniSnul ma sagzao amomrTvel ebma farTo gamoyeneba hpoves. isini xasiaTdebian simartiviTa da siiafiT. zogierTi maTgani xasiaTdeba sakmao sizustiT, magram am aparatebs gaaCniaT rigi uaryofiT iTvisebebi. maTTvis damaxasiaTebel ia meqanizmis moqmedebis sakmaod dabal i siCqare; kontaktebis eroziis gamomuSaobis SezRudul i vada, SezRudul i swrafqmedeba, moITxoven periodul regul irebas. Aam tom ukanasknel

xanebSi am, meqanizmebis marTvis sqemebSi iyeneben meqanizmis mdgomareobis ukontaqto gadamwodebs.

e) meqanizmis mdgomareobis ukontaqto gadamwodebi uzrunvel yofen meqanizmis maRal swrafqmedebas da CarTvaTa did sixSires. maT uaryofiT iTvisebad iTvl eba maTi sizustis damokidebul eba kvebis Zabvisa da temperaturis cvlil ebaze. moITxovnil ebidan gamomdinare am moyobil ebis gamosaval aparatad SeiZl eba gamoyenebul i iyosan ukontaqto l ogikuri el ementi an el eqtrul i rel e.

el eqtroamZravebis zusti gaCerebis sqemebSi ukontaqto gadamwodebi SeiZl eba gamoyenebul i iqnes rogorc dabal siCqareze gadasvl isas, aseve gaCerebis brZanebis gasacemad.

yvel aze ufro gavr cel ebul ia Semdegi tipis ukontaqto gadamwodebi: induqciuri, generatorul i, magnitogerkonul i da fotoel eqtronul i. Aam gadamwodebs ar aqvT meqanikuri kontaqti sakontrol eben moZrav obieqtTan.

induqciuri gadamwodebis muSaobis principi dafuZnebul ia feromagniturgul ariani koWis induqciur winaRobis cvl il ebaze magnitur wredSi sahaero RreCos cvl il ebis dros. Mmeqanizmis mdgomareobis kontrol isaTvis gamoiyeneba ИКВ-22 tipis induqciuri gadamwodi, metal urgiul saamqroebSi ИД-5, liTonsaWrel qarxnebsi gamoiyeneba mcire gabaritioni БСП tipis sagzaogadamrTvel i liogikuri elementiT an БРП tipis el eqtrul i rel eTi.

liTonsaWrel i Carxebis avtomatizaciisaTvis gamoiyeneba maRal i sizustis?ВКБатipis gadamwodebi.

generatorul i gadamwodebis gamoyenebis SemTxvevaSi sakontrol o sididis cvl il eba gardaiqmneba gamosasvl el ze e.m.Z-is cvl il ebad. aseT gadamwodebSi gamosasvl el i sididis cvl il ebisTvis ar moiTroveba cal ke kvebis wyaro. Ggeneratorul i gadamwodebi xasiaTdebian maRal i sizustiTa da kompaqturobiT. gansakuTreb iT kargad muSaoben КВД-6М; КВД-25; КВП-8 da КВП-16 seriis gadamwodebi.

v) kontrol erebi kontrol erebi warmoadgenen mra val wredian el eqtrul aparatebs xel is amZraviT,

roml ebic gamoiyeneba 440v Zabvamde mudmivi denisa da 500 v Zabvamde cvl adi denis Zravebis Zal ovani wredbis komutaciisaTvis. Kkonstruqciis mixedviT isini iyofian: muStadol ur, brtyel da magnitur kontrol erebad.

cvl adi denis Zabvebis marTvisaTvis gamoiyeneba KKT-61; KKT-61A; KKT-62; KKT-101; KKT-102 tipis kontrol erebi, romel Tac gaaCniat meqanizmis moZraobis orive mxares simetriul i kontaqtebi 380 v nominal ur Zabvaze.

mudmivi denis Zravebis marTvisaTvis gamoiyeneba ККП-101 da ККП-102 tipis kontrol erebi 440 v Zabvamde. maT gaaCniat 12 Zal ovan kontaqtebamde da saxe-

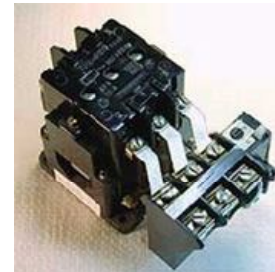
a)



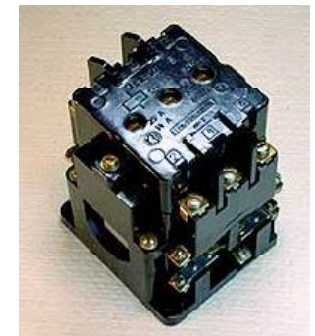
b)



g)



d)



nax. 4.8. magnituri amamuSavebl ebi

I uris nul ovani mdebareobidan TiToeul mxares 6 poziciamde. TiToeul pozicias gaaCnia fiqsacia.

ufro metad gamoiyeneba magnituri kontrol erebi, roml ebic Sedgebian **komandokontrol erebisagan** da kontaktoresbisagan. **Kkomandokontrol eri** kontaktebis daxmarebiT CarTavs an gamorTavs Zabvas kontaktores koWaze, romel ic Tavisi Zal ovani kontaktiT CarTavs an gamorTavs el eqtroZravis. Ees saSual ebas iZi eva avamaRI oT automatizaciis xarisxi el eqtroamZravis moZravi meqanizmebis marTvis sistemebSi.

4.3. distanciuri marTvis Zal ovani aparatebi

a) magnituri amamuSavebl ebi mokl edSerTul - rotoriani asinqronul i el eqtroZravebis amuSaveblis, gaCerebis, reversirebisa da dacvisaTvis distanciuri marTvis ZiriTadi el eqtrul i aparatebia. isini Seicaven kontaktores, roml ebic axorciel eben Zal ovani el eqtrul wredebis komutacias nominal uri da gadatvirTvis denebis dros; marTvis Ril akebs; Tbur rel eebis, roml ebic icaven Zravebs gadatvirTvisagan umetesad gavrcel ebul ia amamuSavebl ebi, romel - Ta Zal ovani wredis komutacia xdeba el eqtromagnituri amZraviT.

dRevandel pirobebSi bazarze warmodgenil ia rogorc rusul i, aseve evropul i firmebis mier warmoebul i magnituri amamuSavebl ebi 690v muSa Zabvamde da 250 a denis Zal amde.

Nmax. 4.8-ze warmodgenil ia sxvadasxva seriis magnituri amamuSavebl ebi.



N

a)

b)

nax. 4.9. kontaktoresbi

nax. 4.8 a,b -ze warmodgenil ia KNL seriis magnituri amamuSavebl ebi. maT gaaCniaT marTvis sxvadasxva varianti, rogorc distanciuri, aseve adgil obrivi.

Nmax. 4.8. g-ze warmodgenil ia ПМА-300 seriis, xol o nax.4.8.d-ze ?ПМЕ-200 seriis magnituri amamuSavebl ebi. Ees magnituri amamuSavebl ebi gamoiyenebian stacional ur danadgarebSi samfaza asinqronul i Zravebis distanciuri amuSavebisaTvis uSual od qsel Tan CarTvis, gaCerebisa da reversirebisaTvis.

b) el eqtromagnituri kontaktoresbi warmoadgenen distanciuri moqmedeebis aparatebs, romel Ta daniSnul ebaa Zal ovani el eqtrul i wredebis komutacia. Kkontaktoresbis CarTva-gamorTva xdeba el eqtromagnituri amZravis daxmarebiT. igi Sedgeba ZiriTadi kvanZebisagan: mTavari kontaktebi, rkal mqrobi sistemebi, el eqtromagnituri sistemebi, damxmare kontaktebi.

mTavari kontaktebi axorciel eben Zal ovani wredis CarTva- gamorTvas, isini gaTvl il i unda iyos nominal uri denis xangrZi iv gatarebaze da CarTva-gamorTvis did ricxvze.

rkal mqrobi sistemebi uzrunvel yofen mTavari kontaktebis gaTiSvis dros wrmodgenil i el eqtru-

l i rkal is Caqrobas. rkal mqrrobi sistemebis konstru-
qcia ganisazRvreba mTavari wredis denis saxebiTa
da kontaktores muSaobis reJimiT.

Kkontaktores el eqtromagnituri sistema
uzrunvel yofs kontaktores distanciur marTvas.
Eel eqtromagnituri sistema Sedgeba gul aras, Ruzis,
koWisa da samagri detal ebisagan.

Ddamxmare kontaktebi awarmoeben gadarTvebs
kontaktores marTvis bl okirebasa da signal izaciis
wredesi. isini gaTvl il ia ara umetes 20a denis xan-
grZl iv gatarebaze da araumetes 5a denis gamorTvaze.
Kkontaktebi srul deba rogorc nC, ise nR saxiT.

kontaktoresbi daniSnul ebis mixedviT gvxdaba
mudmivi da cvl adi denis, ukanasknel xaneSi didi
gamoyeneba aqvT vakuumur kontaktoresb.

nax. 4.9-ze warmodgenil ia ori tipis kontaktores.

nax. 4.9, a-ze warmodgenil ia KT-7100 Y seriis kon-
taktores, roml is nominal uri denia 125 a, nominal uri
Zabva 630 v, xol o koWa SeiZl eba gaTvl il i iyos 36, 127,
220, 380, 440, 500 da 600 v cvl ad Zabvaze.

Nnax. 4.9, b-ze Zabvaze warmodgenil ia KB 1 seriis
vakuumuri kontaktores, romel ic warmoebis mier ga-
moSvebul ia 160, 250,400a denze da1140 v Zabvamde.

KkoWa gaTvl il i SeiZl eba iyos 24, 36, 75, 110, 220v
mudmiv da 127, 220, 380v cvl ad Zabvaze.

**g) magnituri amamuSavebl ebisa da kontaktores-
bis diagnostika.**

magnitur amamuSavebl ebs da kontaktoresb amowme-
ben Semdegi programis mixedviT: gare daTval iereba,

magnituri da kontaktores sistemis regul ireba, den-
gantari nawil ebis izol aciis winaRobis Semowmeba.

MmTavari kontaktebis mdgomareoba. kontaktores
sistema warmoadgens magnituri amamuSavebl ebisa da
kontaktoresbis ZiriTad nawil s, amitom maTi mdgomar-
eobis Semowmebisas unda gamoCenil iqnes gansakuTre-
bul i yuradReba. Semowmebis dros mowmdeba yvel a
detal is: aramagnituri safenis, mokl ed SerTul i xviis,
rkal mqrrobi kameris, damWeri WanWikebisa da qanCebis,
sayel urebis arseboba

kontaktebi unda irTvebodes erTdroul ad. ara-
erTdroul oba SeiZl eba aRmoifxvras mTavari kon-
taktebis Ril akze cal uRis ("OIIOO") gadaWeriT.

CarTul mdgomareobaSi kontaktebi erTmaneTs unda
exebodnen qveda nawil ebiT . kontaktebis mTel si-
grZeze ar unda gadiodes sinaTl is sxivi. Kkontakte-
bis zrdapirze metal is wveTebis arseboba zrdis
kontaktores winaRobas 10 da metjer, amitom aseTi wveT-
ebis SemCnevis SemTxvevaSi isini unda movacil oT
ql ibiT. Kkontaktebis zedapiris zumfaris qaRal diT
gawmenda da gapoxva akrZal ul ia. CarTul i kontakte-
bis Semowmeba unda moxdes mikroometriT.

**Mmagnituri sistemebis mdgomareobis Semow-
mebisas** pirvel rigSi xel is dawol iT mowmdeba
kontaktores svl is simsubuqe. Mmagnituri sistemis
svl a unda iyos mdore biZgebisa da CaWeqvis gareSe.
cvl adi denis kontaktores koWaSi denis gavl is dros
unda ismodes susti xmauri. Zl ieri guguni miuTiTebis
Ruzis an gul aris araswor damagrebaze, mokl edSerTu-
l i xviis dazianebase an el eqtromagnitur gul arasTan

aramwidro mibjenaze. Ggugunis Semcirebisatvis saWiroa: 1. Ruzisa da gul aras damWeri xrxnis daWera; 2. Aan dazianebul i mokl edSerTul i xviis gamocvli a; amamuSavebl is el eqtromagnituri sistemis orive naxevis Sexebis zedapirebis gasufTaveba da morgebis sizustis Semowmeba.

Ruzasa da gul aras Soris Sexebis sizustis Semowmebisatvis maT Soris unda davdoT qaRal dis TeTri furceli da xeliT davawveT kontaktores, an amamuSavebel s. Sexebis zedapiri unda iyos magnitogamtaris ganivkveTis aranakl eb 70%.

mcire Sexebis zedapiris dros es defeqti SeiZleba gamoswordes gul arisa da Ruzis swori dayenebiT. Tu RreCo didia, maSin saWiroa magnituri sistemis furcl ovani fol adis gaswriw zedapiris gaxexva.

Ggarda amisa gansakuTrebiT sapsuxismgebl o kontaktoresda da magnitur amamuSavebl ebSi gansazRvraven mTavari kontaktebis sawyis da sabol oo dawolis Zalas. sawyisi dawolis Zala iqmneba kontaktebis Sexebis momentSi sakontrol o zambaris mier. igi axasiaTebis zambaris drekadobas. Ddawolis sabol oo Zala axasiaTebis mTli anad CarTul kontaktores dros kontaktebis dawolis. Ddawolis sawyisi da sabol oo Zalebi ganisazRvrebadi namometris daxmarebiT

Ruzis miwebeba gul arasTan. Ruzis miwebeba gul arasTan xdeba aramagnituri safenis ar arseboba an misi arasakmarisi sisqis gamo, amamuSavebeli SeiZleba ar gamoirTos koWidan Zabvis mTli ani moxsnis SemTxvevaSic ki. Aam dros saWiroa sakmarisi sis-

qis aramagnituri safenis gamoyeneba an sahaero RreCos arseboba.

CarTvis dros ar xdeba amamuSavebl is TviT-bl okireba. Aam dros saWiroa Semowmdes amamuSavebl is mabl okirebeli kontaktebis mdgomareoba. Kkontaktebi CarTul mdgomareobaSi mwidrod unda iyos mibjenili ertmaneTs da unda irtvebodnen mTavar kontaktebtan ertad. Bbl ok-kontaktebis RreCoebi ar unda aRematebodes dasaSveb mniSvnel obebs. saWiroa CavataroT amamuSavebl is bl ok-kontaktebis regul ireba. Tu bl ok-kontaktebis Cavardna 2mm-ze naklebia, maSin bl ok-kontaktebi unda Seicval os.

Kkontaktoresis da magnituri amamuSavebl ebis dengamtari nawil ebis izolaciis winaRoba mowmdeba megaometriT 500 an 1000 v Zabvaze. koWis izolaciis winaRoba ar unda iyos 0.5 momze naklebi.

4.4.Ddacvis Zal ovani aparatebi

Ddacvis aparatebis daniSnul ebaa avtomaturad amortos dasacavi el eqtruli wredi muSaobis aranormaluri rejimis dros.

Ddacvis aparatebis miekuTvneba: dnobadi mcveli, avtomaturi amomrTveli, denisa da Tburi rel eebi.

a)Ddnobadi mcveli es aris el eqtruli aparati, romelic icavsel eqtrodanadgars gadatvirTvisa da mokl ed SerTvis denebisagan denis gansazRvruli mniSvnel obis gadaWarbebis SemTxvevaSi special urad amisaTvis gaTval iswinebuli dengamtari nawilis gawvetis gziT.

xangrZI ivi eqspl uataciis pirobebSi mcvel ebi icvl ian Tavisi maxasiaTebi ebs – “Zveli debian”. Amითომ საუროა ისინი periodul ad Sevcval oT axl iT.

Mmcvel ebiis momsaxureoba daiyvaneba kontaqhuri SeerTebebis mdgomareobis Semowmebamde da gadamwvari mcvel ebiis saTadarigo qarxnul i wesiT damzadebul i mcvel ebiT Secvl amde.

praqtikaSi xSirad dnobad mcvel ebs cvl ian spilenZis sadeniT, romel sac amagreben masris garezedapirze, rac yovl ad dauSvebel ia. sadenis gadawwis SemTxvevaSi SeiZl eba gaCndes xanZari an daTvalierebis dros SeiZl eba miviRoT Tval is travma an xel is damwvroba.

Mmcvel ebiis Secvl is dros unda davi cvaT usafrTxoebis wesebi. Mmcvel i unda Sei cval os moxsnil i Zabvis dros. Tu Zabvis moxсна SeuZl ebel ia, maSin mcvel ebiis Secvl a unda moxdes diel eqtrul i xel TaTmanebis an marwuxebis saSual ebiT.

PH2 tipis (max. 4.10) dnobad mcvel s usafrTxo momsaxurebis atvis gaacnia T-sebri gamonaSveri, rom-

l iTac special uri saxel uris gamoyenebiT advil ad gamovirebT kontaqtebidan.

dnobadi mcvel is gamoyenebas gaacnia mnisvnel ovani dadebiTi Tvisება, kerZod, romელი me ubnis dazianebis SemTxvevaSi gamrTavs mxol od amubans da danarCeni darCeba muSaobaSi.



ნახ.4.10. PH2 tipis dnobadi mcvel i

0.4.kv sahaero xazebis datvirTvis dnobadi mcevel ebiis gamoyenebisას, el eqtrodanadgaris mowyobis wesebis Tanaxmad, ისინი arCeul unda iqnas mokl ed SerTvis denebis mnisvnel obaze 3-jer nakl ebi sididis.

Bb) avtomaturi amomrTvel ebi. avtomaturi amomrTvel ebiis daniSnul ebaa daicvas el eqtrul i wredebi gadatvirTvisa da mokl ed SerTvis denebisagan. Aaseve SeiZl eba gamoyenebul iqnes ubnebis operatiული i marTvis gansaxorciel ebl ad. gadatvirTvisagan dacva xorciel deba Tburi an el eqtronul i mowyobil obiT, xol o mokl ed SerTvis denebisagan dacva xorciel deba el eqtromagnituri an el eqtronul i gamTiSebiT.

avtomaturi amomrTvel ebiis Tanamedrove Taobas miekuTvneba nax. 4.11-ze mocemul i BA-47-29 seriiis amomrTvel ebi.

Eel eqtrul wredebSi gadatvirTvisa da mokl ed SerTvis denebisagan dasacavad, mokl ed SerTul rotoriani asinqronul i Zravebis, gaSvebis, gaCerebisა da datvirTvis, agreTve 380 vol t Zabvamde el eqtrul wredebSi normal ur reJimSi komutaciisaTvis zemoTx-senebul is garda farTod gamoiyeneba sxvadasxva seriiis



ნახ. 4.11. BA-47-29 seriiis avtomaturi amomrTvel i



a)

nax. 4.12. a) AE-2040seriis samfaza avtomaturi amomrTvel i; b)A63 seriis erTfaza avtomaturi amomrTvel i



b)

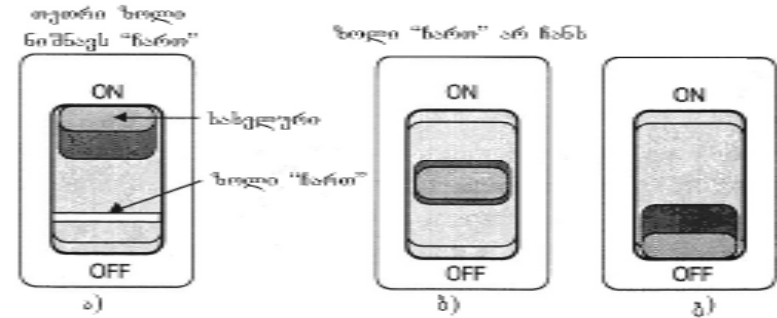
avtomaturi amomrTvel ebi. Mmagal iTisaTvis nax. 4.12-ze moyvanil ia ori maTgani.

miuxedavad avtomaturi amomrTvel ebis tipebis mraVal ricxovnebis, yvel aisini Sesdgebian xuTi Zir iTadi nawil isagan, esenia: korpusi, muSa meqanizmi, kontaqtEBi da rkal mqroBEBi, dacvis el ementEBi da SemaerTebel i kl emebi.

Kkorpusi Camosxmul ia pol imerul an minaboWkovan masal isagan, romel Sic Serwymul ia cveTamdegoba da maRal i el eqtrul i simtkice. korpusSi ganl agebul ia amomrTvel is detal ebi da rac yvel aze mTavaria korpusi uzrunvel yofs Zabvis qveS myofi detal ebs Soris izol acias.

muSa meqanizmi uzrunvel yofs CarTvasa da gamorTvas saxel uris saSual ebiT. "ON" mdgomareobidan "OFF" mdgomareobaSi an (nax. 4.13, a) piriqiT.

muSa meqanizmi dacvis meqanizmi sagan damouki debel ia anu saxel uris "ON" mdgomareobaSi daWera xel s ver SeuSl is dacvis amoqmedebas. Tu amomrTvel is saxel uri imyofeba zeda ("ON") mdgomareobaSi, maSin

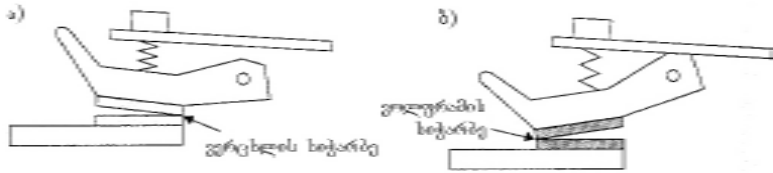


Nnax.4.13. amomrvel is saxel uris mdgomareoba

avtomaturi amomrTvel i CarTul ia (nax. 4.12, a), Tu imyofeba qveda ("OFF") mdgomareobaSi- gamorTul ia (nax. 4.2, b), xol o Tu imyofeba Sua mdgomareobaSi (nax. 4.12, b),maSin es niSnavs,rom imoqmeda dacvam. xel axal i CarTvisaTvis saWiroa j er saxel urs davawveT Zirs mdgomareoba "OFF", xol o Semdeg gadaviyvanOT saxel uri "ON" mdgomareobaSi.

KkontaqtEBi da rkal mqroBEBi. moZravi da uZravi kontaqtEBi qmian wyvil s. amomrTvel is CarTva-gamorTvis dros maTze modis didi datvirTva, amitom kontaqtEBis masal ebi airCeva Semdegi sami kriteri umidan: minimal uri winaRoba, maqsimal uri cveTamdegoba da miwebebisadmi maqsimal uri medegoba. Amitom kontaqtEBis meqanizmi damuSavebul ia CarTvisa da gamorTvis adgil ebiS dayofiT. CarTvis adgil i Seicavs didi raodenobiT vercxl s, xol o gamorTvis (rkal is warmoqmnis) adgil i-vol frams. (nax. 4.14).

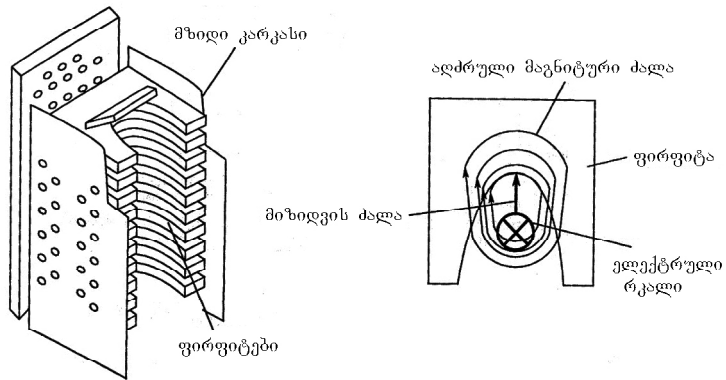
Mmokl ed SerTvis denebis gaTiSvis dros warmoiqmneba saWiroeba gavfantoT rkal isa da gamoyofil i siTbos saxiT aRZrul i energiis didi raodeno-



Nmax. 4.14. ორმაგი მოყმედა კონტაქტები:
 a) CarTვა; b) gamorTვა

ბა. ამისათვის გამოიყენება რკალი მკობი მესერი (ნახ. 4.15), რომელიც შედგება special ურის ფორმის, ერთმანეთისაგან იზოლირებული ფოლადის ჩიქიტისაგან. როცა კონტაქტები გაითიშება, მაშინ ვარმოიქმნება ელექტრული რკალი, ჩიქიტასი არიზვრება მანტური ველი, რომელიც რკალს ვაანაცვლებს მესერისაკენ. ელექტრული რკალი გრძელდება ისე ება მრავალ მცირე რკალად, რომელთა ტემპერატურა ეცემა მესერის ჩიქიტების მარალი ტბოგამტარობის გამო და არარ ივვევს ჰერის იონიზაციას.

დდაცვის ელემენტები. ამ ელემენტების ფუნქციაა გადართვის ან მოკლედ სერტვის შემთხვევაში გათისოს მუშა მექანიზმი.



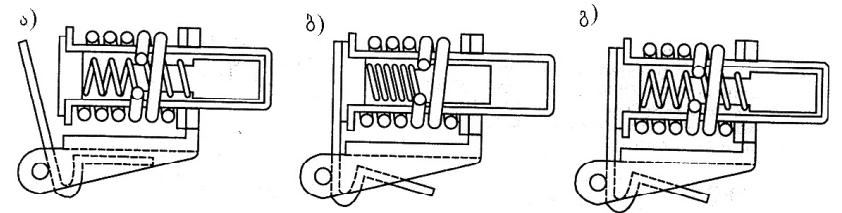
Nmax. 4.15. რკალი მკობი

გადართვის შემთხვევაში არსებობს გათისვის ორ მეთოდი: ბიმეტალიური და ჰიდრული. ბიმეტალიური მეთოდის გამოყენების დროს ვრდებიან ისეთი სხვადასხვა გვარის მალისაგან შედგენილი ბიმეტალიური ელემენტი. დიდი დენების გავლის დროს ბიმეტალიური ელემენტი მოირუნება იმდენად, რომ იმოყმედას გამთისავ ჩიქიტაზე. ეს ელემენტი აივობა მხოლოდ საყარხნო პირობებში და არ შეიძლება დავარდნილი მათი მთლიანობა.

ჰიდრული მეთოდი დაფუძნებულია სოლენოიდის გამოყენების დენის მერ გამოვლელისაზე. ნორმალურ პირობებში ელექტრომაგნიტის ძალა (ნახ. 4.16) გავონასვრეულია ვამბარის ვნების ძალაზე. გადართვის დროს ელექტრომაგნიტის ძალა იზრდება, რის გამოც იზრდება დავალი ვამბარაზე და მოვრავი რკალის გული გათისავს მუშა მექანიზმს.

მოკლედ სერტვის შემთხვევაში საშიშროა უფრო სწრაფ-მოყმედი დაცვის მოვობილიობა. ამ მიზეზით ტერმული ელემენტთან ერთად გამოიყენება მანტური გათისვის პრინციპი.

მოკლედ სერტვის შემთხვევაში მოკლედ სერტვის დენი აივრეულია ელექტრომაგნიტის მიზიდვის ძალაზე, რომელიც



ნახ. 4.16. ჰიდრული გათისვის მეთოდი:
 a) ნორმალური მოყმედა; b) სენილებული მოყმედა; g) მისერი მოყმედა

xsnis gamTisvel meqanizms. Ees procesi xdeba Zal ian swrafad da Seadgens daaxl oebiT 20 mwm

SemaerTebel i kl emebis saSual ebiT amomrTvel i uerTdeba kvebis wyarosa da datvirTvas. Aarsebobs SeerTebis ramdenime meTodi. Mmagal iTad sal teebiT, WanWi kebiT, gasarTebiTa da sxva.

avtomaturi amomrTvel ebis gamocdis dros gasazom sidides warmoadgens denis mocemul i sididisas (romel ic aRemateba avtomaturi amomrTvel is nominal ur dens) gamorTvis dro.

gamocdis dros avtomaturi amomrTvel i unda iyos dayenebul i vertikal urad da gamorTul i qsel idan. Aavtomaturi amomrTvel is TiToeul pol usSi Camontajebul ia Tavisi Tburi el ementi, romel ic moqmedebs saerTo momxsnel ze.

rom davrwundeT yvel a Tburi el ementis moqmedebis sisworeSi saWi roa ToToeul i maTgani Sevamomot cal ke, radganac TiToeul i amomrTvel is Semowmebaze ixarj eba ramdenime saaTi, ami tom rekomendire-



max. 4.17. PT-2048-01 tipis gamosacdel i kompl eqti

bul ia gamovcadoT igi ormagi-sammagi nominal uri denis sididiT yvel a pol usis erTdroul i datvirTvis dros. Tu Tburi el ementi ar arsebobs, maSin avtomaturi amomrTvel i uvargisia da Semdgom gamocdas aRar eqvemdebareba. Aavtomaturi amomrTvel ebis gamocdis aTvis gamouyenebel ia sxadasxva tipis aparatebi. max. 4.17-ze moyvani ia PT-2048-01 tipis gamosacdel i kompl eqti, romel is regul irebis diapazonia 10-1000 amperi.N

4.5. rel eebi

rel e ewodeba mowyobil obas, romel Sic gansazRvrul sazRvrebSi uwyvetad cval ebadi marTvis (Sesaval i) signal is zemoqmedebiT xorciel deba gamosavali i signal is cvl il eba (gadarTva).

rel eebma farTo gamoyeneba hpoves avtomatikis sistemebSi, radganac maTi daxmarebiT mcire simZl avris Sesaval i signal iT SeiZl eba didi simZl avreebis marTva; I ogikuri operaciebis Sesrul eba, mraval funqciuri sarel eo mowyobil obebis Seqmna; el eqtrul i wredis komutacia; sakontrol o parametrebis mocemul i donidan gadaxris dafiqsireba; damamaxsovrebel i el ementebis funqciis Sesrul eba da sxva. Uupirvel esi gamoyeneba rel eebma hpoves sarel eo dacvisa avtomatikis mowyobil obebSi.

rel eebis kl asifikacia xdeba sxvadasxva nisnebis mixedviT: Sesaval i fizikuri sididis, romel zecisini reagireben; marTvis sistemebSi Sesrul ebul i funqciis, romel sacisini asrul eben; konstruqciisa da a.S. fizikuri sididis mixedviT gasaxvaveben

el eqtrul , meqanikur, Tbur magnitur da a.S. rel eeb. amave dros unda aRiniSnos, rom rel em SeiZl eba reagireba moaxdinos ara mar to konkretul i sididis mniSvnel obaze aramed mniSvnel obaTa sxvaobaze (diferencial uri rel e); sididis niSanis cvl il eba ze (pol arizebul i rel e) an Sesaval i sididis cvl il ebis siCqareze.

rel es mowyobil oba. Cveul ebriv rel e Sedgeba sami ZiriTadi funqcional uri el ementisagan: mimRebi, Sual eduri da Semsrul ebel i. mimRebi (pirvel adi) el ementi miiRebs sakontrol o sidides da gardaqm-nis mas sxva fizikur sidided. Sual eduri el ementi Seadarebs am sididis mniSvnel obas mocemul mniSvnel obas da misi gadaWarbebis SemTxvevaSi gadascems zemoqmedebisaTvis Semsrul ebel el ements. Semsrul ebel i el ementi axorciel ebs zemoqmedebas rel es an Zravas wredSi.

Semsrul ebel i el ementis mixedviT rel eebi iyo-fa kontakturn da ukontaqto rel eebad.

Kkontakturni rel e zemoqmedebis Zravas wredze el eqtrul i kontaktebis daxmarebiT. Kkontaktebis Caketil i an gaxsnil i sistema saSual ebas iZl eva uzrunvel yoT gamosavl el i wredis Caketva an mTliani meqanikuri gaxsna.

Uukontaqto rel e zemoqmedebis marTvis wredze el eqtrul i wredis gamosavl el i parametrebis (win-aRoba, induqciuroba, tevadoba) mkveTri (naxtomise-buri) an Zabvis (denis) sididis cvl il ebis gziT.

rel es ZiriTadi maxasiaTebl ebi ganisazRvreba Sesaval i da gamosaval i parametrebis Soris damok-idebul ebiT.

ganasxvaveben rel es Semdeg ZiriTad maxasiaTebl ebs:

1. rel es amuSavebis sidide X_{am} -warmoadgens Sesaval i sididis parametris mniSvnel obas, roml is drosac rel e CairTveba, amuSavebis sidides, romel zec daregul irebul ia rel e, ewodeba dayeneba ("ONOAAEA")

2. rel es amuSavebis simZl avre P_{am} -minimal uri simZl avre, romel ic saWiroa miviyvanoT mimReb organoTan mSvidi mdgomareobidan muSa mdgomareobaSi gadasayvanad.

3. rel es mmarTvel i simZl avre P_{mmar-T} - romel ic marTavs rel es makomutirebel organoebis gadarT-vis procesSi. marTvis simZl avris mixedviT ganasxvaveben mcire (25vt-mde), saSual o (100vt-mde), da didi simZl avris (100vt zemoT) rel eeb es ukanasknel i miekuTvneba Zal ovan rel eebis (kontakto-rebs).

4. rel es amuSavebis dro t_{am} -es aris drois Su-al edi rel es Sesaval ze X_{am} signal is miwodebidan marTvis wredze zemoqmedebamde. amuSavebis drois mixedviT ganasxvaveben normal ur, swrafmoqmed, Senel ebul da drois rel eebis.

CarTvis xerxis mixedviT rel eebi iyofian: pirvel ad da meoreul rel eebad. P

pirvel adi rel e uSual od aris CarTul i dasacav el ementTan. Aam rel eebis mTavari Rirsebaa is rom maTi CarTvisTvis ar moiTxoveba sazomi transformatorebi, operatiul i denis wyaro da sakontrol o kabel ebi.

Mmeoreul i rel e CairTveba denis an Zabvis sazom transformatoris gavliT. Uupiratesi gamoyeneba hpova meoreul ma rel eebma sareleo dacvis teqnikaSi. Aam rel eebis Rirsebad miCneva is rom: izol irebul ia maRal i Zabvisagan, ganl agebul ia momsaxureobisaTvis mosaxerxebel adgil as; srul deba standartul 5 (1)a densa da 100v Zabvaze, miuxedavad dasacavi wredis Zabvisa da denis sididisa.

Sesrul ebis mixedviT rel eebi iyofa: **el eqtromeqanikuri an induqciuri**_moZravi el ementebiT da **statikuri**- uZravi el ementebiT (el eqtronul i, mikroprocesorul i).

DdaniSnul ebis mixedviT rel eebi iyofa: el eqtromagnituri, sazomi. Ddenis, Zabvis, drois, siCqaris, foto, winaRobebis gerkonul i da sxva.

a) el eqtromagnituri rel e (nax. 4.18) warmoadgens distanciuri marTvis el eqtrul aparats, roml is daniSnul ebaa el eqtrul i zemoqmedebis mocemu-



nax. 4.18. el eqtromagnituri eqtrodanadgarebis dacrel es saerTo xedi

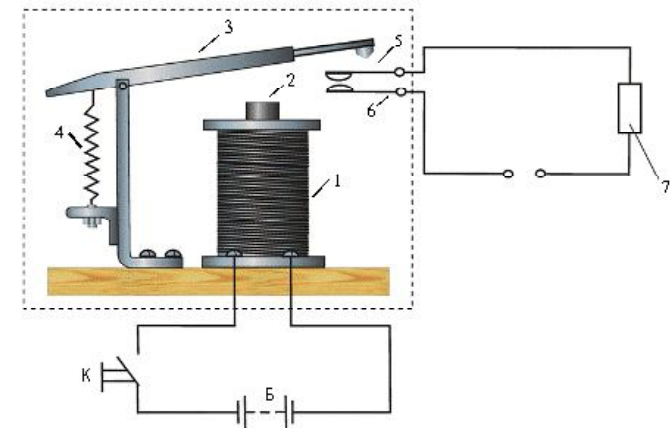
li mniSvnel obis dros ganaxorciel os marTvis wredesi naxtomiseburi cvl il eba. Tavis moqmedebis principis simartivisa da maRal i saimedobis gamo el eqtromagniturma rel eebma farTo gamoyeneba hpoves avtomatikis sistembsa da el-

vis sqemebSi. Eel eqtromagnituri rel eebi iyofa mudmivi da cvl adi denis rel eebad, mudmivi denis rel eebi Tavismxriv iyofa neitral ur da pol arizebul rel eebad. Nneitral uri rel e erTnairad reagirebs mudmiv denze orive mimarTul ebiT, xolo pol arizebul i rel e reagirebs marTvel i signal is pol arobaze.

Eel eqtromagnituri rel es moqmedebis principidafuznebul ia el eqtromagnituri Zal ebis gamoyenebaze, roml ebic aRiZvrebian metal ur gul araSi masze Camocmul koWaSi gamaval i denis dros.

rel es detal ebi damontajebul ia fuZeze da daxurul ia saxuraviT, el eqtromagnitis gul aris Tavze dayenebul ia Ruza (firfita) erTi an ramdenime kontaktiT. am kontaktebis mopirdapire mxares moTavsebul ia uZravi kontaktebis Sesabamisi wyvil i. sawyis mdgomareobaSi Ruza daWeril ia zambariT.

gavecnoT nax. 4.19-ze moyvanil i mudmivi denis rel es muSaobas. KCamrTvel is CarTvis Semdeg el eqtro-



nax. 4.19. el eqtromagnituri rel es sqema

kveba miwodeba koWas 1 da masSi gaivl is deni, ris Sedegadac metal ur gul araSi 2 aRiZvrebian el eqtro- magnituri Zal ebi da miizidaven Ruzas 3, romel ic daZl evs zambaris 4 drekadobis Zal as da CarTavs moZrav 5 da uZrav 6 kontaktebs ris Sedegadac winaR- obaSi 7 gaivl is cvl adi (~~") deni.

CamrTvel is gaTiSvis Semdeg zambara daabrunebs Ruzas sawyiss mdgomareobaSi da 5 da 6 kontaktebi gaiTiSeba, ris gamoc kveba Seuwydeba winaRobas 7.

naperwkl ianobis Tavidan acil ebis mizniT kon- taqtorebTan paral el urad rTaven kondensators. sa- marTavi wredi el eqtrul ad aranairad ar aris dakav- Sirebul i marTvel wredTan. Uufro metic samarTav wredSi gamaval i deni SeiZl eba bevrad aRematebodes marTvel wredSi gamaval s. Ee.i. am SemTxvevaSi rel e arsebiTad asrul ebs el eqtrul wredSi denis, Zabvis da simZl avris gamaZl ierebl is funqcias.

cvl adi denis rel eebi muSaobs koWaze gansazRvru- l i sixSiris Zabvis miwodebis dros, aseTi rel eebis konstruqcia msgavsia mudmivi denis rel eebis kon- struqciebis. Aam SemTxvevaSi gul ara da Ruza mzad- deba el eqtroteqniki fol adis furcl ebisagan, raTa Semcirdes danakargebi histerezisze da griga- l ur denebze.

b) denis rel e. Ddenis rel e iseTi rel ea, rom- l is mimRebi organo reagirebs denis cvl il ebaze. mimRebi organo aris aparatis nawil i, romel ic uSu- al od iRebs rel esTan moyvanil i el eqtrul i sidi- dis cvl il ebas da awarmoebS Sesabamis cvl il ebas rel es danarCen organoebSi.



a)



b)

nax. 4.20. denis rel eebi

Ddenis rel eebi SeiZl eba iyos: pirvel adi, romel - ic CamontaJebul ia amomrTvel is amZravSi; meoreul i, romel ic CarTul ia denis transformatorebis gav- l iT; el eqtromagnituri; induqciuri; Tburi; difer- encial uri; integral ur mikrosqemebze; denis uku- Tanmimdevrobis rel e-fil tri.

nax. 4.20, a-ze naCveneblia PƏB-830 tipis kontrol is rel e. romel ic gamoiyeneba minimal uri denis rel ed, mudmivi denis wredSi. igi mzaddeba nominal ur den- ze 1.6-630 amperis fargl ebSi, xol o nax. 4.20, b-ze naCveneblia PT-81...PT-86 tipis maqsimal uri denis rel e, romel ic gamoiyeneba el eqtrul i manqanebis, transformatorebis, gad- amcemi xazebis datvirTvis, gada- tvirTvisa da mokl ed SerTvis dros. PT-81 da PT-82 tipis rel ee- bi moqmedeben myisierad mokl ed SerTvis dros da drois day- ovnebiT gadatvirTvis dros; PT-85 da PT-86 muSaoben cvl ad operati-



nax. 4.21. Zabvis rel e



nax. 4.22. PGT-50 tipis transformatoris bazuri dacvis rel e

ul denze da gaaCniaT agreTve Camketi sasignal o kontakti.

g) Zabvis rel eebi. re-agireben Zabvis cvl il eba-ze da denis rel eebis ms-gavsad isini aris pirvel a-di, meoreul i, el eqtromag-nituri, mikrosqemebze da Zabvis rel e-fil tri. Nnax. 4.21. naCvenebia PH-55 tipis Zabvis rel e, romel ic muSaobs Zabvebs Soris Zvr is kuTxenze 20^o-40^o Soris.

aRniSnul i rel e gamoiyeneba avtomaturi ganmeorebi-Ti CarTvis sqemebSi ormxrivi kvebis xazebSi. rel e akontrol ebs xazebze Zabvis arsebobas da Zvr is kuTxes xazebisa da qvesadguris sal teebis Zabvebis veqtorebs Soris.

d) maCvenebel i rel eebi. Aam rel eebis sxvagvar-ad sasignal o rel eebis uwodeben. isini emsaxurebian rogorc TviT rel es, aseve sxva meoreul i aparatebis moqmedebis registracias. Nnax. 4.22-ze warmodgenil ia PGT-50 tipis transformatoris gazuri dacvis rel e. romel sac gaaCnia martivi da saimedo konstruqcia da moxerxebul ia eqspl uataciaSi. am rel es sasigna-l o kontaktebi Caiketeba zeTis donis dawebis dros. masSi gamoyenebul ia maRal i el eqtrul i simtkicis gerkonebi. rel es konstruqcia iZl eva saSual ebas



nax. 4.23 drois rel e ВЛ-4U

movaxdinoT sakontrol o kvan-Zis daTval iereba da Seavl a adgil ze, rel es gaxsnis gareSe.

dayenebis regul irebis xraxni gamoyvanil ia rel es korpusis saxuravze, ris gamoc dayeneba SeiZl eba varegu-l iroT rel es gaxsnis gareSe. am rel es zomebi saSual e-bas iZl eva yovel gvari gada-

keTebis gareSe Sevcval oT eqspl uataciaSi myofi sxva tipis rel eebi.

e) drois rel eebi emsaxurebian dacvis moqmede-bis Senel ebas. Nnax. 4.23-ze warmodgenil ia ВЛ-4U ti-pis rel e, roml is daniSnul ebaa winaswar gansazRvrul i drois dayovnebiT el eqtrul i wredebis komuta-cia. igi gamoiyeneba avtomatikis sqemebSi. Nnax. 4.24-ze warmodgenil ia YT1-Pic tipis orarxiani real uri drois universal uri taim-eri. Mmisi daniSnul ebaa drois mocemul momentSi Sesrul ebul i meqanizmebis avtomaturi CarTva-gamorT-va da gamoiyeneba ganaTebis marTvisatvis quCaSi. saTbu-rebsa da inkubatorebSi, agreTve teqnol ogiur pro-cesebSi, sadac danadgaris CarTva-gamorTva dakavSire-



Nnax. 4.24. YT1-Pic tipis universal uri taimeri

bul ia kal endarul TariR-
Tan an dRe-Ramur drosTan.

v) **Sual eduri rel eebi** emsaxurebian rel euri dacvis el ementebS Soris urTierTkavSiris ganxorciel ebas. Mmisi daniSnul e-



nax. 4.25. Sual eduri rel eebi

baa sxva rel edan miRebul i signal ebis gamravl eba, am signal ebis gaZl iereba da brZanebis gadacema sxva aparatebze. Nmax. 4.25-ze warmodgenil ia ПП21М-В tipis Sual eduri rel e, romel ic gamoiyeneba mudmivi denis 220v Zabvamde da 50 hc sixSiris cvl adi denis 380 v Zabvamde wredebSi.

z) **Tburi rel eebis** daniSnul ebaa mokl ed SerTul rotoriani samfaza asinqronul i Zravebis dacva xangrZl ivi gadatvirTvisagan agreTve erTi fazis gawyvetis dros warmoqmnil i gadatvirTvisagan.

T) **sazomi rel eebi**. Aam tipis rel eebisaTvis damaxasiaTebel ia sayrdeni el ementis arseboba zambaris, stabil uri Zabvis, denis wyarosa da sxvaTa saxiT. sayrdeni el ementebi Sedian rel es kompl eqtaciaSi da awarmoeben raim fizikuri sididis winaswar dadgenil i mniSvel obas (e.w. dayenebas), romel Tanac Sedardeba sakontrol o sidide. sazomi rel e xasiaTdeba maRal i mgrZnobiarobiTa da gaaCnia maRal i koefficienti.

i) **winaRobis rel e** reagirebas axdens Zabvisa da denis fardobaze



nax. 4.26. fotorel eebi: a) Z7-LMS; b) ФР-1М1 da g) ФР-7М tipis

v) **simZl avris rel e** reagirebs mokl ed SerTvis simZl avris gadinebis mimarTul ebaze

l) **sixSiris rel e** reagirebs el eqtrul el ementebze Zabvis sixSiris cvl il ebaze.

m) **cifrul i rel e** warmoadgens mraval funqciur cifrul mowyobil obas, romel ic erTdroul ad asrul ebs denis, Zabvis, simZl avris da sxva rel eebis funqciebs

n) **foto rel es** daniSnul ebaa ganaTebis CarTva-gamorTva dRis cvl il ebis intesivnobis cvl il ebiT. mgrZnobiarobis farTo diapazonSi cvl il eba iZl eva saSual ebas gamoyenebul iqnes quCebSi, vitrinebis, Suqrekl amebis ganaTebisaTvis. Nmax.4.26-ze warmodgenil ia sxvadasxva tipis fotorel eebi.

ФР-7М tipis fotorel e garda zemoTaRniSnul isa damatebiT gamoiyeneba samrewvel o avtomatikis mowyobil obebSi, mi si gadamwodis gatana SeiZl eba 50m manZil ze.

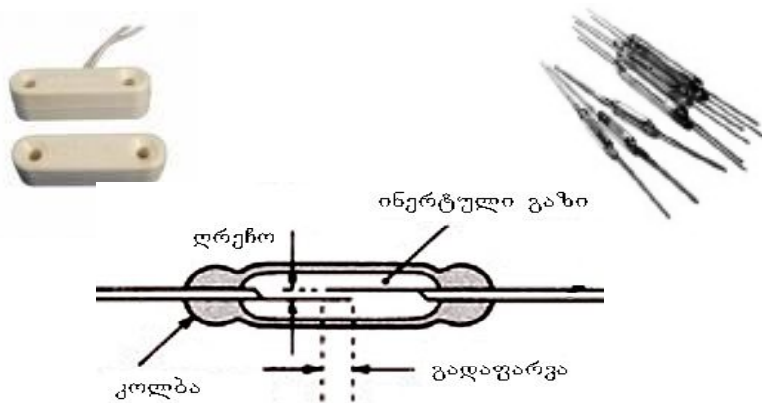
o) **gerkonebi da gerkonul i rel eebi**. Eel eqtromagnituri rel es nakl ebad saimedo kvanZad iTvl eba kontakturni sistema, arsebiT nakl ad iTvl eba agreTve

moxaxune detal ebis arseboba, romel Ta cveTas mi vya-
 varT rel es muSaunarianobis daqveiTebamde. CamoTv-
 l il ma uaryofiTma mxareebma saWi ro gaxada germetu-
 l i, magniturad marTvadi kontaktebis Seqmna, romel -
 sac gerkonebi ewodeba

gerkonebis moqmedebis principi dafuZnebul ia
 magnitur vel Si feromagnitur rel eebS Soris aRZrul
 urTierTqmedebis Zal is gamoyenebaze. es Zal ebi iwveven
 deformacias da feromagnituri dengamtarebis el e-
 mentebis gadaadgil ebas.

magniturad marTul i kontakti(gerkoni) warmoad-
 gens el eqtrul aparats, romel ic magnituri vel is
 gavl eniT Caketavs an gaxsnis el eqtrul i wredis kon-
 taqtebs.

Tanamedrove pirobebSi gerkonebis bazaze Seqm-
 nil ia gerkonul i rel eebis, Ril akebis, tumbi erebis,
 gadamrTvel ebis,signal ebis gamanawil ebl ebis, gadam-
 wodebisa da regul atorebis didi raodenoba.



ნახ. 4.27. გerkonul i rel e

mcire gardamaval i winaRobis Sesaqmnel ad kon-
 taqtebis zedapirobi dafarul ia Zvirfasi l iTonebiT:
 oqroTi, radiumiT, pal adiumiT an vercxl iT.

gerkonul rel eebSi gragnil Si denis gaTiSvis
 Semdeg el eqtromagnitis Zal a qreba da drekadobis
 Zal is moqmedebiT kontaktebi gaiTiSeba.

umartivesi gerkonul i rel e Camketi kontaktebiT
 Sedgeba maRal i magnituri SeRwevadobis (permal oi)
 ori sakontaqto gul arisgan, romel ebic moTavsebu-
 l ia hermetul minis bal onSi. Bbal oni avsebul ia
 inertul i airiT, rac xel s uSl is sakontaqto gu-
 l arebis daJangvas. minis bal oni Cayenebul ia mar-
 Tvis gragnil is SigniT, romel ic ikvebeba mudmivi
 deniT. gragnil Si denis gatarebisas aRiZvreba magni-
 tური vel i, romel ic qmnis wredis el eqtromagnitur
 Zal as, es Zal a gadasZl evs sakontaqto gul arebis
 drekadobis Zal as da kontaktebs erTmaneTTan Se-
 aerTebS. ნახ. 4.27-ზე warmodgenil ia gerkonul i rel e
 da misi Wril i

gerkonebi ideal uria miniaturul i el eqtromow-
 yobil obebisaTvis. sakomutacio denisa da simZl avris
 gazrdisaTvis gerkonul rel eebS gaaCniaT damatebi-
 Ti rkal mqrobi kontaktebi. aseT rel eebS gersikone-
 bi ewodebaT. warmoebis mier gamoSvebul ia 6.3-dan 18
 amperამდე denis Zal is gersikonebi. Ggersikonebis
 daxmarebiT SeiZl eba ganxorციელ des 3 kvტ-მდე sim-
 Zl avris asinqronul i Zravebis gaSveba.

4.6. el eqtrul i aparatebis koWebi da maTi diagnostika

koWa ewodeba izol irebul i sadenisagan karkasze an ukarkasod daxveul gragnil s, romel sac gaaCnia gamomyvanebi SesaerTebi ad. Kkarkasi mzaddeba muyaos qaRal disa an pl astmasisagan. koWebi, umetesi el eqtrul i aparatebis ZiriTadi Semadgenel i el ementia da emsaxurebian magnituri nakadis Seqmnas, roml ebic qmnian el eqtromagnitur Zal ebs aparatebis asamuSavebl ad an induqciuri winaRobis Sesaqmnel ad, Tu koWa war-moadgens drosel s

a) koWebis kl asifikacia. koWebi iyofa or j g-ufad: 1) denuri, romel ic Seicavs didi kveTisa da mcire raodenobis xviebs; 2) Zabvis, romel ic Seicavs mcire kveTisa da didi raodenobis xviebs.

koWebi gamoiyeneba el eqtromagnitur kontaktoebSi, magnitur amamuSavebl ebSi, rel eebSi, avtomatur amom-rTvel ebSi, el eqtrul muxruWebSi, el eqtrosazom xel sawyoebSi.drosel ebis saxiT l uminescenciuri naturebis gamSveb-maregul irebel aparatebSi da avtomatikisa da radioteqnikis aparatebis kvebis bl okebSi.

erTi da igive zomis koWebi SeiZl eba damzadebul i iqnes sxvadasxva Zabvebze, cvl ad – 36; 110; 220; 380 da 669 v Zabvaze. mudmiv – 6; 12; 24; 36; 48; 60; 110; 220; 440 v Zabvaze. ami tom axal i aparatebis koWebi unda Semowmdes Sesabamis Zabvaze, razec isini aris damzadebul i. Tu koWas ar gaaCnia etiketi, maSin unda gavzomomT misi winaRoba da SevadarOT igive tipis aparatis koWas.

koWebis gadaxureba iwvevs sadenis aqtiuri winaRobis gazrdas, gamaval i denis Semcirebas da Sesabamisad mcirdeba el eqtromagnitis gul aris mizidvis Zal a, ramac SeiZl eba gamoiwvios rel es mcdari mocveTa, sahaero RreCos gazrda Ruzisa da gul aras Soris da koWas ki dev ufro gadaxureba da gragnil is izol aciis dawva. Aami tom yuradReba unda miვაqციOT, rom koWebi ar gadaxurdes gareSe siTbos wyarodan, magal iTad dayenebul i rezistorebidan

koWis maRal i temperatura SeiZl eba ganpirobebul i iyos SenobaSi arsebul i maRal i temperaturiT; marTvis karadebSi aparatebis mier gamoyofil i maRali i temperaturiT; agreTve aparatis xSiri CarTva-gam-orTviT. maRal i temperatura aCqarebs koWas izol aciis daZvel ebis process. Nnestianobam SeiZl eba SeaRwios fenebs Soris izol aciaSi, rac iwvevs mokl ed SerTvas da Sesabamisad SeiZl eba moxdes gragnil is xviis gawyveta an koWas garkveul i nawil is daSunteba.

dabal i temperaturis dros nesti SeiZl eba gaiyinos koWasSi da koWa gamovides mwyobridan. koWaze gavl enas axdens agreTve meqanikuri zemoqmedebebi, vibraciisa da ryevis saxiT.

zemoTganxil ul zemoqmedebebis gamo koWasSi SeiZl eba dairRves denis wredi xviis gawyvetis, gamomyvani momWer ebis daJangvis, gamomyvanebis gawyvetis, xviaTa nawil is an mTl ianad xviis izol aciis dawvis gamo, ukansknel SemTxvevaSi amboben rom koWa gadaiwva.

b) koWebis diagnostika koWebis diagnostika pirvel rigSi iwyeba maTi daTval ierebiT, radgan umetes SemTxvevaSi iwvis koWis garegani izol acia.

Tu garegani izol acia damwvari ar aris da koWa ar muSaobs, maSin unda movaxdinoT koWis xviebis Semowmeba gawyvetaze Zabvis indikatorisa da ommetris saSual ebiT.

Zabvis indikatoris gamoyenebis dros vargisi gragnil is SemTxvevaSi Zabva unda arsebobdes, rogorc gragnil is erT, ise meore bol oze. Ees uknasknel i Secdomis Tavidan acil ebis mizniT unda iyos gaTiSul i wredidan.

ommetris gamoyenebis dros misi orive bol o unda miuerToT wredidan gamorTul i koWas bol oe bze da vargisianobis SemTxvevaSi ommetri gviCvenebs misi pasportiT naCveneb winaRobas; xol o xviebis damokl ebis SemTxvevaSi - nakl eb winaRobas. Tu xviebis mokl ed SerTva xdeba mxol od Zabvis moqmedebis qveS, maSin ommetrma SeiZl eba ar gviCvenos winaRobis cvl il eba.

g) koWebis Secvl a. xviis gawyvetis, mokl ed SerTvis an sxva dazianebis SemTxvevaSi unda moxdes koWebis Secvl a.

koWebi unda SeirCes arsebul i koWas, Zabvisa da gabaritul i zomebis mixedviT. KkoWas damagrebis win unda Semowmdes xom ar exeba el eqtromagnituri moZravi detal ebi koWis izol acias; Tu exeba, maSin koWa unda davayenoT ise, rom ar iyos Sexeba an dava regul iroT moZravi nawil ebis svl a da mxol od amis Semdeg davamagroT koWa.

yuradReba unda mivaqcioT, rom el eqtromagnitis Ruzisa da gul aras Sexebis dros maT Soris ar darCes sahaero RreCo, radganac sahaero RreCos arseboba

amcirebs gragnil is induqciur winaRobas, am SemTxvevaSi izrdeba deni, ris gamoc SeiZl eba koWa gadaxurdes da gamovides mwyobridan.

4.7. rogor movaxdinoT el eqtrul i aparatebis koWebis gadaxveva erTi saxebidan meoreze

el eqtroaparatebis (rel e, amamuSavebel i, kontaktori da sxva) remontis dros zogj er saWi ro xdeba mudmivi denis koWidan cvl adi denis koWaze gadasvl a an piriqit. Aam dros mosaxerxebel ia visargebl oT martivi formul ebiT da ar vawarmooT magnituri wredis gaangariSeba.

dauSvaT moiTxoveba mudmivi denis koWidan gada videT cvl adi denis koWaze. Aam SemTxvevaSi unda movaxdinoT koWas gadaxveva. Ggadaxvevamde saWi roa:

1. gavzomoT koWas omuri winaRoba (R_1 an R_2)
2. gavzomoT gragnil is srul i winaRoba (Z_1 an Z_2)

ampermetrisa da vol tmetris meTodiT cvl ad denze, formul iT:

$$Z = \frac{V}{I} \text{ omi.}$$

3. daviTval oT (W_1 an W_2) xvიაTa ricxvebi

4. ganvsazRvroT sadenis diametrebi d_1 da d_2 , mm.

R_1, Z_1, W_1, d_1 mniSvnel obebi mi ekuTvneba mudmivi denis koWas anu gadaxvevamde, xol o R_2, Z_2, W_2, d_2 mi ekuTvneba cvl adi denis koWas anu gadaxvevis Semdeg.

gragnil ebis gadaxvevis dros saWi roa amper-xviebis tol oba e.i.

$$I_1 W_1 = I_2 W_2 \text{ anu } \frac{V_{mudm}}{R_1} W_1 = \frac{V_{cvl\ adi}}{Z_2} W_2.$$

radganac cvl adi denis dros induqciuri winaRoba didia, ami tom saWiroa koWis xviaTa ricxvi SevamiciroT n -jer anu $W_2 = \frac{W_1}{n}$.

amperxvibis SenarCunebisaTvis deni unda gazar-dos n -jer, ami tom sadenis diametric unda gazar-dos

$$d_2 = d_1 \cdot \sqrt{n}.$$

srul i winaRoba axal i koWas xvibis ricxvis Semcirebis Semdeg tol i iqneba:

$$Z_2 = \frac{Z_1}{n^2}.$$

Tu CavsvamT $W_2 Z_2$ mniSvnel obebs gamosaxul ebebSi mi vi RebT:

$$G^n = \frac{V_{mudm}}{V_{cvl\ adi}} \cdot \frac{Z_1}{Z_2},$$

sadac Z_1 - gragnil is srul i winaRobaa gadaxvevamde,

4.8. el eqtrul i aparatebis kontaqtobi

a) kontaqtobis kl asifikacia da maTi defeqtobis daxasiaTeba. kontaqtobi warmoadgenen el eqtrul i wredis el ementebis, roml ebic real izebul ia sakontroli o kvanZebisa da sakontaqto SeerTebebis saxiT.

sakontaqto kvanZi sakomutacio aparatebis ZiriTadi nawil ia, xol o sakontaqto SeerTeba axorciel ebs el eqtrul i wredis araganrTvad kontaqtis.

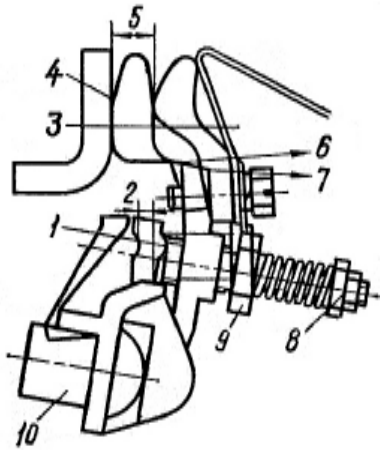
kontaqtobSi garda "el eqtrul i" defeqtobisa (gawyveta) arsebobs specifikuri defeqtobis, roml ebic damokidebul ia maT mier Sesrul ebul funqciaze. Ppirvel rigSi yuradReba unda mieqces im defeqtobis, roml ebic iwveven kontaqtobis muSa mdgomareobis maxasiaTebl i parametrebidan gadaxras da maTi temperaturebis awevas.

sakontaqto kvanZebisaTvis damaxasiaTebl ia defeqtobi, roml ebic xel s uSl ian maTi pirdapiri daniSnul ebiT gamoyenebas, anu wredis CarTva-gamortvas.

b) Eel eqtrul i aparatebis sakontaqto kvanZebis Semowmeba. sakontaqto kvanZebis muSaobis xarixi pirvel rigSi fasdeba iseTi parametreb iT, rogoricaa RreCo, ganacveTi da kontaqtobis dawol a.

RreCo ewodeba gaTisul mdgomareobaSi moZrav da uZrav kontaqtobis Soris minimal ur dasorebas, xol o ganacveTi-dasorebas romel zec gadaadgil deba erTi kontaqt i, Tu movaSorebT meores, romel ic xel s uSl is pirvel is gadaadgil ebas maTi Sexebis Semdeg. Kkontaqtobis ganacveTi SeiZl eba gansazRvrul i iqnes rogorc kontaqtisWerebis svl asa da kontaqtis RreCos Soris sxvaoba. Kkontaqtis konstruqciisa da tipis mixedviT RreCosa da ganacveTis gansazRvrisaTvis zomaven sxvadasxva dasorebebs, xol o maTi regul irebisaTvis iyeneben sxvadasxva saregul irebel el ementebis.

kontaqtis RreCos dasaSvebi mniSvnel oba gansazRvrul ia konkretul el eqtrul aparatis konstruqciul dokumentaciaSi rkal is saimedo Caqrobis principi dan gamomdinare.



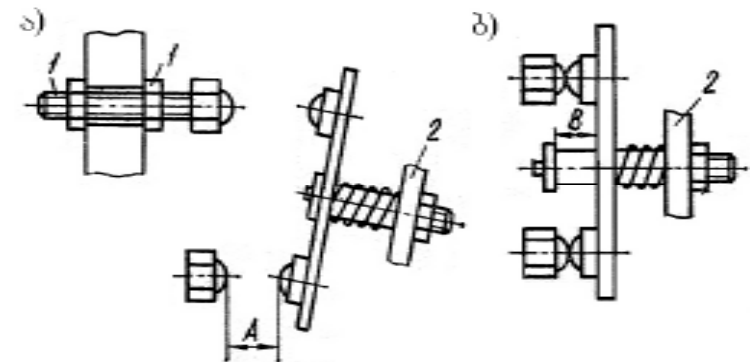
nax. 4.28. KT-6000 tipis kontaktoris el ementebi:
 1-sawyisi dawol is Sesamowmebl ad qaRal dis zol is dayenebis adgil i; 2-kontakrorsa da maregul irebel xraxns Soris arsebul i RreCo; 3-kontaqtebis Sexebis xazi; 4-sabol oo dawol is Sesamowmebl ad qaRal - dis zol is dayenebis adgil i; 5-kontaqtebs Soris RreCo gaTiSul mdgomareobaSi; 6-sabol oo dawol is gansazRvris dros modebul i Zal vis mimarTul eba; 7-modebul i Zal vis mimarTul eba sawyisi dawol is dros; 8-maregul irebel i el ementi (xraxni-qanCis wyvil i), romel ic cvl is zambaris SekumSvas; 9-maregul irebel i el ementi(xraxni), romel ic cvl is kontaktebis ganakveTs; 10-mabruni l artya.

ganacveTs irCeven imgvarad, rom zesadebis maqsimal urad dasaSvebi cveTis SemTxvevaSi kontaktebiT uzrunvel yofil i iqnes wredis saimedo CarTva, radganac praqtikul ad ganacveTis mniSvnel obis gansazRvra SeuZI ebel ia, ami tom amowmeben RreCos, makontrol ebel ganacveTs da mTavari kontaktebis mTI i-anad CarTvis dros kontaktsaWerisa da moZravi kon-

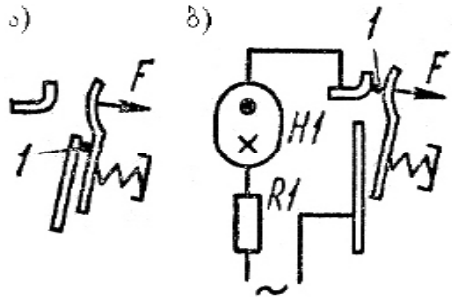
taqtebis wamyvani saxel uris maregul irebel xraxns Soris warmoqmnil RreCos.

MmTavari kontaktebis ganacveTs akontrol eben kontaktoris magnituri sistemis Caketil i mdgomareobis dros. Kkontaktebis zedapiris cveTis Sedegad ganacveTi mcirdeba, rac amcirebs kontaktebis dawol as, ris gamoc izrdeba kontaktebs Soris gardamavali i winaroba da kontaktebi gadaxurdeba.

RreCo da makontrol ebel i ganacveTi izomeba firfitovani sal teebiT. RreCos mniSvnel oba tol ia kontaktebs Soris Semaval i firfitebis jamuri sisqis. Sedegis Sesamowmebl adjer firfitebis nakrebs Seamcireben erT-erTi yvel aze Txel i sisqis firfitiT. Tu gazomva sworad aris Sesrul ebul i, maSin darCenil i firfitebis nakrebi Tavisufl ad unda Sevides RreCoSi.. amis Semdeg pirvel sawyiss nakrebs dau-mateben erT yvel aze Txel i sisqis firfitas. Aam SemTxvevaSi firfitebis nakrebi ar unda Sevides RreCoSi.



nax. 4.29. RreCosa (a) da ganacveTis (b) gazomva sarqvel uri sistemis kontaktoresSi



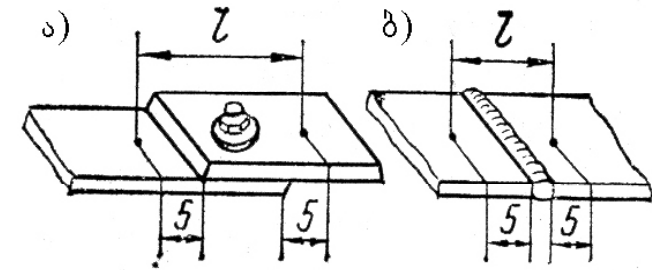
Nax. 4.30. kontaktebis dawol is gazomva

nax. 4.28-ze naCvenebia KT-6000 tipis kontaktoris el ementebi. Nnaxazze qanCi 9 warmoadgens maregul irebel el ements, romel sac SeuZl ia Secval os ganacveTi mocemul i konstruqciis kontaktebSi. kontaktebis RreCo regul irdeba Ruzis Tavis RerZis garSemo subj enamde mobrunebiT, rac gvaZl evs saSu-al ebas vawarmooT am parametris safexurebrivi regul ireba.

sarqvel uri sistemis kontakto rebSi (nax. 4.29) kontaktebis RreCos maregul irebel el ements warmoadgens xraxni_qanCis wyvil i romel ic sqemaze aRniS-nul ia l-iT, Tu Sevcvl iT qanCis mdgomareobas xraxn-ze, maSin Seicvl eba daSoreba A, anu RreCo kontaktebs Soris.

kontaktebis ganacveTi B regul irdeba RreCos svl iT da Sesabamisad traversiT 2, romel zec damagreb- ul ia moZravi kontakti.

kontaktebis dawol a izomeba dinamometriT. amasTanave Zal va unda moedos im mimarTul ebiT rac naCvenebia sakomutacio aparatis konkretul doku- mentebSi. (nax.4.30, a)



nax. 4.31. sakontaqto SeerTebis winaRobis gazomva a) qanCiT SeerTeBa; b) SeduRebiT SeerTeBa

sabol oo Ddawol a izomeba im momentSi, roca Caqre- ba neonis naTura n1, romel ic mimdevrobiT aris CarTu- l i kontaktis wredSi. (nax.4.30, b)

g) sakontaqto SeerTebebis Semowmeba. WanWi ke- biT sakontaqto SeerTebebis Semowmeba SeiZl eba Cava- taroT vizual uri dakvirvebiT, roml is drosac yura- dReba unda mi eqces WanWi kebis raodenobas, zomas, saCe- ri el ementebis arsebobas, SemaerTebel i metal ebis mdgomareobas. gamoTul i Zabvis dros sal teebis sakontaqto zedapirebis momWeris xarisxi mowmdeba maT Soris RreCos gazomviT. sisqIT 0,02-0,03 mm da siganiT 10mm ar unda Sevides sal teebis Soris RreCo- Si sayel uris parametrebiT SezRudul i zonis iqiT. sakontaqto SeerTebis ufro zusti Sefardeba xor- ciel deba winaRobis koeficientiT (nax. 4.31)

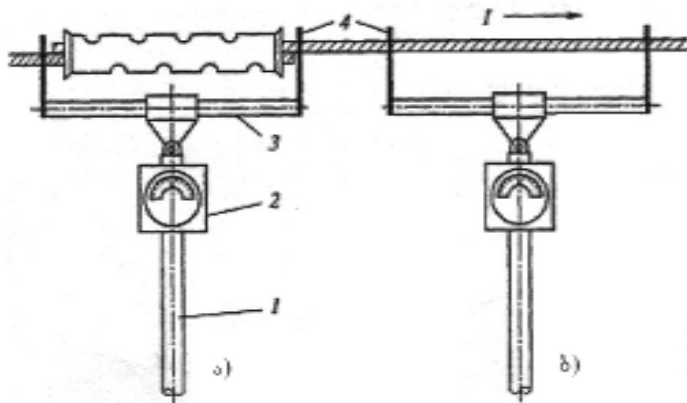
$$K_R = \frac{R_K}{R_{II}} \leq 1,2,$$

sadac R_K - aris l sigrZis ubnis winaRoba, romel ic Sei cavs kontaktur SeerTeBas; R_{II} - aris l sigrZis ubnis winaRoba, romel ic ar Sei cavs kontaktur SeerTeBas.

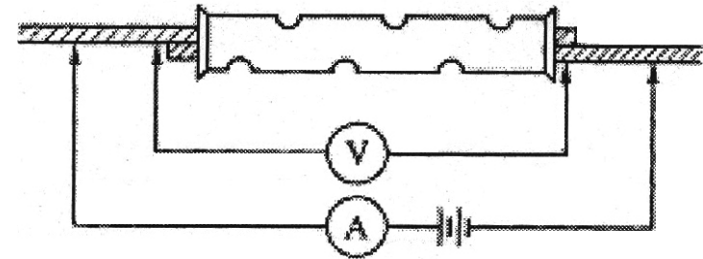
kontaktebis gacxel ebas gansazRvraven maqsimal uri datvirTvis periodSi, magram kontaktebis metal ebs, rogorc cnobil ia aqvT mniSvnel ovani Tbotevadoba da Tbogamtaroba. Aamitom kontakqtis defectis gansazRvra Znel ia.

eqspl uataciis procesSi kontaktebis mdgomareobis ufro zusti Sefaseba SesaZl ebel ia ara gaxurebis aramed: 1) SeerTebis ubanze Zabvis vardnis sidi iT, kontakqtSi denis gavl is dros; 2) gardamaval i winaRobis sididis gazomviT mil ivol metris an ampermetris (an mikroometris) daxmarebiT.

pirvel SemTxvevaSi gazomvas awarmoeben muSa Zabvis qveS sazom Stangaze damagrebul i mil ivol tmetris saSual ebiT ise, rogorc naCvenebia nax.4.32-ze,



Nmax. 4.32. Zabvis gazomvis dros Stangis Tavis mdgomareoba: Aa) sakontaqto SeerTebaze; b) sadenis ubanze; 1-sazomi Stangis izol irebul i nawil i; 2- mil ivol tmetri; 3-sazomi Stangis Tavi; 4- sacecebi, roml iTac CarTul ia mil ivol tmetri



Nmax.4.33. sakontaqto SeerTebis winaRobis gansazRvra mil ivol tmetrisa da ampermetris meTodiT

gazomvis meTodi dafuZnebul ia Zabvis vardnebis Sedarebaze. Ppirvel rigSi zomaven Zabvis vardnas ubanze, romel ic Seicavs sakontaqto SeerTebas, Semdeg im ubanze, romel ic ar Seicavs sakontaqto SeerTebas. Oorive SemTxvevaSi datvirTvis deni unda iyos ucvl el i.

meore SemTxvevaSi wredis gamorTul da damiwebul ubanze CarTaven xel sawyoebis nax.4.33-ze mocemul i sqemiT. xel sawyos kveba xorciel deba mudmivi denis wyarOTi.

xel sawyoebis Cvenebebis mixedviT gansazRvreba gardamaval i winaRoba formul iT:

$$R = \frac{V}{I}.$$

el eqtrul i kontakqturi SeerTebis winaRobis gazomva xdeba 20° temperaturis dros, Tu gazomva xdeba gansxvavebul temperaturaze, maSin winaRobis miRebul i mniSvnel oba daiyvaneba saangariSo (20°) temperaturaze.

**Tavi V. aRricxvis kvanZebis montaJi da
diagnostika**

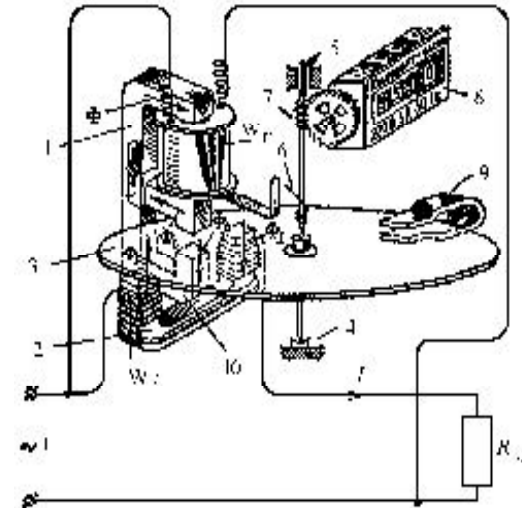
**5.1. el eqtrul i mricxvel ebi, maTi moqmedebis
pricipi da diagnostika**

samrewvel o sixSiris cvl adi denis wredebSi daxarj ul an gamomuSavebul el eqtro energias aRricxaven el eqtrul i energiis mricxvel ebiT. dRei-saTvis gamoyenebul ia induqciuri da el eqtronul i sistemebis mricxvel ebi farTo speqtri. Ppirvel rig-Si ganvixil avT induqciuri sistemis mricxvel ebs, roml ebic j er kidev farTod aris gamoyenebul i aRricxvis sistemebSi.

inducquri sistemebis xel sawyoebi warmoadgenen sazomi vatmetrebis sistemas da miekuTvnebian ara maCvenebl , aramed maintegrirebel i (maj amebel i) sistemis xel sawyoebis. maTi moZravi nawil is mobrunebis kuTxe ar aris SezRudul i da is brunavs simZI avris mniSvnel obis proporciul i sididiT. am SemTxvevaSi moZravi nawil is brunvaTa ricxvis raodenobis mixedviT izomeba el eqtroenergia, romel ic ganisazRvreba simZI avris droze namravl iT ($W = Pt$)

el momaragebis sqemis mixedviT ganaxvaveben **erT-faza** da **samfaza** mricxvel ebs. **erTfaza mricxvel ebi** gamoiyeneba iseTi momxmarebl ebi mier daxarj ul i el eqtroenergiis aRricxvisaTvis, roml ebic ikvebian erTfaza deniT.

nax. 5.1-ze moyvanil ia aqtiuri energiis erTfaza induqciuri mricxvel is mowyobil obis sqematuri gamosaxul eba. mis ZiriTad kvanZebis warmoadgenen:

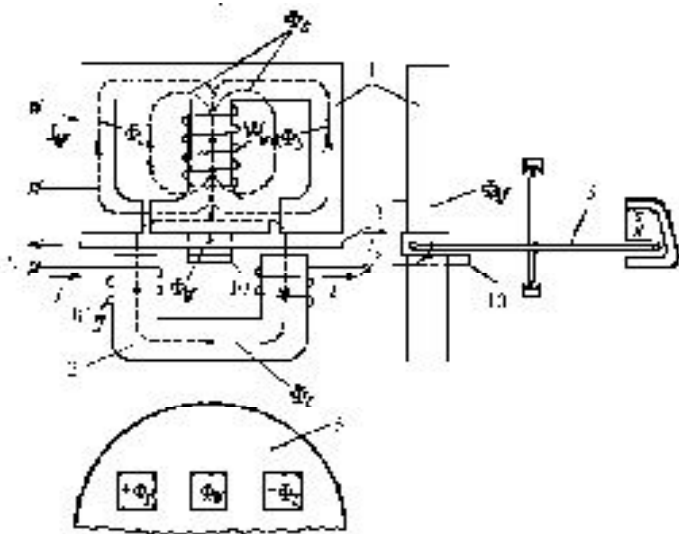


**nax. 5.1. aqtiuri energiis erTfaza induqciuri
mricxvel is mowyobil obis sqematuri gamosaxul eba**

el eqtromagnituri koWa1, romel zec Camocmul ia ramdenime aTasi spil enZis izol irebul i wvril i sadenebisagan daxveul i Zabvis gragnil i W_v , misi winaRoba Seadgens aseul oms; el eqtromagnituri koWa 2, romel zec Camocmul ia ramdenime xviasagan Semdgari spil enZis msxvil i sadenisagan daxveul i denis gragnil i W_r , misi winaRoba TiTqmis nul is tol ia; MmaT Soris moTavsebul ia al uminis Senadnobisagan damzadbul i disko 3, romel ic Tavisufl ad brunavs saqul e 4 da sakisar 5 Soris damagrebul i RerZi 6-is garSemo. RerZze 6 Camocmul ia kbil ana 7, romel ic Tavis mxriv dakavSirebul ia mTvl el meqanizmTan 8. ukumoqmedi anu damamuxruWebel i momentis SeqmnisaTvis gamoyenebul ia mudmivi magniti 9, roml is pol usebs Soris moZraobs al uminis disko; da ukupol usi 10.

nax. 5.2-ze moçemul ia aqtiuri energiis erTfaza induqciuri mricxvel is moqmedebis principis asaxsnel i sqema.

rogorc nax. 5.1-dan Cans Zabvis gragnil i W_V qsel Tan mierTebul ia paral el urad da igi mudmivad **Zabvis qveS imyofeba**. am gragnil Si gamaval i deni I_V daZrul ia VZabvisagan faziT daaxl oebiT 90° (radganac am gragnil s gaaCnia didi induqciuri winaRoba). I_V deni el eqtromagniti 1 Sua gul araSi qmnis magnituri nakads, romel ic iyofa Φ_V, Φ_L da Φ_S nakadebad. nakadi Φ_V Seikvreba ukupol usi 10 gavl iT da gadahkveTs al uminis diskos 3 erT adgil ze, xol o Φ_L



Nnax. 5.2. aqtiuri energiis erTfaza induqciuri mricxvel is moqmedebis principis asaxsnel i sqema

nakadi. Seikvreba el eqtromagniti 1 gverdiTi Reroebis gavl iT ise, rom ar gadahkveTs al uminis diskos 3.

Φ_S fantvis nakadia igi Seikvreba Zabvis gragnil is xviebTan da ar gadahkveTs al uminis diskos.

Φ_V cvl adi nakadi magnitur pol usebs Soris diskoSi aRZravs e.m.Z-s. radgan disko warmoadgens Caketil konturs, amitom e.m.Z diskoze magnitur pol usebs Soris warmoqmnis el eqtromagnitur nakadebs. Eel eqtromagnitur nakadebsa da el eqtromagnitur pol usebs Soris warmoiSveba mizidul obis F_1 da F_2 Zal a. radgan $F_1 = F_2$, amitom disko gawonasworebul ia da igi ar gadaadgil deba.

Ddiskos qvemoTa mxridan moTavsebul ia el eqtromagniti 2, romel zec Camoçmul ia W_I denuri gragnil i, romel Sic gadis datvirTvis deni I , es deni qmnis Φ_I nakads, da radgan magnitogamtars aqvs U-sebri forma, amitom es nakadi orjer gadahkveTs al uminis diskos 3. Ddiskoze moxdeba magnituri Zal xazebis veqtoruli i Sekreba.

erT mxares magnituri nakadi Semcirdeba da gveqneba $\vec{\Phi}_V - \vec{\Phi}_I$, xol o meore mxares magnituri nakadi gairdeba da gveqneba $\vec{\Phi}_V + \vec{\Phi}_I$,

$$\text{e.i. } \vec{\Phi}_V - \vec{\Phi}_I < \vec{\Phi}_V + \vec{\Phi}_I,$$

$$\text{aqedan } F_1 < F_2.$$

diskoze moqmedi Zal ebis wonasworoba dairRveba da disko iwyebis brunvas. rac ufro meti deni gairveba

I is denur koWaSi, miT ufro gairdeba sxvaoba F_1 da F_2 Soris da disko ufro swrafad iwyebis brunvas. Cven Tu Zabvis an denur koWas Sevucvl iT pol arobas, davinaxavT rom disko brunvas daiwyebis sawinaaRm-dego mimarTul ebiT.

diskoze warmoqmnil i mabruni momenti momxmarebl is P aqtiuri simZl avris proporciul ia

$$M = CVI \cos \varphi = C \cdot P, \quad (5.1)$$

sadac C – proporciul obis koeficientia;

$\cos \varphi$ - simZl avris koeficienti, misi mniSvnel obebi mocemul ia danarTSi 2.

rac ufro metia momxmarebl is P aqtiuri simZl avre miT ufro metia al uminis diskos brunvis siCqare da garkveul i drois ganmavl obaSi daxarj uli W el eqtroenergia gamoiTvl eba formul iT:

$$W = VIt \cos \varphi, \quad (5.2)$$

sadac V – fazuri Zabvaa (kv);

I – fazuri deni (a);

t – dro (sT).

mricxvel is konstruqciaSi teqnol ogiurad ganxorcziel ebul ia (5.2) gamosaxul ebaSi Semaval i yvel a parametris funqcia.

samfaza denis wredebSi el eqtroenergiis aRricxvisaTvis gamoyenebul ia samfaza mricxvel ebi, romel - Ta kl asifikacia xdeba Semdegi saxiT:

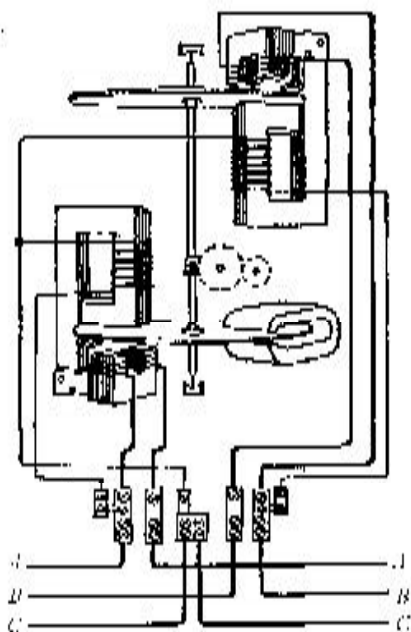
gasazomi energiis saxeobis mixedviT- **aqtiuri** da **reaqtiul i** energiis;

el eqtromomargebis sqemis mixedviT – **samsadeniani** mricxvel ebi, roml ebic muSaoben qsel Si neitral uri sadenis gareSe da **oTxsadeniani**, roml ebic muSaoben neitral ur sadenian qsel ebSi.

CarTvis wesis mixedviT samfaza mricxvel ebi iyofian sam j gufad: **UsaSual o anu pirdapiri** CarTvis, roml ebic qsel Si irTvebian sazomi transformatorebis gareSe. aseTi mricxvel ebi gamoSvebul ia 0.4/0.23 kv Zabvaze da 100 amperamde denze; **naxevrad iribi** CarTviT, aseTi mricxvel ebi denuri gragnil ebiT CarTul ia sazomi transformatorebis gavliT, xol o Zabvis gragnil ebi CarTul ia uSual od qsel Si. aseTi mricxvel ebi gamoiyeneba 1kv Zabvamde; **iribi** CarTvis mricxvel ebi wredSi CairTvebian denisa da Zabvis sazomi transformatorebis gavliT, aseTi mricxvel ebi gamoiyeneba 0.4 kv zeviT;

transformatorul i mricxvel ebi - roml ebic irTvebian qsel Si sazomi transformatorebis gavliT da gaaCniaT gadasaangariSebel i koeficienti $(10 \cdot n)$;

transformatorul i universal uri mricxvel ebi, roml ebic irTvebian qsel Si sazomi transformatorebis gavliT da gaaCniaT transformaciis nebismieri koeficienti. aseTi mrcxvel ebisaTvis gadasaangariSebel i koeficienti gani sazRvreba dadgmul i sazomi transformatorebis koeficientis mixedviT. daniSnul ebidan gamomdinare mricxvel s eniWeba pirobiTi aRniSvna. aRniSvnebsi cifrebi da asoebi aRniSnaven: C - mricxvel i; 00- erTfaza; ΔA - aqtiuri



nax. 5.3. orel ementiani samfaza induqciuri mricxvel is sqematuri gamosaxul eba

energiis; p - reaqtiul i energiis; γ - universal ebi 3 an 4-samsadeniani an oTxsadeniანი wredisaTvis.

aqtiuri da reaqtiul i energiis mricxvel ebi, roml ebi aRWurvil ia damatebiTi mowyobil obebi TmiekuTvnebian specialuri danSnul ebi mricxvel ebs, aseTebia:

o r t a r i f i a n i m r i c x v e l e b i, roml ebi gamoiyenebian iseTi el eqtroenergiis aRricxvisaTvis, roml is tarifi icvl eba

dRe-Ramisa da datvirTvis maqsimumis mixedviT.

tel esazomi mricxvel ebi, roml ebi aRWurvil ia impul sebis gadamwodebiT da mTvl el i meqanizmis Cvenebas gadascemen distancieurad mudmivi denis impul sebis saxiT.

sanimuSo mricxvel ebi, gamoiyenebian saerTo daniSnul ebi mricxvel ebi Sesamowmebl ad.

nax. 5.3-ze moyvanil ia orel ementiani samfaza mricxvel i. aseT mricxvel ebSi gamoyenebul ia iseTve konstruqciul i el ementebi (ori an sami), rac gamoyeneb-

ul ia erTfaza mricxvel ebSi. Ddiskoebi (ori an sami) damagrebul ia saerTo RerZze. Ddiskoebze moqmedi mbrunavi momentebi ij ameba da diskoebis brunvis sicqare damokidebul ia jamur moxmarebul simZl avreze.

sizustis kl asis mixedviT aqtiuri energiis mricxvel i mzaddeba: 0.5; 1.0; 2.0; 2.5; xol o reaqtiul i energiis mricxvel ebi mzaddeba: 1.5; 2.0 da 3.0 kl asis

5.2. mricxvel ebi dayeneba da CarTva

moTxovnebi mricxvel is dasadgmel i saTavsoebisadmi. Mmricxvel is Cvenebis sizusteze gavlenas axdens gareSe faqtorebi: temperatura, tenianoba, haeris qimiuri Semadgenl oba, vibracia da sxva. amitom mricxvel is dasadgel ma adgil ma unda daakmayofil os rigi moTxovnebi:

saTavso, sadac idgmeba mricxvel i unda iyos mSrali, unda Tbebodes da masSi temperatura ar unda aRematebodes $+40^{\circ}\text{C}$ -s. Hhaeri ar unda Seicavdes agre siul minarevebs.

moTxovnebi el eqtromricxvel is montajisaTvis gankuTvnil i konstruqciebisadmi. Mmricxvel ebi idgmeba karadebSi, panel ebze, kompl eqturi gamanawil ebel i mowyobil obebis kamerebSi, kedl ebze, niSebSi. Kkonstruqcia, romel zec idgmeba mricxvel i unda iyos sakmaod mtkice, anu ar unda eqvemdebarebodes vibracias, deformacias da wanacvl ebas.

dasaSvebia mricxvel ebi damagreba xis, pl astmasisa da metal is farebze. Ddadgmis simaRl e unda iyos $0.8\div 1.7$ m. dasaSvebia mricxvel is dadgma ufro

dabal simaRI eze, magram ara umcires 0,4 m-ze. Mmricx-
vel i dadgmul i unda iyos mkacrad vertikal ur si-
brtyeSi.

dauSvebel ia mricxvel ebis dadgma KCO-266 da KCO-
272 da sxva amgvari uj redebis karebebze, radganac
gamokvl evam aCvena, rom am SemTxvevaSi amomrTvel ebis
muSaobis dros ryevis gamo mricxvel ebi ziandeba.

mricxvel is damagreba unda moxdes iseTnairad, rom
SesaZI ebel i iyos misi moxsna da dadgma sibrtiyis
waRma mxridan.

mricxvel ebis dadgmis Tanmimdevroba. Mmricx-
vel ebis dadgmis win saWiroa Sedges samontaJo sqema
an Setanil iqnes saWiro cvl il ebebi mocemul i SeerTe-
bis meorad wredebSi. dadgmisaTvis momzadebul mricx-
vel s unda Cautardes gare daTval iereba. igi gaw-
mendil i unda iqnes mtverisa da WuWysagan; mowmdeba
vargisianoba, misi tipisa da teqnikuri maxasiaTebi ebis
mixedviT da saxel mwifo Semowmebis pl ombebis arse-
boba garsacmis damamagrebel xraxnebze.

pl ombebze aRniSnul i unda iyos saxel mwifo
Semowmebis wel i da kuartal i, agreTve unda gaaCndes
saxel mwifo Semowmebis damRa. Mmowmdeba garsacmisa
da sarkml is minis mTl ianoba, yvel a xraxnisa da sax-
uravis Siga mxareze sqemis arseboba.

mricxvel i dacul i unda iqnas dartyimisagan da
ryevisagan, radgan maT SeuZI iaT gamoiwvi on sayrdeneb-
is dazianeba da RerZebis gaRunva, rac Tavistavad
gamoiwvevs cdomil ebebs. Aamitom mricxvel ebis trans-
portireba unda moxdes special uri SefuTvit.

mricxvel i damagrebul i unda iqnes sami xraxniT
aucil ebl ad vertikal ur mdgomareobaSi.

sadenebis mricxvel Tan SeerTebis dros mizanSe-
wonil ia maragis saxiT 6-7 santimetri sigrZis sade-
nis datoveba. Ees SesaZI ebl obas iZI eva moxdes ga-
zomvis Catareba el eqtrosazomi marwuxebiT; agreTve
Tu sqema akrefil ia arasworad, advil ad moxdes sad-
enis gadaadgil eba. bol os sadenebs unda Camoecvas
niSnsadebi saWde.

TiToeul i sadeni moWeril i unda iqnes ori xrax-
niT. j er msubuqad moeWireba zeda xraxni, xol o Sem-
deg - qveda. Tu montaji srul deba mraval ZarRviani
sadeniT, maSin misi bol oebi winaswar unda iqnes da-
farul i kal iT.

uSual o CarTvis mricxvel ebis montajis dros, Tu
mricxvel is nominal uri deni 20 amperi da metia, ma-
Sin saimedo kontaktebis uzrunvel yofis mizniT
sadenebis SemaerTebel kontaktebs ukeTdeba dabol oe-
bebi. Ddabol oeba sadenTan mirCil ul i unda iqnes
mZI avri sarCil aviT. mricxvel ebTan axl os sadenis
sigrZe datovebul i unda iqnes ara nakl eb 12 sm -isa.

nul ovani sadenis garsacms unda hqondes ganmasx-
vavebel i feri. montajis damTavrebis Semdeg mricxve-
l i, momWerebis krebul i, gadamyvani kol ofebi unda
iqnes dal uqul i.

mricxvel is meqanizmi mTl ianad moTavsebul ia
pl astmisis daxurul yuTSi, mxol od garedan fan-
j araSi ikiTxeba mricxvel is sapasporto monacemebi
da Cvenebebi, rogoricaa: mricxvel is tipi, saqarxno
nomeri, nominal uri Zabva da deni, gadacemaTa rixvi,

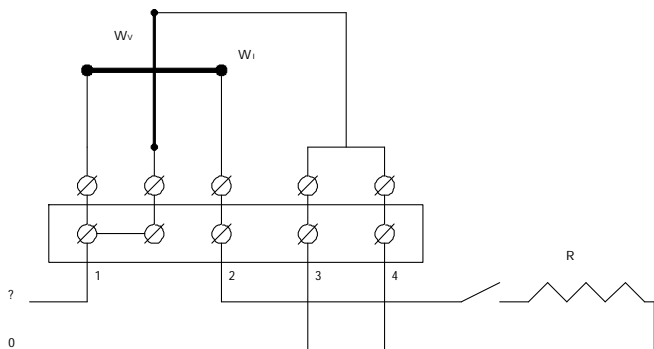
aRricxul i energiis raodenoba, diskos moZraobis mimarTul eba, sizustis kl asi da sxva. mricxvel i gadis l aboratoriul Semowmebas da korpusi il uqeba, magram eqspl uataciis periodSi saWiroeba moiTxovs mis periodul Semowmebas adgil ze, mricxvel is mouxsnel ad muSa mdgomareobaSi.

5.3. aqtiuri energiis erTfaza mricxvel is Semowmeba

Nnax. 5.4-ze moyvanil ia aqtiuri energiis erTfaza mricxvel is el eqtrul i sqema.

Semowmebas viwyebT mricxvel is vizual uri daTval i erebiT. mricxvel s garedan ar unda emCneodes raime fizikuri Zal is zemoqmedebis niSani, amis Semdeg viwyebT mricxvel is muSaobis Semowmebas.

Tavdapirvel ad mricxvel is Semowmeba warmoebis mricxvel is diskos TviTsvl aze. EamisaTvis saWiroa mricxvel s movxsnaT datvirTva anu amovrToT mricx-



Nnax. 5.4. aqtiuri energiis erTfaza mricxvel is el eqtrul i SeerTebis sqema

vel is gamomaval qsel ze SeerTebul i amomrTvel i. am dros disko anel ebs moZraobas da Cerdeba. Tu disko ar gaCerde da gaagrZel a brunva momdevno wreze, maSin aseT mricxvel s gaaCnia TviTsvl a da igi uvargisia.

Semdgom mricxvel i unda SevamowmoT datvirTvis qveS. amisaTvis saWiroa CavrToT ammorTvel i da wammzomis saSual ebiT gavigoT diskos brunvis siCqare da gamovTval oT mricxvel Si gamaval i aqtiuri simZl avre mocemul momentSi formul iT:

$$P_{mr} = \frac{3600 \cdot n}{N \cdot t} kvt \quad (5.3)$$

sadac n aris Semowmebis procesSi aTvl il i diskos mier Sestrul ebul i srul i brunvaTa ricxvi;

t - diskos brunvaTa ricxvis Sesabamisi dro (wm);

N - mricxvel is gadacemaTa ricxvi (br/kvt·sT).

amis Semdeg gavzomoT qsel Si gamaval i simZl avre simZl avris sazomi raime xel sawyoTi. Tu aseTi xel - sawyo ar gagvaCnia, maSin mricxvel i datvirToT iseTivirtiT, romel Ta $\cos \varphi = 1$. aseTebia, gamaxurebel i xel sawyoebi: uTo, el eqtroqura, wyl is gamacxel ebel i, varvara naTurebi; xol o danarCeni xel sawoebi gamovrToT qsel idan da mricxvel is Semowmeba CavararoT wammzomisa da denis marwuxis (nax. 2.26) saSual ebiT. Ddenis marwuxis saSual ebiT gavzomoT qsel is Zabva da datvirTvis deni. Semdeg gamovTval oT qsel Si gamaval i simZl avre mocemul momentSi formul iT:

$$P_{qs} = V \cdot I \cdot \cos \varphi kvt. \quad (5.4)$$

bol os (5.3) da (5/4) formul ebiT miRebul i Semowebis Sedegebi Sevadar oT erTmaneTs:

$$P_{qs} \approx P_{mr} \quad (5.5)$$

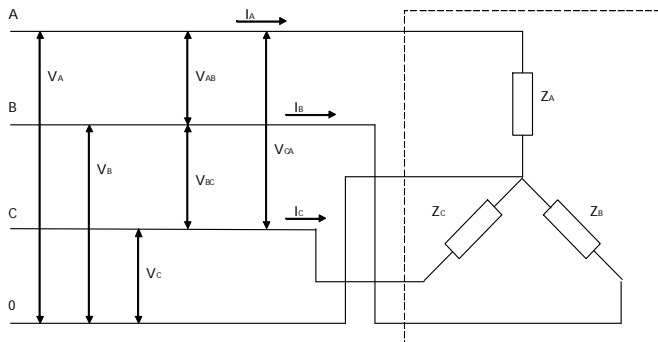
gansxvaveba am or si dides Soris ar unda aRematebodes 2%-s

$$\delta_p = (P_{mr} - P_{qs}) \cdot 100 / P_{qs} \leq 2\%.$$

5.4. dabal i Zabvis pirdapiri CarTvis aqtiuri energiis samfaza mricxvel i

samrewvel o da samoqal aqo el eqtromomargeba, dabal i Zabvis mxares yvel aze xSirad ganxorciel ebul ia nax. 5.5-ze mocemul i samfaza, oTxsadeniani sqemiT, romel Sic xazuri Zabva (V_{AB}, V_{BC}, V_{CA}) 380 v-ia, xol o fazuri (V_A, V_B, V_C) 220 v. aseTi SeerTebis dros qsel is jamuri simZl avre tolia TiTeul i fazis aqtiur simZl avreTa jamisa:

$$F P_{\Sigma} = P_A + P_B + P_C \text{ kvt.}$$



nax. 5.5. el momaragebis samfaza oTxsadeniani sqema

rogorc zemoT avRniSneT, samfaza mricxvel Si konstruqciul ad moTavsebul ia sami erTfaza mricxveli, sami el ementisagan Semdgari, im gansxvavebiT, rom mricxvel is samive el ementi zemoqmedebas axdens mricxvel is erT diskoze da Sesabamisad mricxvel is mTvl el i axorciel ebs el energiis jamur aTvl as.

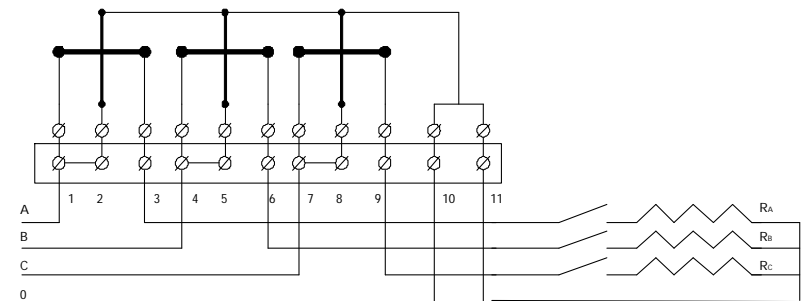
nax. 5.6-ze mocemul ia pirdapiri CarTvis samfaza aqtiuri energiis mricxvel is el eqtrul i SeerTebis sqema. samfaza sistemis cnebidan gamomdinare, aqtiuri energiis mricxvel is veqtorul diagramas eqneba nax. 5.7-ze mocemul i saxe, sadac φ_A, φ_B da φ_C warmoadgenen Zvris kuTxeebs denebsa da Sesabamis fazur Zabvebs Soris.

veqtorul i diagramidan gamomdinare, jamuri simZl avre tolia

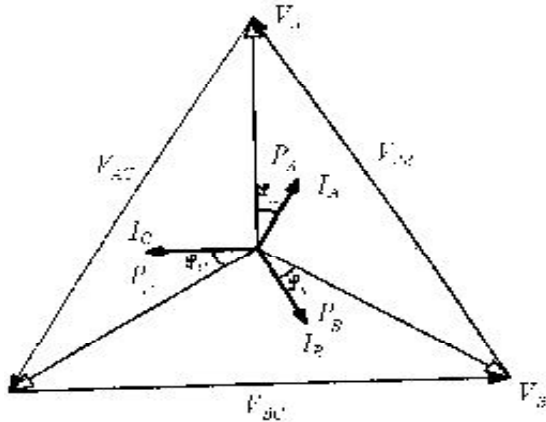
$$P_{\Sigma} = P_A + P_B + P_C = V_A \cdot I_A \cdot \cos \varphi_A + V_B \cdot I_B \cdot \cos \varphi_B + V_C \cdot I_C \cdot \cos \varphi_C.$$

Tu miviRebT, rom samive fazaSi datvirTvebi tolia, maSin

$$F P_{\Sigma} = \sqrt{3} V_A \cdot I_A \cdot \cos \varphi_A, \text{ kvt.}$$



nax. 5.6. pirdapiri CarTvis samfaza aqtiuri energiis mricxvel is samontaJo sqema



nax. 5.7. aqtiuri mricxvel is veqtorul i diagrama

magram praqtikaSi denebi samive fazaSi umetesad gansxvavebul ia, ami tom $P_{P_{\Sigma}}$ -is gamosaxul ebaSi unda SevitanoT samive fazis denebis saSual o sidide da P_{Σ} miRebs Semdeg saxes:

$$P_{\Sigma} = \sqrt{3} \cdot V_s \frac{I_A + I_B + I_C}{3} \cos \varphi. \quad (5.6)$$

gamartivebis Sedegad miReba

$$P_{\Sigma} = V_f (I_A + I_B + I_C) \cos \varphi. \quad (5.7)$$

mricxvel is Semowmebas vawarmoebT igive meTodiT, rogorc erTfaza mricxvel is dros romel ic aRweril ia §5.3-Si. im gansxvavebiT, rom mricxvel is Semaval momWerebze unda davicvat samfaza denis fazebis swori Tanmimdevroba. Semowmebas vawarmoebT fazamaCvenebl iT. fazebis pirdapiri Tanmimdevrobis dros aRniSnul i xel sawyos disko brunavs saat isris mimarTul ebiT, xol o ukuTanmimdevrobis dros

- sawinaaRmdego mimarTul ebiT. uku Tanmimdevrobis SemTxvevaSi mricxvel is romel ime or fazas unda Seucval oT adgil ebi. pirvel rigSi mricxvel s vawarmoebT TviTsvl aze. Semdeg simZl avris sazomi raimexel sawyos arsebobis SemTxvevaSi gavzomoT qsel is TiToeul fazaSi gamaval i simZl avreebi cal-cal ke da miRebul i Sedegebi Sevaj amoT. j amuri simZl avre tol i iqneba:

$$P_{\Sigma} = P_A + P_B + P_C \text{ kvT.}$$

Tu simZl avris sazomi xel sawyo ar gagvaCnia,maSin wammzomiTa da denis marwuxiT CavataroT gazomvebi igive meTodiT ,rogorc erTfaza mricxvel is SemTxvevaSi da (5.6) an (5.7) formul ebiT gansazRvroT qsel is aqtiuri simZl avre.

miRebul i sidide SevdaroT (5.3) formul iT miRebul P_{mr} sidides.Tu

$$P_{\Sigma} \approx P_{mr}.$$

maSin mricxvel i sworad muSaobs.

pirdapiri CarTvis aqtiuri energiis mricxvel ebi saSual ebas iZl eva gamoviyenoT iseT qsel Si, sadac datvirTva ar aRemateba 120 ampers. Uufro mZl avr qsel Si simZl avris aRsaricxavad gamoiyeneba iribi-SeerTebis mricxvel ebi, roml ebi qsel TanmierTebul i arian denis transformatoris saSual ebiT.

5.5. gazomvis zRvaris gafarToebs

zemoT ganxil ul i mricxvel ebi qsel Si uSual od aris CarTul i, amitom aseT mricxvel ebs pirdapiri CarTvis mricxvel ebs uwodeben. Pirdapiri CarTvis

mricxvel ebiT SeiZl eba aRiricxos qsel Si gamaval i energia, roml is deni ar aRemateba 120 ampers, xol o Zabva 400 vol ts. magram praqtikaSi gvxdება SemTxvevebi, rodesac saWiroa mricxvel ebSi 120 amperze meti denis gatareba an qsel Si aris 400 v Zabvaze meti. aseT SemTxvevaSi sazomi xel sawyoebis gazomvis zRvris gafarToebis mizniT gamoiyeneben denisa da Zabvis sazom transformatorebs, roml ebic saSual ebas gvaZl even qsel Si gamaval i didi sididis deni an qsel is maRal i Zabva davadabl oT mricxvel is nominal ur denamde da Zabvamde.

5.6. denis sazomi transformatori

denis sazomi transformatori (Semokl ebiT denis transformatori) gamoiyeneba iseTi sazomi xel sawyoebis zRvris gafarToebisaTvis romel Tac gaaCniaT denuri gragnil i (ampermetrebi, mricxvel ebi, fazometrebi, vatmetrebi da sxva). Ddenis transformatori Sedgeba magnitogamtarisagan, erTi pirvel adi da erTi an ramdenime meoreul i gragnil isagan.

dabal i Zabvis iribi SeerTebis mricxvel is nominal ur deni standartiT miRebul ia 5 a. Aami tom denis sazomi transformatorebis meoreul i gragnil is nominal uri deni Cveul ebriv 5 amperzea gaTval iswinebul i. iSviaTad gvxdება denis transformatorebi 1a da 10 a meoreul i deniT. Ppirvel adi deni SeiZl eba icvl ebodes 5-15000 amperis fargl ebSi sazomi transformatoris tipis mixedviT.

denis transformatoris el eqtrul i sqema mocemul ia nax. 5.8-ze.

pirvel adi gragnil i warmoadgens spil enZis an al uminis sal tes, romel ic gatarebul ia gul aras SuaSi da gankuTvnil ia uSual od Zal ovan qsel Si CasarTvel ad, xol o meoreul i gragnil i, romel ic ramdenime aTeul i xvii sagan Sedgeba, daxveul ia aRniSnul gul araze da gankuTvnil ia el .aparaturaze misaerTebl ad. Ffaqtobrivad denis sazomi transformatori warmoadgens Zabvis amamaRI ebel transformators, magram radgan meoreul i gragnil i mierTebul ia iseT xel sawyoebTan rogoricaa: mricxvel ebis denis gragnil i, ampermetri da sxva romel Tac wi naRoba TiTqmis ar gaaCnia, meoreul gragnil s mokl ed SerTvis rejimSi uwevs muSaoba da amitom mas denis transformators uwodeben. aqedan gamomdinare usafRTxoebis mizniT, qsel Si CarTul i denis transformatoris meoreul i gragnil i, Tu is gamoyenebul i ar aris an Semowmebis dros moiTxovs wredis gaxsnas, yovel Tvis unda iyos damokl ebul i. wi naaRmdeg SemTxvevaSi meoreul wredSi aRiZvreb a didi e.m.Z (1000-1500v), romel ic saSiSia adami anis sicocxl isa da meoreul i gragnil is izol aciisaTvis.

denis transformatoris pirvel i gragnil is sawyisi da bol o aRiniSneba Λ_1 da Λ_2 , xol o meoreul i gragnil isa - I_1 da I_2 . Λ_1 da I_1 momWerebi erTsaxel a momWerebia. es niSnavs rom Tu pirvel ad wredSi deni mimaRTul ia Λ_1 -dan Λ_2 -saken, maSin meoreul wredSi I_1 iqneba Semaval i, xol o I_2 gamomaval i. gamanawl ebel mowyobil obebSi denis transformatore-

bi unda gayendes ise rom Λ_1 momWeri mimarTul i iyos Semkrebi sal teebis mxares.

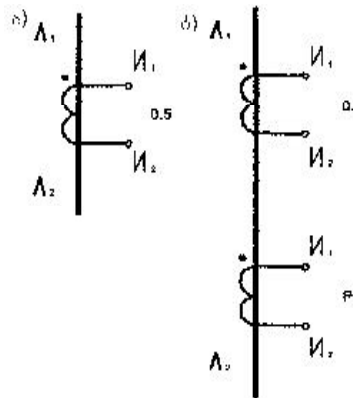
denis transformatorSi pirvel adi denis Sefardebas Sesabamis meoreul denTan denis transformatoris transformaciis koeficienti ewodeba da gani sazRvrebaf formul iT:

$$FK_i = \frac{I}{i}, \quad (5.8)$$

sadac I - pirvel adi denis sidide;
 i - meoreul i denis sidide.

transformaciis koeficienti transformatoris pasportSi naCvenebia wil adis saxiT. mricxvel Si naCvenebia nominal uri pirvel adi deni, xol o mniSvnel - Si _ meoreul i deni. Mmag. 100/5 a, anu $K_i = 20$.

aRniSnul i wredebSi gamoyenebul i denis transformatorebis sizustis kl asi ar unda aRematebodes 0,5.



max. 5.8. denis sazomi transformatoris el eqtrul i sqema

max. 5.9-ze naCvenebia denis transformatoris sizustis kl asi datvirTvaze damoyidebul ebis grafiki.

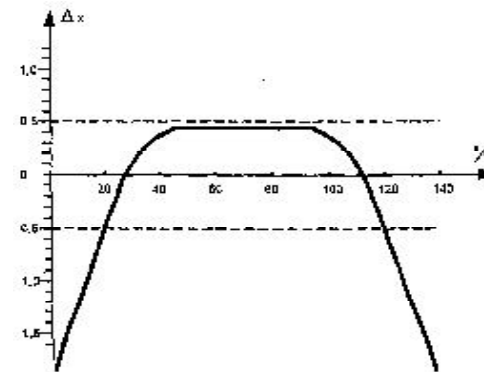
rogorc grafikul i gamosaxul ebidan cans, denis transformatoris sizustis kl asi 20%-dan 120%-is datvirTvis fargl ebSi akmayofil ebs sizustis kl asis pirobas. danarCen SemTxvevaSi sizustis kl asi dar-

Rveul ia. rac ufro mcired da rac ufro zedmetad aris datvirTul i denis transformatoris, miT ufro izrdeba cdomil eba. Aaqedan gamomdinare denis transformatoris SerCevisas saWiroa gaviTval iswinot zemoT aRniSnul i pirobebi.

denis transformatorze damagrebul ia misi sapasporto monacemebi: tipi, saqarxno nomeri, dasaSvebi Zabva, nominal uri simZl avre, sizustis kl asi.

udidesi datvirTva, roml is drosac denis transformatoris cdomil eba ar gamodis sizustis kl asis sazRvrebidan naCvenebia sapasporto cxril Si. Mmag., 0,5 kl asi ТПЛ tipis denis transformatoris gragnil is datvirTva ar unda aRematebodes 0,4 oms.

denis transformatoris damontaJebisas denis transformatorebis meoreul i gragnil is erTi bol o da garsacmi unda iqnes Camiwebul i da unda gaaCndes Semowmebis oqmi, sadac dafiqsirebul i iqneba misi sapasporto monacemebi da gazomvis Sedegebi, rogori- caa:



max. 5.9. sizustis kl asi datvirTvaze damokidebul ebis grafiki

1. izolacia;
2. vol tamperuli maxasiaTebl ebi;
3. transformaciis koeficienti;
4. pol aroba.

rac Seexeba maRal i Zabvis (6/10)kv. Ddenis transformatorebs, maT gaaCniaT ori meoreul i gragnil i (nax 5.8, b) aRricxvisa da sazomi xel sawyoebisatvis 0.5 kl asiT da sarel eo dacvisatvis gankuTvnil i gragnil i, roml is kl asi aris 10.

maRal i Zabvis denis transformatorebis izolacia damatebiT unda iqnas Semowmebul i maRal Zabvaze.

nax. 5.10-ze naCvene bia sxvadasxva tipis denis transformatorebi.



a)



b)



g)



d)



z)

v)

nax. 5.10. denis transformatorebi:

- a) T-0,66; b) ТПОЛ-10-1; g) УТТ-5М;
 e) ТШЛ; v) ТЗРЛ; z) ТЗЛМi tipis

denis transformatorebis arCeva unda moxdes Semdegi monacemebis mixedviT: a) nominal uri denis; b) transformatoris koeficientis; g) sizustis kl asis, romel ic gansazRvravs fardobiTi cdomil ebis sidides nominal uri datvirTvis dros; d) pirvel adi wredis nominal uri Zabvis mixedviT.

denis transformatorebi mzaddeba 0.66; 6; 10; 15; 20; 24; 27; 35; 110; 150; 220; 330; 500; 750 kv nominal ur Zabvaze da 1-40000a nominal ur denze.

denis transformatorebs Semokl ebul i aRniS-vnebi: T-denis transformatori; II-gamaval i; O-erTx-viani; W-sasal te; K-koWiiani; Ф-faifuris izolaci iT; Λ-izolacia sinTetikuri fisisagan; γ-gaZl ierebul i; B-amomrTvel Si CaSenebul i; B-swrafgaJRenT-vadi; D,3-diferencial uri da mokl ed SerTvis dacvis; A-al uminis pirvel adi gragnil iT; P- sarel eo dacvis; H- gare dayenebis; M i- zeTiani; q?- amaR- l ebul i sixSiris.

5.6. Zabvis sazomi transformatori

Zabvis sazomi transformatori (Semokl ebiT Zabvis transformatori) gamoiyeneba avtomatikis, sarel eo dacvis, signal izaciis kvebisa da aseTi xel sawyoebis gazomvis zRvaris gafarToebisatvis, romel Tac gaaCniaT Zabvis gragnil ebi (vol tmetrebi, mricxvel ebi, vatmetrebi, fazometrebi, sixSirmzomebi da sxva).

maRal i Zabvis qvesadgurebSi Zabvis makontrol ebel i xel sawyoebi rogoricaa: kil ovol tmetri, rel euri dacvis Zabvis gragnil ebi, mricxvel is Zabvis gragnil ebi da sxva standartis mixedviT damzadebul ia

100v sidids Zabvaze, amitom Cveul ebriv Zabvis transformatoris meoreul i Zabva 100 vol tia. Zabvis transformatori maRal Zabvas (6-10kv) daadabl ebs 100 vol - tis sididemde, magram faqtiuri Zabvis mniSvnel obis misaRebad saWiroa miRebul i Zabva gavamravl oT Zabvis transformatoris koeficientze. Zabvis transformatoris koeficienti tol ia

$$K_V = \frac{V_{mal}}{V_{dan}} \quad (5.9)$$

Tu Cven SemTxvevaSi maRal i Zabva 6kv-ia, maSin

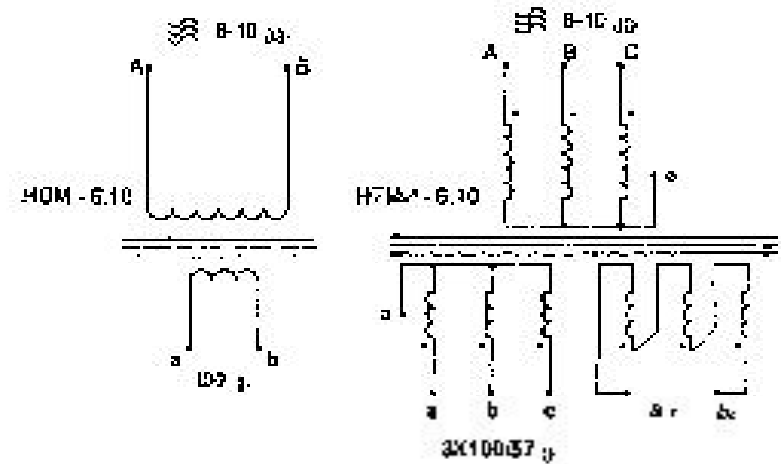
$$F K_V = \frac{6000}{100} = 60,$$

xol o Tu maRal i Zabva 10 kv-ia, maSin

$$F K_V = \frac{10000}{100} = 100.$$

Zabvis transformatori SeiZl eba iyos rogorc erTfaza, ise samfaza. erTfaza Zabvis transformatoris pirvel adi gragnil is (BH) gamomyvanebi aRiniSnebian A-X-iT. es gragnil i qsel is ZabvasTan paral el urad aris mierTebul i; meoreul i gragnil is (HH) gamomyvanebi aRiniSneba a-x-iT. Ees gragnil i mierTebul ia vol tmetrTan an ufro rTul i xel sawyos Zabvis gragnil Tan.

samfaza Zabvis transformatoris pirvel adi gragnil is gamomyvanebi aRiniSneba A, B, C asoebiT, xol o meoreul i gragnil is gamomyvanebi - a, b, c-Ti. samfaza Zabvis transformators damatebiT gaaCnia kidev erTi gragnil i. Ria samkuTxedi, romel ic gamoiyeneba qve-



ა) ერთფაზის ტრანსფორმირების სქემა ბ) სამფაზის ტრანსფორმირების სქემა
ნახ. 5.11. Zabvis transformatoris el eqtrul i sqema

sadgurebSi Camiwebis dacvis kontrol isaTvis. Mmisi gamomyvanebi aRiniSnul ia a_g da x_g -Ti. Zabvis transformatorebis nominal uri simZl avre 200-2000 vol - tamperia. gazomvebis dros Secdomis Tavidan acil ebis mizniT Zabvis transformatoris meoreul gragnil Tan unda CairTos xel sawyoTa iseTi raodenoba, romel Ta saerto momxmarebl is simZl avrem ar gadaWarbos am transformatoris nominal ur simZl avres. Nnax. 5.11-ze moyvanil ia erTfaza da samfaza Zabvis transformatoris el eqtrul i sqema

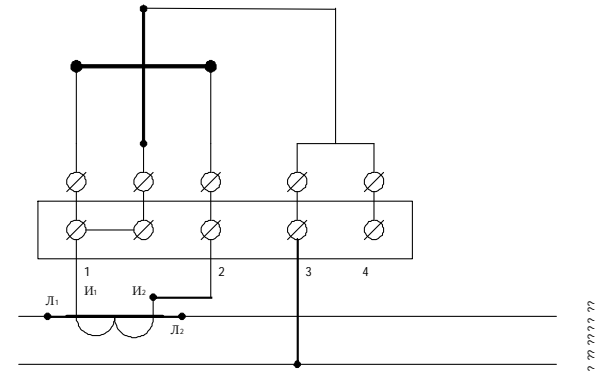
Zabvis transformatoris saSiS rejimad iTvl eba meoreul i wredis momWerebis mokl ed SerTva, radgan am SemTxvevaSi aRiZvrebian didi zedenebi. zedenebi-sagan dacvis mizniT Zabvis transformatorebi maRa- l i Zabvis qsel Tan dakavSirebul ia mdnobadi mcvel eb-

5.7. dabal i Zabvis arapirdapiri mierTebis aqtiuri energiis samfaza mricxvel is montaJi da Semowmeba

naxevrad iribi CarTvis SemTxvevaSi mricxvel is qsel Tan mierTeba ganxorciel ebul ia denis transformatoris saSual ebiT. denis transformatoris SerCeva xdeba \$ 5.5-Si moyvanil i monacemebis mixed-viT. nax. 5.14-ze mocemul ia erTfaza aqtiuri energiis mricxvel is naxevrad iribi CarTvis sqema. am SemTxvevaSi mricxvel is Semowmeba mimdinareobs igive meTodiT, rogorc pirdapiri CarTvis SemTxvevaSi, im gansxvavebiT, rom aq (5.3) gamosaxul ebaSi damatebiT Sedis denis transformatoris transformaciis koeficientis K-s mniSvel oba da gamosaTvl el formul as aqvs Semdegi saxe;

$$P_{mr} = \frac{3600 \cdot n}{N \cdot t} K \text{ kvт.} \quad (5.10)$$

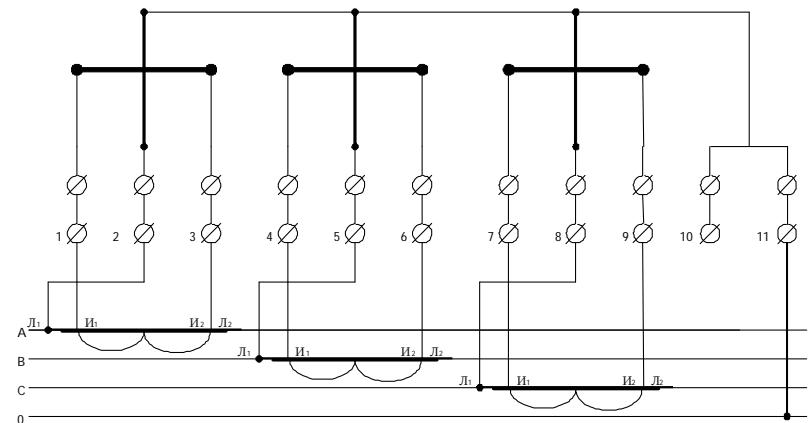
naxevrad iribi CarTvis samfaza aqtiuri energiis mricxvel i warmoadgens samel ementian mricxvel s, romel ic gankuTvnil ia oTxsadenian sistemaSi muSao-bisTvis yovel i el ementis denis gragnil ebi gaTv- l il ia $I_H=5$ a-ze, xol o Zabvis gragnil ebi gaTvl il ia $V_H=220$ v fazur Zabvebze. Zabvis gragnil ebi erTmaneTTan SeerTebul ia varskvl avad, amitom mricxvel is Zabvis 2-5-8 momWerebze, erTTmaneTs Soris gvaqvs xazuri Zabvebi 380 v, xol o igive momWerebsa da nul s Soris - fazuri Zabvebi 220 v. aseTi oTxsadeniani sistemis mricxvel ebze Zabva aRiniSneba 220/380 v-iT. Mmricxvel is el eqtrul i sqema igivea, rac pirdapiri CarTvis samfaza mricxvel is N(nax. 5.6) SemTxvevaSi,



nax. 5.14. erTfaza aqtiuri energiis mricxvel is naxevrad iribi CarTvis sqema

xol o samantaJo sqema gansxvavebul ia imiT, rom aq Zabvis gragnil ebi 2-5-8 gamoyvanil ia cal ke momWerebze (nax. 5.15) da zRedarebi gaTiSul ia.

praqtikaSi gamoyenebul ia samfaza iribi mricxvel is denis transformatorebTan SeerTebis sami sqema,



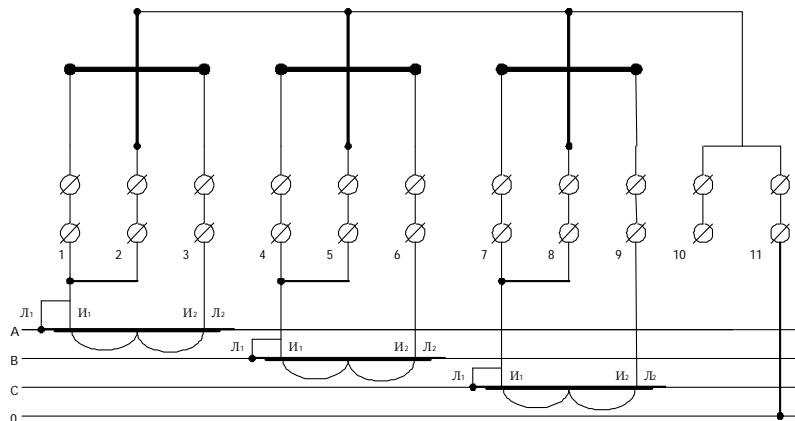
nax. 5.15. samfaza aqtiuri energiis mricxvel is naxevrad iribi CarTvis sqemis pirvel i varianti

roml ebic variantebis saxiT mocemul ia nax. 5.15; nax. 5.16; nax. 5.17-ze.

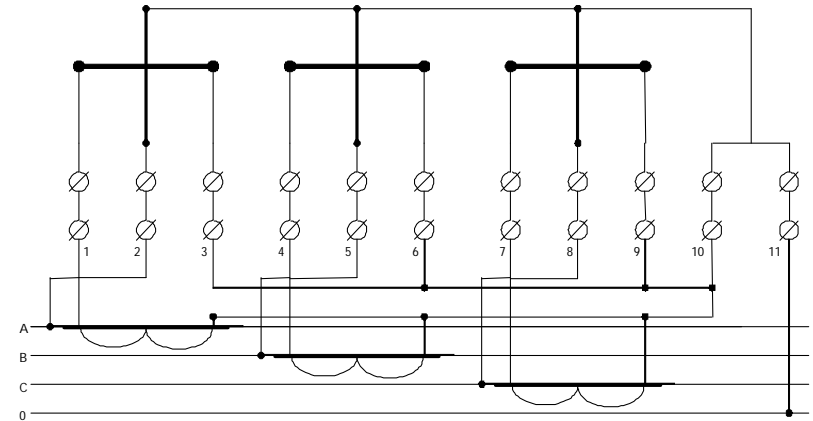
sadeni, roml is saSual ebiTac aRricxvis kvanZis meoreul komutacias vawarmoebT, unda iyos aucil e-bl ad spil enZis da misi kveTi 2.5 mm² unda Seadgendes. Ees im SemTxvevaSi, Tu sadenis sigrZe denis transformatorebidan mricxvel amde ar aRemateba 10 metrs

sadenis sigrZis zrdaSTan erTad unda gavzardoT misi ganivkveTis farTobi.

mricxvel ebis CarTva denis transformatorebTan moiTxovs mocemul i sqemis zust Sesrul ebas. winaaRmdeg SemTxvevaSi aRricxvis kvanZi imuSavebs cdomi-l ebiT. yuradReba unda mivaqciOT imas, rom mricxvel s ar gaaCndes TvITsvl a. amisaTvis saWi-roa pirvel rigSi § 5.4-Si moyvanil i pirdapiri CarTvis samfaza mricxvel is Semowmebis anal ogiurad Sevamow-



nax. 5.16. samfaza arapirdapiri CarTvis aqtiuri energiis mricxvel is denis transformorebTan mierTebis sqemis meore varianti



nax.5.17. samfaza aqtiuri energiis mricxvel is naxebrad iribi CarTvis sqemis mesame varianti

moT mricxvel is Zabvis momWerebze fazebis swori Tanmimdevroba.

amis Semdeg SevamowmoT mricxvel is yovel i el ementi cal cal ke mricxvel is diskos brunvis mimarTul ebaze. amisaTvis saWi-roa viqoniOT damatebiTi aqtiuri winaRoba simZl avriT 2-dan 5 kvT-mde. aRniSnul i winaRobiT unda davtvirToT qsel i saTiTaod fazebis mixedviT da erTdroul adv unda davakvird-eT mricxvel is diskos. disko yovel Tvis unda muSaob-des "win" mimarTul ebiT. Tu romel ime fazaze disko brunavs "ukan" mimarTul ebiT, maSin am el ementze Semaval i denis sadenis wwerebi unda gadavaadgil OT erTmaneTSi. Tu amanac ar uSvel a, maSin unda vivarau-doT rom Zabvis sadenebis wwerebi sworad ar aris SerCeul i Tavis fazaze. Ddisko, romel ime el ementis Semowmebis dros, SeiZl eba saerTod ar daiZras, maSin

unda movZebnoT denis wredSi dazianeba (an sadenia gawyvetil i, an denis transformatoris meoreul i gragnil ia dazianebul i) an SeiZl eba am el ements Zabva ar miwodeba. sabol ood unda mivaRwi oT imas, rom yovel i el ementis Semowmebis dros, mricxvel i unda midiodes "win" mimarTul ebiT.

magram aris iseTi SemTxveva, rodesac mricxvel is disko TiTeul i el ementis Semowmebis dros midis "win"mimarTul ebiT, magram qsel Si gamaval i simZl avre dasaSvebze metad gansxvavdeba mricxvel is mier naCvene bi simZl avrisagan:

$$P_{qs} \neq P_{mr}$$

es im dros xdeba, rodesac mricxvel is samive el ementze denebi miwodeba SebrunebiT da Zabvebi ki Sesabamisad denebs ar eTanadeba, anu Zabvebi daZrul ia denebis mimarT.am SemTxvevaSi, Tu qsel Si gvaqvs sufTa aqtiuri datvirTva, mricxvel i aRricxavs naxevar simZl avres, xol o Tu qsel Si gvaqvs reaqtul i simZl avre, maSin Zabvebis DdaZvriT mricxvel ma SeiZl eba aRricxos faqtur simZl avresTan SedarebiT an Zal ian mcire (SeiZl eba mricxvel is diskom sawinaaRmdego mimarTul ebiTac imozraos) anZal ian didi energia.

qsel Si arsebul i simZl avris koeficientis dasadgenad, Tu saWiro xel sawyoebi ar gagvaCnia dagvexmareba aRricxvis wredSi aqtiur mricxvel Tan erTad CarTul i reaqtul i mricxvel i.

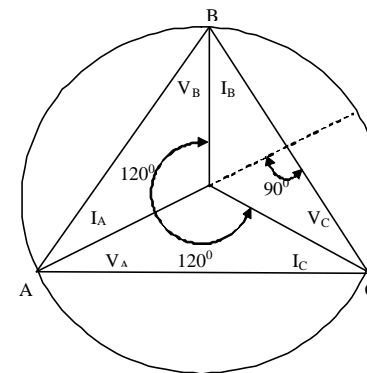
5.8. dabal i Zabvis reaqtul i energiis samfaza mricxvel is montaJi da Semowmeba

Tu aqtiuri energiis samel ementian mricxvel Si CarTvis sqemas Sevcvl iT iseTnairad, rom TiToeul i el ementis densa da Zabvas Soris iqneba damatebiTi 90°-iani Zvris kuTxე, maSin aqtiuri energiis mricxveli i gardaiqmneba reaqtul i energiis mricxvel ad, radgan $\sin\varphi = 90^\circ - \varphi$, xol o samfaza wredis reaqtul i energia gamoiTvl eba formul iT:

$$Q = \sqrt{3}V_x \cdot I_x \cdot \sin\varphi, \text{ kvar}, \quad (5.11)$$

sadac $\sin\varphi$ -s mniSvnel oba aiReba danarTi 2-Si mocemul i cxril idan.

90°-iani Zvris kuTxis miRebis principi aixsneba nax. 5.18-ze warmodgenil i veqturul i diagramiTa da nax. 5.19-ze mocemul i samfaza reaqtul i energiis 90°-



nax. 5.18. samfaza reaqtul i energiis 90°-iani Zvris kuTxis mqone mricxvel is veqturul i diagrama

iani Zvris kuTxis mqone mricxvel is sqemiT, sadac Zabvis gragnil ebi SeerTebul ia samkuTxedad da denur gragnil ebTan SedarebiT gadaadgil ebul ia. am naxazebidan Cans, rom pirvel el ementSi I_A deni SeuRl ebul ia ara V_{AB} ZabvasTan, rogorc es xdeba aqtiuri energiis SemTxvevaSi, aramed V_{BC} ZabvasTan. sufTa aqtiuri datvirTvis dros I_A

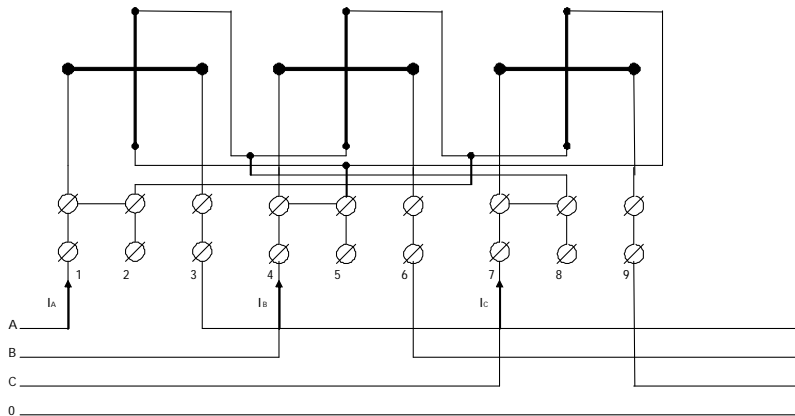
deni umTxveva V_A Zabvas da daZrul ia V_{BC} Zabvisagan 90° -iT. Tu I_A da V_A -s Soris Zvris kuTxearis φ , maSin I_A deni V_{BC} Zabvis mimaRT daZrul i iqneba ($90^\circ + \varphi$) kuTxiT. anal ogiurad 90° -iani Zvra miReba or sxva danarCen el ementebze da samfaza jamuri reaqtiul i energia gamoiTvl eba formul iT:

$$Q_\Sigma = Q_A + Q_B + Q_C = \frac{V_{BC}}{\sqrt{3}} I_A \cdot \sin \varphi_A + \frac{V_{CA}}{\sqrt{3}} I_B \cdot \sin \varphi_B + \frac{V_{AB}}{\sqrt{3}} I_C \cdot \sin \varphi_C. \quad (5.12)$$

Tu mi viRebT, rom

$$V_{BC} = V_{CA} = V_{AB}; I_A = I_B = I_C; \angle \varphi_A = \angle \varphi_B = \angle \varphi_C,$$

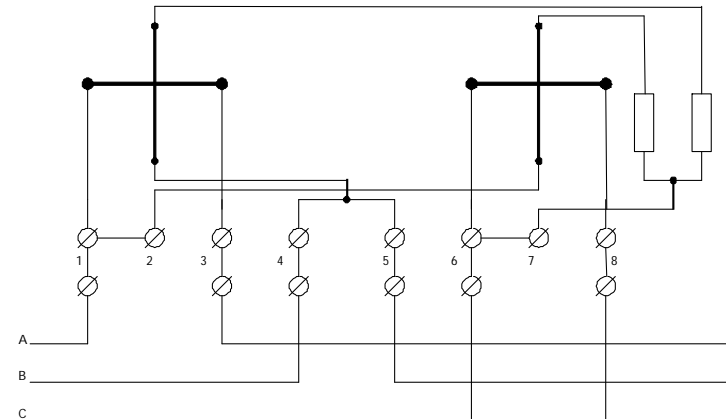
$$\text{maSin } Q = \sqrt{3} V_x \cdot I_f \cdot \sin \varphi. \quad (5.13)$$



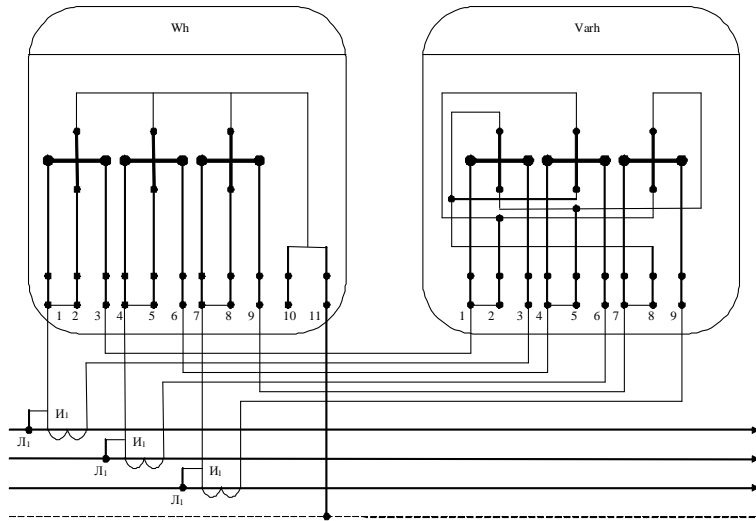
max. 5.19. samfaza reaqtiul i energiis 90° -iani Zvris kuTxis mqone mricxvel is sqemea

reaqtiul i energiis gazomvisaTvis samel ementian mricxvel ebTan erTad sam- da oTx sadenian sistemeb-Si nul ovani sadenis gareSe farTod gamoiyeneba agreTve martivi orel ementiani samfaza mricxvel i 60° -iani Zvris kuTxiT. aseTi Zvra miRweva Zabvis wredebSi damatebiTi rezistorebis CarTviT. 60° -iani Zvris KkuTxeari eba Sesazl ebl obas mi viRoT $\sin \varphi$ -s proporciul i mbrunavi momenti martivi konstruqci iT. 60° -iani Zvris kuTxis mqone mricxvel i (max. 5.20) ufro moxerxebul ia, radgan misi CarTvis sqema isetivea rogorc orel ementiani aqtiuri energiis mricxvel isa. reaqtiul i energiis mricxvel is. Ddenis gragnil ebi gaTvl il ia 5 a denze, xol o Zabvis gragnil ebi -400 v Zabvaze.

reaqtiul i mricxvel is mier aRricxul i el energia ganisazRvrebaze 5.3-Si moyvanil i aqtiuri energiis mricxvel is Semowmebis anal ogiurad, formul iT:



max. 5.20. 60° -iani Zvris kuTxis mqone samfaza reaqtiul i energiis mricxvel is sqemea



max. 5.21. samfaza reaqtiul i energiis mricxvel is CarTvis sqemis erT-erTi varianti

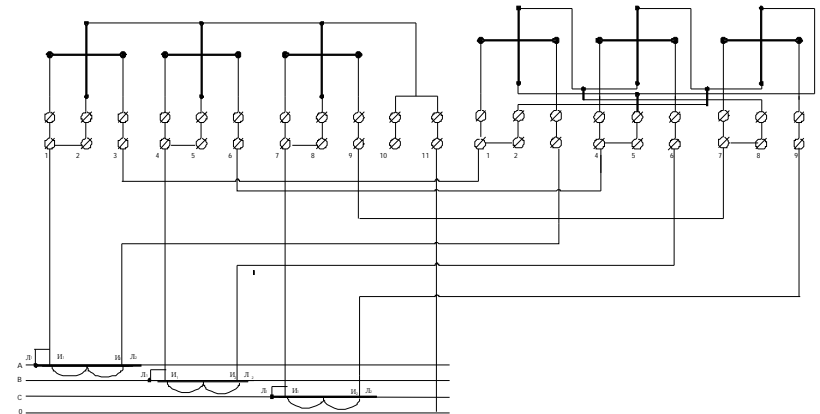
$$Q_{mr} = \frac{3600 \cdot n \cdot K}{N \cdot t} \text{ kvar.} \quad (5.14)$$

ZiriTadad reaqtiul i mricxvel ebi CarTul ia aRricxvis wredSi aqtiur mricxvel ebTan erTad. Ees saSual ebas iZl eva advil ad gamoiTval os reaqtiul i simZl avris koeficienti mocemul momentSi, formul iT:

$$Q_{mr} / P_{mr} = tg \varphi. \quad (5.15)$$

Semdeg danarTi 2-Si mocemul i cxril is saSual ebiT vpoul obT $\cos \varphi$ sididis mniSvnel obas. Tu cxril i ar gagvaCnia, maSin $tg \varphi$ -s mi xedvi T vsazRvravT qsel is simZl avris koeficients formul iT:

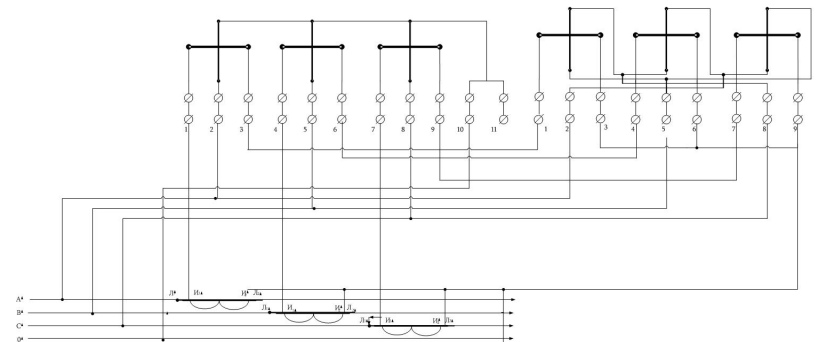
$$\cos \varphi = \frac{1}{\sqrt{1 + tg^2 \varphi}}. \quad (5.16)$$



max. 5.22. aqtiuri da reaqtiul i energiis samel ementiani mricxvel ebis oTxsadenian qsel Si naxevrad iribi CarTvis sqema Zabvisa da denis SeTavsebul i wredebiT

$$\text{xol } \sin \varphi = \sqrt{1 - \cos^2 \varphi}. \quad (5.17)$$

max. 5.22-ze mocemul ia aqtiuri da reaqtiul i energiis samel ementiani mricxvel ebis oTxsadenian qsel Si naxevrad iribi CarTvis sqema Zabvisa da denis SeT-



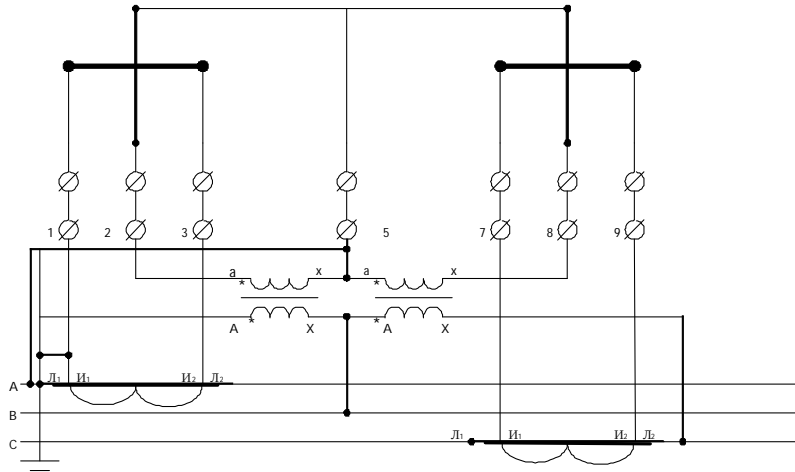
max. 5.23. aqtiuri da reaqtiul i energiis samel ementiani mricxvel ebis oTxsadenian qsel Si naxevrad iribi CarTvis sqema gancal kevebul i wredebiT

avsebul i wredebiT,xol o nax. 5.23-ze -gancal kevebu-
li wredebiT.

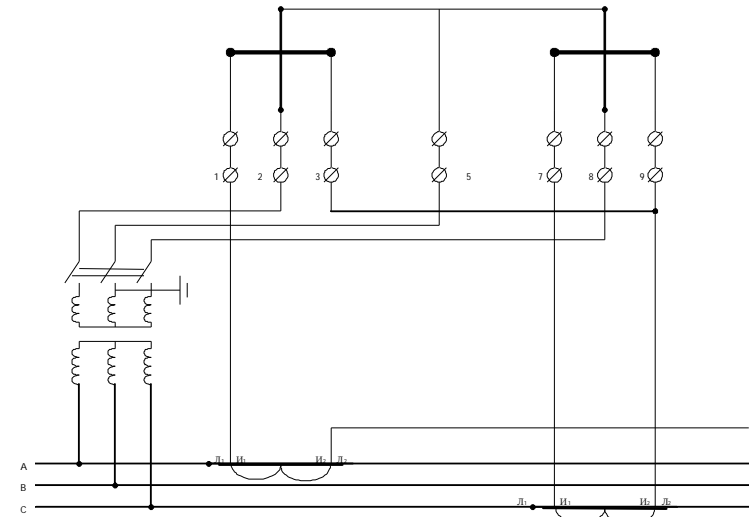
aqtiuri da reaqtul i mricxvel ebis mier aR-
ricxul i el energiis dRe-Ramuri an Tviuri xarj eb-
is mixedviT (5.15)da (5.16) gamosaxul ebebiT SeiZl eba
gaangariSebul i iqnes dRe-Ramuri an Tviuri saSua-
l o Sewonil i aqtiuri da reaqtul i simZl avris
koeficientebi.

5.9. maRal i Zabvis aqtiuri da reaqtul i energiis samfaza mricxvel is montaJi da Semowmeba

maRal i Zabvis (6/10kv) qsel i waroadgens samsade-
nian sistemas (sami faza nul ovani sadenis gareSe).
aseTi sistemis aqtiuri energiis aRricxvi saTvis gam-

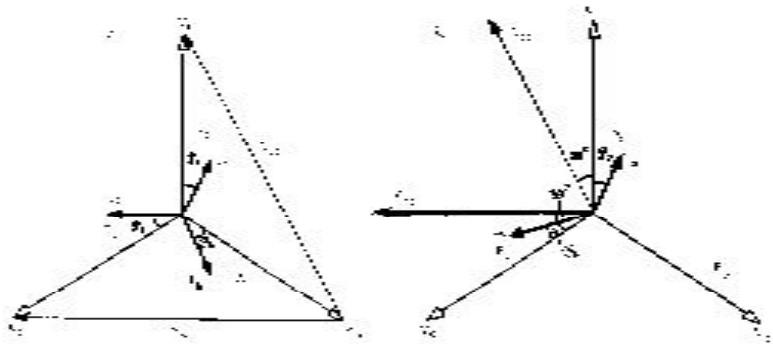


nax. 5.24 aqtiuri energiis mricxvel is ori erTfaza
Zabvis transformatoris saSual ebiT maRal i Zabvis
qsel Si CarTvis sqema



nax.5.25.orel ementiani aqtiuri energiis mricxvel is
samfaza Zabvis transformatoriT CarTvis sqema

oiyeneba orel ementiani mricxvel ebi,romel Ta denis
gragnil ebi Sesrul ebul ia 5 a denze, xol o Zabvis
gragnil i Sesrul ebul ia 100 v Zabvaze. Zabvis grag-
nil ebi mricxvel Si CarTul ia xazur Zabvaze Ria
samkuTxedis sqemiT. es sqema uzrunvel yofs simetri-
ul samfaza xazur Zabvebs da amitom gamoiyeneba fa-
zebs Soris CarTul i xel sawyoebisa da rel eebis
kvebisatvis.Nnax. 5.24-ze mocemul ia aqtiuri energiis
mricxvel is ori erTfaza Zabvis transformatoris
saSual ebiT maRal i Zabvis qsel Si CarTvis sqema,xol o
nax.5.25-ze -orel ementiani aqtiuri energiis mricxve-
l is samfaza Zabvis transformatoriT CarTvis sqema.



nax. 5.26.orel ementiani mricxvel is veqtorul i diagrafmebi

nax. 5.26.a-ze mocemul ia orel ementiani mricxvel is veqtorul i diagrafma. am veqtorul i diagrafmas mi vceT nax. 5.26.b-ze warmodgenil i saxe:

am veqtorul i diagrafmebidan gamomdinareobs, rom

$$P = P_a + P_c = V_{ab} \cdot I_a \cdot \cos(30^\circ + \varphi_a) + V_{bc} \cdot I_c \cdot \cos(30^\circ - \varphi_c).$$

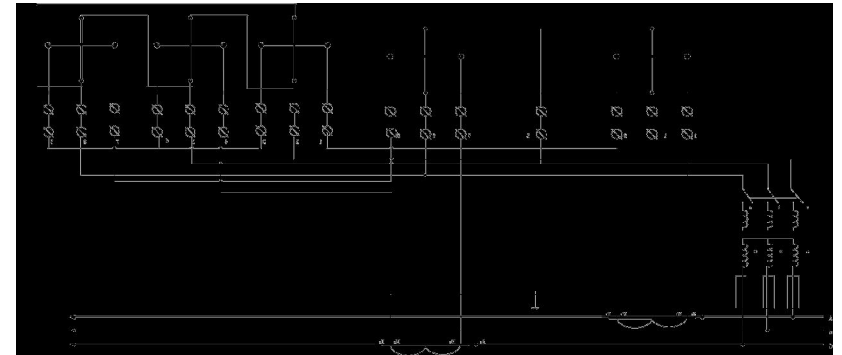
Tu mi vi RebT, rom $V_{bc} = V_{ab}; I_a = I_c; \angle \varphi_a = \angle \varphi_c,$

maSin $P = \sqrt{3} V_b \cdot I_f \cdot \cos \varphi.$

aqedan gamomdinareobs rom samsadenian sistemaSi, orel ementiani mricxvel iT, samfaza aqtiuri energi is aRricxva SesaZl ebel ia.

rac Seexeba maRal i Zabvis samfaza reaqtul i energi is mricxvel s, igi warmoadgens samel ementian mricxvel s, anal ogiurs im mricxvel isa, romel ic adre gvqonda ganxil ul i, mxol od im gansxvavebiT, rom aq Zabvis gragnil ebi 100 v-zea Sesrul ebul i.

maRal i Zabvis samfaza aqtiuri da reaqtul i energi is mricxvel ebi aRricxvis kvanZSi erT siste-



nax. 5.27.aqtiuri da reaqtul i energi is mricxvel ebi samontaJo sqema

maSia gaerTianebul i. Nax. 5.27-ze mocemul ia aqtiuri da reaqtul i energi is mricxvel ebi qsel Tan mi-erTebis el eqtrul i sqema.

5.10. maRal i Zabvis aRricxvis kvanZis Semowmeba

maRal i Zabvis aRricxvis kvanZis Sesamowmebl adD gamoiyeneba xel sawyo AAO-i. Tavdapirvel ad iwyeba Zabvebis Semowmeba mricxvel is me-2, me-5 dame-8 momWerebze erTmaneTisa da korpuss mimarT. im SemTxvevaSi, Tu b faza aris Camiwebul i, maSin me-2 da me-8 momWereb sa da korpuss Soris Zabva tol i unda iyos Zabvis transformatoris meoreul i xazuri Zabvisa (100v fargl ebSi), xol o me-5 momWersa da korpuss Soris - nul is tol i.e.i.

$$V_{ab} = V_{bc} = V_{ac} = V_{ao} = V_{co} = 100v, \text{ xol o } V_{bo} = 0.$$

Tu Camiwebul ia Zabvis transformatoris dabal i mxaris neutral i, maSin xazuri Zabvebi tol ia:

$$F \quad V_{ab} = V_{bc} = V_{ac} = 100 \text{ v,}$$

xol o fazuri Zabvebi tol i iqneba:

$$V_{ao} = V_{co} = V_{bo} = 57 \text{ v.}$$

am SemTxvevaSi aucil ebl ad unda davrwundeT, rom b fazis gragnil is gamomyvani namdvil ad mierTebuli ia me-5 momWerTan.. amisaTvis saWiroa Zabvis transformatoris maRal Zabvaze droebiT gavTiSoT a da c fazis mcveli. Aam dros Zabvebi $V_{ao} = V_{co} = 57 \text{ v}$, xol o V_{bo} nul is tol i gaxdeba, an sul ramdenime vol tis fargl ebSi iqneba. amis Semdeg unda aRvadginoT mcveli i da AAO-is saSual ebiT SevamowmoT fazebis mimdevroba mricxvel ze. AAO-is I imfi unda brunavdes saaTis isris moZraobis mimarTul ebiT. Tu I imfi datrial da sawinaaRmdego mimarTul ebiT, maSin mricxvel ze unda gadavaadgil oT a da c fazebis gragnil ebis momWerebi erTmaneTis mimarT.

amis Semdeg viwyebT meoreul i denebis Semowmebas, rogorc nax. 5.27-dan Cans denis transformatorebi qsel Si mxol od or fazaSi aris CarTul i arasrul i varskvl avis meTodiT, es niSnavs, rom qsel Si simetriul i datvirTvis dros $I_a = I_c$. Aam dros denis transformatorebis meoreul i gragnil ebis neutral Sic igive sididis deni gadis, romel ic sididiT I_b -s warmoadgens. e.i.:

$$I_a = I_b = I_c.$$

magram Tu gazomviT miviReT, rom I_b deni 1.73-j er metia vidre I_a an I_c deni, maSin adgil i aqvs erT-erTi denis transformatoris araswor CarTvas da ami tomUnda vecadoT, rom yovel Tvis dacul i iyos piroba:

$$I_a \approx I_b \approx I_c.$$

amis Semdeg ganvsazRvroT aqtiuri da reaqtul i energiis mricxvel ebis mier dafiqsirebul i aqtiuri da reaqtul i simZl avreebi.

aqtiuri energiis mricxvel is mier dafiqsirebul i simZl avre P_{mr} ganisazRvreb (5.7) formul iT, oRond am SemTxvevaSi transformaciis koeficienti tol ia:

$$K = K_v \cdot K_i. \quad (5.20)$$

sadac K_i aris denis transformatoris transformaciis koeficienti (5.8);

K_v - Zabvis transformatoris transformaciis koeficienti (5.9).

imave (5.7) formul iT ganisazRvreb reaqtul i energiis mricxvel is mier dafiqsirebul i reaqtul i simZl avre Q_{mr} .

sazomi xel sawyoebis gamoyenebiT gavzomoT meoreul wredSi gamaval i denebi da modebul i Zabvebi da ganvsazRvroT qsel Si gamaval i aqtiuri da reaqtul i simZl avreebi, formul ebiT:

$$F P_{qs} = \sqrt{3} V_x \cdot \frac{(I_a + I_b + I_c)}{3} K \cdot \cos \varphi. \quad (5.21)$$

$$Q_{mr} = \sqrt{3} V_x \cdot \frac{(I_a + I_b + I_c)}{3} K \cdot \sin \varphi. \quad (5.22)$$

aq V_x aris Zabvis transformatoris meoreul i xazuri Zabva, kv.

I_a, I_b, I_c - denis transformatoris meoreul i denebi, aK

$tg\varphi, \cos\varphi$ da $Asin\varphi$ gansazRvrisaTvis gamoviyenoT (5.15), (5.16) da (5.17) gamosaxul ebebi.GAN

Tu mosaxerxebel ia da amis saSual ebas maRal i Zabvis uj redi iZl eva, umj obesia maRal i Zabvis marwuxis saSual ebiT gavzomoT maRal i Zabvis pirvel adi denebi, maSin:

$$P_{qs} = \sqrt{3}V_x \cdot \frac{(I_A + I_B + I_C)}{3} K_v \cdot \cos\varphi, \quad (5.23)$$

$$Q_{qs} = \sqrt{3}V_x \cdot \frac{(I_A + I_B + I_C)}{3} K_v \cdot \sin\varphi, \quad (5.24)$$

aq V_b aris qsel is meoreul i Zabva, kv.

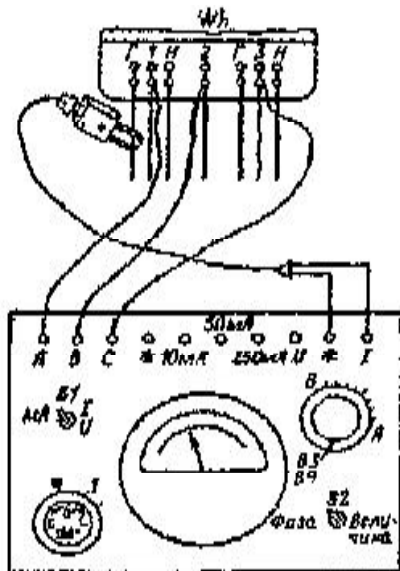
I_a, I_b, I_c aris qsel - Si pirvel adi denebi, a sabol ood unda movaxdinoT P_{qs} da P_{mr} , Q_{qs} da Q_{mr} simZl avreebis Sedareba

$$P_{qs} \approx P_{mr}.$$

$$Q_{qs} \approx Q_{mr}.$$

aRricxvis kvanZis nominal uri muSaobis suraTis misaRebad gamogvadgeba AAO-is saSual ebiT veqtorul i diagramis ageba.

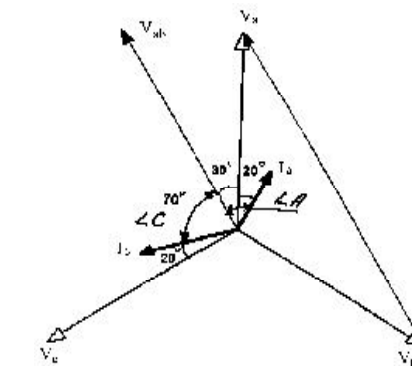
veqtorul i diagramis gadaReba xdeba Semdegnairad (nax. 5.28):



nax. 5.28. veqtorul i diagramis gadaReba VAΦ-85 xel sawyoti

xel sawyos A, B, C momWerebi uSual od SeerTebul ia mricxvel is Zabvis gragnil is momWerebTan TanmimdevrobiT marcxnidan marjvniv. muxruWis aSvebis Semdeg I imfis brunvis mimarTul ebis mixedviT gansazRvrebafazaTa Tanmimdevroba. I imfis brunva saatis isris moZraobis mimarTul ebiT Seesabameba fazaTa pirdapir Tanmimdevrobas Semdeg I imfi unda damuxruWdes. xel sawyoebis gamomyvanebTan (*) da (I) SemaerTebel i SI angiT CairTveba el eqtrosazomi marwuxi. SemaerTebel i Cangl ebis manWval ebi unda Sevides marwuxebisa da xel sawyos erTsaxel a aRniSvnebis budeebSi.

gadamtvel i B1 unda davayenoT mdgomareobaSi "U,I", gadamtvel i B2-mdgomareobaSi "Величина", gadamtvel i B3-mdgomareobaSi "5a an 1A" denis mosal odnel i mniSvnel obidan gamomdinare. marwuxebiT pirvel rigSi moicaven mricxvel is denis gragnil s A fazis Semaval sadens. Mmarwuxis niSnul i (*) mimarTul i unda iyos denis transformatoris mxares.



nax. 5.29. AAO-iT gadaRebuli veqtorul i diagrama

izomeba denis mniSvnel oba A fazaSi. Semdeg B2 gadamtvel i unda davayenoT mdgomareobaSi "Фаза". I imfis brunviT xel sawyos isari unda davayenoT nul ze. am dros isris mabrunebis mimarTul eba unda iyos I imfis brunvis mimarTul ebis Tanxvedrili.

mizanSewonil ia vabrunoT I imfi saaTis isris moZraobis mimarTul ebis sawinaaRmdegod. vafiqsirebT am dros isris nul Tan misvl as skal is marj vena mxridan. skal is nul Tan dayenebis Semdeg I imfis danayofebis mixedviT aiTvl eba kuTxe, romel ic SeTavsebul ia nakawrTan. anal ogiurad aiTvl eba sxva fazebisa da nul ovani sadenebis kuTxeebi.

veqtorul i diagramis gadaRebis Semdeg viwyebT mis agebasa da anal izs. dasawyisSi vagebT V_a, V_b da V_c fazuri Zabvebis veqtorebs, roml ebic erTmaneTis mimarT sivrcesi daZrul ni arian 120° -iT. Aamis Semdeg vagebT V_{ab} Zabvis veqtors, romel ic V_a Zabvis veqtorisagan gaswrebul ia 30° -iT. V_{ab} veqtoris mimarT unda gadavzomoT gazomil i kuTxeebi denis veqtorebis asagebad. kuTxe "L" niSniT unda gadavdoT V_{ab} veqtoridan saaTis isris moZraobis mimarTul ebiT, xol o kuTxe "C" niSniT- saaTis isris moZraobis sawinaaRmdego mimarTul ebiT. Bbol os ganvsazRvravT kuTxeebis densa da fazuri Zabvis erTsaxel a veqtorebs Soris da vakeTebT daskvna mricxvel is CarTvis sisworis Sesaxeb. Mmagal iTad davuSvaT $\angle A = 50^\circ L$ da $\angle C = 70^\circ C$ (nax. 5.29), maSin agebul i diagramidan cans, rom A fazaSi V_a Zabvasa da I_a dens Soris kuTxe $\varphi_a = 50 - 30 = 20^\circ$; aseve V_c Zabvasa da I_c dens Soris kuTxe $\varphi_c = 120 - (70 + 30) = 20^\circ$ danarTi 2-is daxmarebiT vadgenT, rom am SemTxvevaSi simZI avris koeficienti $\cos \varphi = \cos 20^\circ = 0,94$.

orel ementiani samfaza mricxvel is Semowmebis dros yuradReba unda mivaqciOT im garemoebas rom qsel Si Tanabari datvirTvis dros mricxvel is orive

el ementi yovel Tvis erTi da igive Zal iT ar axdens zemoqmedebas mricxvel is diskoze. Tu mricxvel is simZI avris gamosaxul ebaSi

$$P = V_{ab} \cdot I_a \cdot \cos(30^\circ + \varphi_a) + V_{bc} \cdot I_c \cdot \cos(30^\circ - \varphi_a).$$

Sevitant kuTxe $\angle \varphi$ -is sxvadasxva mniSvnel obebs mi viRebT, rom rodesac kuTxe $\angle \varphi_a = \angle \varphi_c = 0$, maSin orive el ementis mricxvel is diskoze Tanabari Zal iT axdens zemoqmedebas.

naTqvamis demonstrireba SeiZl eba movaxdinoT Semdegnairad: j er mricxvel is pirvel i el ementis denis gragnil is 1-3 momWers davamokl ebT, xol o Semdeg meore el ementis gragnil is 7-9 momWers da orive SemTxvevaSi davafiqsiroT mricxvel is diskos brunvis siCqare. davinaxavT, rom orive SemTxvevaSi diskos brunvis siCqare erTi da igive iqneba.

kuTxeebis $\angle \varphi_a$ da $\angle \varphi_c$ -s zrdasTan erTad igive cdis dros, pirvel i el ementi nakl ebad zemoqmedebis diskoze, vidre meore el ementi da Sesabamisad diskos brunvis siCqare erTmaneTis mimarT gansxvavebul i iqneba. rodesac kuTxeebi $\angle \varphi_a$ da $\angle \varphi_c$ gautol deba 60° -s, maSin pirvel i el ementi saerTod ar zemoqmedebis diskoze da ZiriTadi zemoqmedebis Zal a diskoze modis meore el ementis saSual ebiT, xol o rodesac kuTxeebi $\angle \varphi_a$ da $\angle \varphi_c$ metia 60° -ze, maSin pirvel i el ementi diskos abrunebs „ukan" mimarTul ebiT, xol o meore el ementi - „win" mimarTul ebiT.

5.11. special uri daniSnul ebis mricxvel ebi

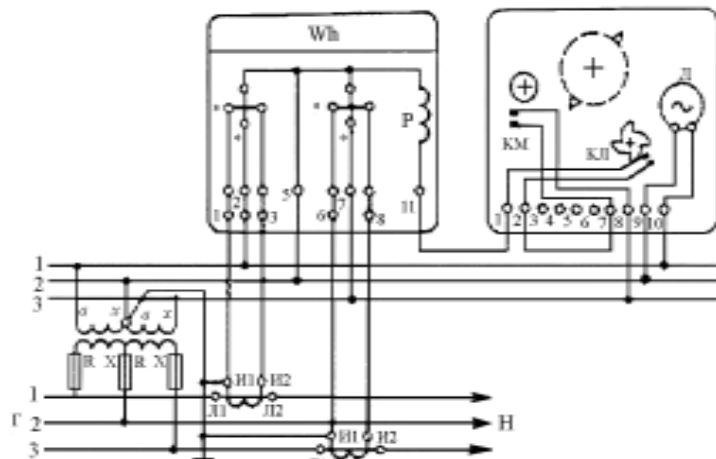
samrewvel o momxmarebl ebis mier el eqt-roenergiis racional uri moxmarebisa da sxvadasxva miznebi-

saTvis gamoyenebian special uri daniS-nul ebis mricxvel ebi.

datvirTvis maqsimumis maCvenebel i mricxvel i .Tanamedrove pirobebSi samrewvel o momxmarebl ebisaTvis gamoiyeneba el eqtroenergiaze organakveTiani tarifi,romelic Sesdgeba TiToeu-l i moxmarebul i kvtsT el eqtroenergiis ganakveTisa da energosistemis maqsimal uri datvirTvis reJimSi muSaobis periodSi moxmarebul i TiToeul i kvtsT el eqtroenergiis ganakveTebisagan.

gadaxdis aseTi sistema stimuls aZl evs el eqtroenergiis momxmarebl ebs,raTa imuSaon racional ur reJimSi da amit Seamciron energosistemis pikuri datvirTvebi.

aseTi tarifiT gaangariSeba xorciel deba special - uri mricxvel ebiT,roml ebic aRWurvil ia datvirTvis



nax.5.30. kontaktebian saaTiani maqsimal uri datvirTvis maCvenebel i mricxvel is CarTvis sqema

maqsimumis maCvenebel iTa da kontaktebiani saaTiT. saaTi aRWurvil ia ZraviT D da ori wyvil i kontaktiT K_M da K_{II} aseTi mricxvel is CarTvis sqema mocemul ia nax. 5.30-ze.

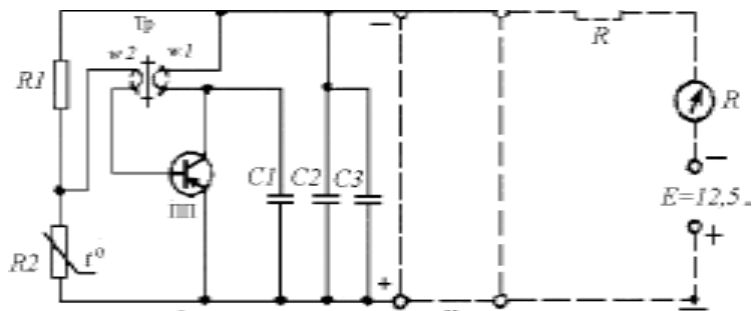
pirvel i K_{II} kontaktebis wyvil i imarTeba mbrunavi diskoTi. am diskos gaaCnia skal a, romelic Seesabameba 24 sT-s da akeTebis dRe-RameSi 1 bruns. am kontaktebis CarTva-gamorTvis dro dayenebul ia energosistemis dil isa da saRamos maqsimumebis dasawysis da dasarul is Sesabamisad.

kontaktebis meore, K_M wyvil i CairTveba drois mocemul (15 an 30 wT) Sual edSi. Semdeg xdeba maTi gaTiSva da drois am Sual edis gasvl is Semdeg myiserad CairTveba. es cikl i meordeba uwyvetad.

mricxvel is datvirTvis maqsimumis maCvenebel is wamyvani isari, roml is gadaxra proprociul ia drois mocemul interval Si (mag.30wT) simZl avris saSual o Sewonil i mniSvel obisa, dakavSirebul ia gadamcemi sistemis brunvis RerZTan. am gadacemis gadaxrasa da gadabmas awarmoebs p el eqtromagnituri rel e, romelic CarTul ia Zabvis orive wyvil i kontaktebis gavliT. 30 wuTis ganmavl obaSi es rel e CarTul ia da isari moZraobs da gadaadgil deba. am drois ganmavl obaSi gadaxreba saSual o simZl avris proprociul i kuTxiT. rel es gaTiSvisa an ganmeorebiTi CarTvis dros aRniSnul i isari zambaris moqmedebiT brundeba nul ovan mdgomareobaSi da Tavidan iwyebs gadaadgil ebas. es cikl i meordeba maqsimumis drois gasvli amde.

wamyvan isarTan dakavSi rebul ia sabuqsire isari, romel ic afiqsirebs wamyvani isris Cvenebas ganvl il i 30 wuTis ganmavl obaSi. Tu drois Semdeg interval Si datvirTva ar gaizarda, maSin sabuqsire isris mdgomareoba ar Seicvl eba, xol o datvirTvis gazrdis SemTxvevaSi wamyvani isari gadaadgil ebs sabuqsire isars ufro didi kuTxiT. amgvarad, sabuqsire isris mdgomareoba Seesabameba energosistemis maqsimal ur reJimSi muSaobis dros momxmarebl is maqsimal uri simZl avris saSual o Sewonil mniSvnel obas naxevari saaTis interval Si. naxevarsaaTiani interval i saWi roa imisaTvis rom maqsimumis maCvenebel Si ar aRniSnos datvirTvis xanmokl e biZgebi. sabuqsire isari SeiZl eba dabrunebul i iqnes sawyis mdgomareobaSi Ril akis saSual ebiT.

tel esazomi mricxvel ebi. aseT mricxvel ebs gaaCniaT impul sebis gadamwodi roml ebic mTvl el i meqani zmis Cvenebas gardaqmni an mudmivi denis impul sebad da gadascemen Sors manZil ze. aseTi mricxvel is tipis aRniSvnaSi figurirebs aso D , magal iTad CA3-H670D impul sebis mimRebi SeiZl eba iyos im-



max. 5.31. impul sebis gadamwodebis sqema

pul sebis el eqtromagnituri mricxvel i an gamomTvl el i manqanis Semaval i mowyobil oba.

Tanamedrove pirobebSi Sei qmna saWi roeba avtomaturad Sevaj amoT cal keul i msxvil i momxmarebl is mier moxmarebul i aqtiuri da reaqtul i energiebi. es iZl -eva saSual ebas vawarmooT angariSebi organakveTiani tarifiT da miviRoT agreTve srul i informacia moxmarebul i el eqtroenergiis reJimebis Sesaxeb. am mizniT gamoSvebul ia el eqtroenergiis aRricxvisa da kontrol is avtomatizirebul i sainformacio-sazomi sistema *ИИСО-1-48*, romel Tanac kavSir gabmul obis arxebis saSual ebiT SeiZl eba mierTebul i iqnas 48- mde tel esazomi mricxvel i.

tel esazomi mricxvel is impul sebis gadamwodi warmoadgens *МТТ41* tipis tranzistorze akrefil ukukavSiriT marTul generators.

sqemis yvel a el ementi garda ukukavSiris T_p transformatorisa ganl agebul ia mTvl el i meqanizmis axl os. mas aqvs feritis gul ara ori (W_1 da W_2) gragnil iT roml is ganaWerSi brunavs disko ori diametral urad sawinaaRmdego amonaWer iT. brunva gadaecema mTvl el i meqanizmis diskos. zogierT modifikasiSi diskos magier brunavs TiTbris al ami, romel ic damagrebul ia moZravi sistemis RerZze. roca al ami mdebareobs transformatoris RreCos gareT, maSin generatori agznebul mdgomareobaSia da kavSiris xazebSi gadis deni, roml is mudmiv mdgenel s aqvs 10 ma rigis mniSvnel oba. al mis RreCoSi Seavl is dros induqciuri cvl il ebis gamo xdeba generaciis Sew-

b) sazomi transformatorebis uwesivroba.

Ddenis transformatoris dazianebe damaxasia Teebel i niSania meoreul i denis Seusabamoba pirvel ad-

Tan $\left(I_2 \leq \frac{I_1}{K_I} \right)$. AamasTanave meoreul i denis mniSvnel o-

vani Semicireba SeiZl eba moxdes sqemis uwesivrobiT daSvebul i Secdomis gamo. Aamitom Semowmebas eqvemdebareba rogorc transformatori, aseve wredi.

Ddenis transformatoris dazianebe gamovl ena SesaZl ebel ia Semdegi damaxasia Teebel i niSnebis mixedvit: meoreul i deni meoreul i wredebis winaRobebis dros nul is tol ia an nul Tan axl osaa (am dros gragnil i damokl ebul ia momWerebze); deni mniSvnel ovnad metia, vidre unda iyos faqtiuri winaRobebis dros.

Zabvis transformatoris dazianebe iwvevs maRal i Zabvis mxares erTi an ramdenime mcvel is gadawvas, ris Sedegadac meoreul i Zabva gamorTul fazaze gaqreba an mniSvnel ovnad Semcirdeba.

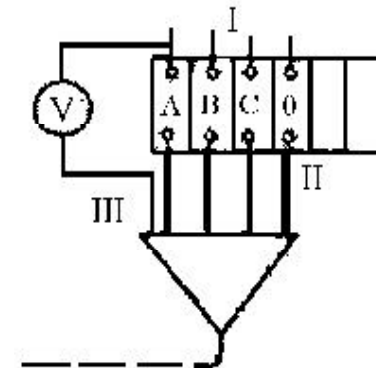
g) sazomi transformatorebis gazrdil datvirTvas, romel ic aRemateba mocemul i sizustis kl asis dasaSveb datvirTvas, Seaqvs damatebiTi uaryofiT i cdomil eba. meoreul i gragnil is datvirTva SeiZl eba ganisazRvros angariSis gziT an eqsperiment al urad. eqsperimentiT datvirTvis gansazRvris dros meoreul wredebSi erTdroul ad zomaven denebsa da Zabvebs. Ggazomvebi SeiZl eba Catardes, rogorc muSa denisa da Zabvis qeS, aseve mierTebebis gamorTvis Semdeg gareSe kvebis wyarodan Zabvis miwodebiT.

Ddenis transformatorebis meoreul i gragnil is datvirTvis Semicireba SeiZl eba denur wredebSi kabel ebis ZarRvebis kveTis gazrdiTa da am wredebidan damatebiTi aparatis gamorTviT.

Zabvis transformatoris datvirTvisa da cdomil ebis SemicirebisaTvis datvirTva SesaZl ebl obis fargl ebSi unda gavanawil oT ise, rom yvel a fazaSi iyos erTnairi.

Tu Zabvis transformatoris meoreul i gragnil i SeerTebul ia Ria samkuTxedad, maSin mizanSewonil ia datvirTva gavanawil oT iseTnairad, rom V_{ca} Zabvaze datvirTva ar CairTos da SesaZl ebl obis fargl ebSi Tanabrad gavanawil oT V_{ab} da V_{ac} Zabvebs Soris.

saWi roa Semowmdes datvirTvis Semicirebis SesaZl ebl oba Zabvis wredebidan damatebiTi aparaturis gamorTvis Sedegad, agreTve unda Semowmdes Zabvis transformatorisa da mricxvel is SemaerTebel sadenebze Zabvis vardna.



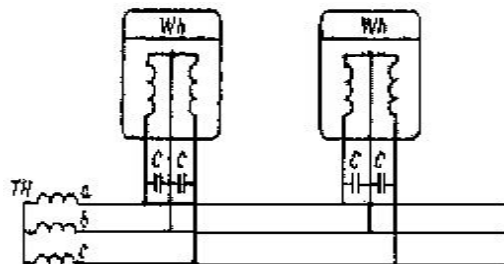
nax. 5.33. sakontrol o kabel Si Zabvis vardnis gazonva: 1-Zabvis transformatoris momWerebi; 2- aRricxvis wredebis momWerebi; 3- sarezervo ZarRvi

sadenebSi Zabvis vardnis gazrdas, roml ebic aerTeben Zabvis transformatoris mricxvel Tan mi vyarT uaryofiTi cdomil ebis gazrdamde. Ppraqtiku- l ad es SeiZl eba moxdes, Tu sadenis sigrZe aRemateba 15 metrs.

Zabvis vardna sadenebSi SeiZl eba ganisazRvros cdiT. am mizniT gamoiyeneba cvl adi denis vol tmetri, roml is Sinagani winaRoba 1-10 komia. vol tmetri CairTveba kabel is ZarRvis bol oebTan (max. 5.33).

Zabvis vardnis gazomvam, rogorc kabel is bol oSi xazuri Zabvebis gazomvam ar SeiZl eba mogvces uaryofiTi Sedegi. Ddidi Secdoma SeiZl eba Seitanos vol tmetrebis cdomil ebam, aTvl is araerTdroul obam da sxva mizezebma.

Zabvis vardnis Semcirebis mizniT saWi roa kabe- l is ZarRvebis kveTis gazrda. cal keul SemTxvevaSi saWi ro xdeba mricxvel ebi vkveboT ara ZabviT saerTo sal teebidan, aramed gaviyvanoT cal ke kabel i. Zabvis transformatorisa da mricxvel is SemaerTebel sadenebSi Zabvis vardnis Semcirebisatvis karg Sede-



Nmax.5.34. Zabvis transformatoris wredSi makompen- sirebel i kondensatoris CarTvis sqema

gebs iZl eva mricxvel is Zabvis gragnil is induqtivo- bis tevadobiT kompensacia.

tevadobiTi kompensacia gamoiyeneba mricxvel is Zabvis gragnil ebis mier moxmarebul i energiis Sem- cirebisatvis maTi simZl avris koeficientis gazrdis gziT. Ees mi iRveva imiT, rom Zabvis TiToeul i gragni- l is paral el urad CairTveba 1-1.5 mkv tevadobis konde- satori (max. 5.34). amgvarad gragnil is induqciuri winaRoba kompensirdeba kondensatoris tevaduri win- aRobiT. Sedegad Zabvis transformatoris $\cos\phi$ izrde- ba 0,8-0,9-mde, xol o misi datvirTvis srul i simZl avre mcirdeba 2.5-3-j er. Ggazomvis sizuste izrdeba Zabvis transformatoris gragnil isa da SemaerTebel sadenebSi Zabvis vardnis Semcirebis xarj ze. Ggarda amisa mcirdeba Zabvis transformatoris kuTxuri cdomil eba, radganac Cos uaxl ovdeba nominal ur mniS- vnel obas (0,8-0,9).

Tu mricxvel ebi erTmaneTisagan daSorebul ia, ma- Sin mizanSewoni l ia kondensatorebi dayendes TiToeul i mricxvel isaTvis. mricxvel ebis central izebu- l i ganl agebis dros sakmarisia dayendes kondensa- torebis batarea.

d) mricxvel is CarTvis araswor sqemas Sei- Zl eba adgil i hqondes or SemTxvevaSi

1. Tu pirvel adi Semowmebis dros daSvebul i iqna Secdoma.

2. Tu eqspl uataciis procesSi sqemaSi Setanil i iqna cvl il eba. Aamitom yvel a SemTxvevaSi aRricxvis

sistemebis darRvevis dros saWiroa Semowmebis xel axl a Catareba.

e) meoreul i wredebis el ementebis uwesivrobas miekuTvneba Zabvis wredis gawyveta, mimdevrobiTi wredis gawyveta da romel ime fazaze mcvel is gadawva. Uumetes SemTxvevaSi uwesivrobas miyavarTerTi mabruni el ementis uwesivrobasTan. Uuwesivroba am dros advil ad vl indeba mricxvel is momWerebze Zabvisa da gazomvis gziT.

5.13. mricxvel ebis diagnostika gamorTul i Zabvis SemTxvevaSi

diagnostikuri samuSaoebi gamorTul i Zabvis SemTxvevaSi srul deba mimdinare eqspl uataciis sazomi transformatorebis kapital uri remontebis dros da aRricxvis sisworis darRvevis SemTxvevaSi meoreul i wredebis gadakeTebis Semdeg.

diagnostikur samuSaoebis miekuTvneba: gare daTval iereba, sadenebis garekva, izol aciis Semowmeba, sazomi transformatorebis erTsaxel a momWerebis Semowmeba.

a).Ggare daTval iereba. Ggare daTval ierebas eqvemdebareba yvel a meoreul i wredi sazomi transformatorebidan mricxvel ebande. Mmowmdeba meoreul i wredebis el ementebis kompl eqtacia da meqanikuri dazianebebis ar arseboba (momWerebis nakrebi, gadamyvani kol ofebi, sacdel i bl okebi da sxva); sakontrol o kabel ebis dacal kevebis xarisxi; mricxvel ebis damagrebis saimedoooba da siswore. sakontaqto SeerTebebSi Jangis ar arseboba da gamaTbobel i mowyobil obis mdgomareoba.

saWiroa mTI i anad Semowmdes sadenebi sa da sakontrol o kabel ebis markireba. Mmricxvel ebis central izebul ad ganl agebis dros mowmdeba warwerebis arseboba mierTebebis dasaxel ebiT. Yyvel a SemCneul i darRveva dauyovnebl iv unda gamoswordes.

b) sadenebis garekva. sadenebis garekvis mizania dadgindes mTI i ani Sesabamisoba principul i sqemis montaJsa da samontaJo sqemas Soris marki rebis Sesabamisobis CaTvl iT.

garekvisatvis SeiZl eba gamoyenebul i iqnes om-
metri an megaometri. Ggamoiyeneba agreTve sakontro-
l o naTura, el eqtrozari an vol tmetri. Kkvebis wyarod
SeiZl eba gamoyenebul i iqnes batarea 4-6-v ZabviT an
damwevi transformatori 220/12 v.

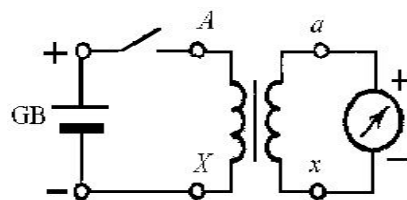
Ggarekvis dawyebis win saWi roa Semowmdes Zar Rvis
arseboba yvel a momWerze vol tmetris an Zabvis maCvene-
l is gamoyenebiT.

Uukuinformaciis Tavidan acil ebis mizniT Zabvis
transformatori gamoTul i unda iyos orive mxri-
dan. Ggasareki sadeni erTi mxridan mainc unda iyos
gamoTul i, rac gamoricxavs SesaZl o Semovl iTi
wredis arsebobas.

Ggarekvis Sedegad dgindeba Semdegi:

sadens ar aqvs wyveta; mokl ed ar aris CarTul i
sxva sadenebTan; sadenebis bol oebi sworad aris
markirebul i; sadenebis bol oebi CarTul ia sqemis
Sesabami sad.

g) izol aciis Semowmeba moicavs, izol aciis
gamocdas 1 wuTis ganmavl obaSi 1000 v cvl adi ZabviTa
da izol aciis winaRobis gazomvas megaometriT. saeqs-

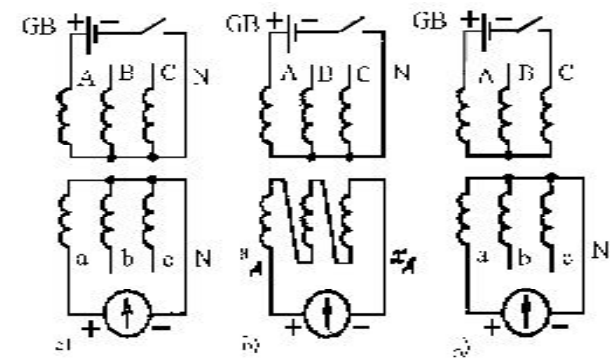


nax.5.35. erTfaza Zabvis transformatoris erTsaxel i a momWerebis gansazRvris sqema

pl uatacio Semowmebis dros dasaSvebia gamo-
sacdel i 1000v cvl adi Zabvis Secvl a 2500v mudmivi
ZabviT Sesabamisi vol tmetris gamoyenebis dros.
Semowmebis win saWi roa gamovrToT denis trans-

formatoris Camiweba. keTdeba sami gazomva: mimdevro-
biT (denur) wredebsa da "miwas" Soris; paral el ur
(Zabvis) wredebsa da miwas Soris. Yyvel a SemTxvevaSi
izol aciis winaRoba ar unda iyos 1 mom-ze nakl ebi.
igive TanmimdevrobiT xdeba izol aciis gamocdac.
Ggamocdis Semdeg sqema unda iqnes aRdgenil i.

d) sazomi transformatoris erTsaxel a momWerebis gansazRvra. sazomi transformatoris erTsaxel a momWerebis gansazRvra aucil ebel ia im SemTxvevaSi: Tu dazianebul ia saqarxno aRniSvnebi, ar gagvaCnia saqarxno sapasporto monacemebi, remon-
tebis Semdeg; fazomgrZnobi are el ementebiani avtoma-
tikisa da sarel eo dacvis mowyobil obebis gamoy-
enebis sas.



nax. 5.36. samfaza Zabvis transformatoris erTsaxel i a momWerebis gansazRvris sqemebi a) samfaza Y_H/Y_H SeerTebiT; b) samfaza Y_H/D SeerTebiT; g) samfaza Y/Y_H SeerTebiT

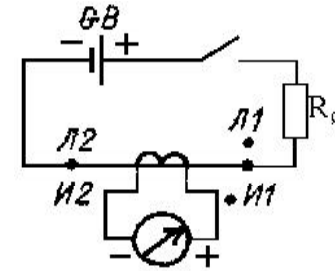
Zabvis transformatoris erTsaxel a momWerebia $A-a-a_g$ da $X-x-x_g$ erTfaza Zabvis transformatoris pol arobis Semowmebas axdenen mudmivi denis impul sebiT nax. 5.35-ze mocemul i sqemiT.

batareisa da xel sawyos (gal vanometris) (+) momWeri SeerTebul ia Sesabamisad Zabvis transformatoris A da a momWerebTan. Tu es momWerebi erTsaxel aa , maSin wredis CarTvis SemTxvevaSi xel sawyos isari gadaxreba marj vniv, xol o gamorTvisas-marcxniv.

zogierTi gansakuTrebul i TvisebiT xasiaTdeba samfaza Zabvis transformatoris momWerebis pol arobis gansazRvra. Tu Zabvis transformatorebis gragnil ebi SeerTebul ia sqemiT Y_H/Y_H (varskvl avi-varskvl avze neitral uri sadenebiT), romel ic naCvenebia nax 5.36, a-ze, maSin wredis CarTvis dros xel sawyos isari gadaxreba marj vniv. xel sawyos (+) momWeris meoreul i gragnil ebi sxva momWerebTan mierTebis dros wredis CarTvisas xel sawyos isari gadaxreba marcxniv.

nax. 5.36, b-ze naCvenebia SeerTebis Y_H/D (varskvl avi-gaxsnil samkuTxedze) dros batareis (+) momWeri rig-rigobiT mierTdeba A, B, C momWerebs, xol o xel sawyos (+) momWeri mudmivad mierTebul ia a_g -sTan. Tu momWerebi erTsaxel aa , maSin wredis CarTvisas xel sawyos isari yovel Tvis gadaxreba marj vniv.

Zabvis transformatoris Y/Y_H SeerTebis dros rekomendirebul ia Semowmeba vawarmooT nax. 5.36, g-ze naCvenebi sqemiT. rigrigobiT xel sawyos (+) momWeri



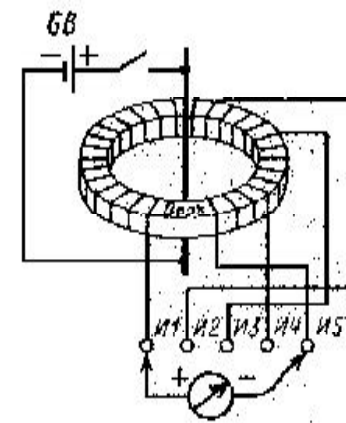
nax. 5.37. denis transformatoris pol arobis Semowmebis sqema

da xel sawyos (+) momWeri mierTebul ia a momWerebTan, maSin misi isari gadaxreba marj vniv; C momWerebTan mierTebisas marcxniv; B momWerebTan mierTebisas umniSnel od gadaxreba nebiSmier mxareze an gadaxra iqneba nul is toil .

denis transformatoris erTsaxel a momWerebia Λ_1 da H_1 (Λ_2 da H_2)Aam momWerebis gansazRvrisaTvis 4-6-v mudmivi Zabvis kvebis wyaro miuerTdeba denis transformatoris pirvel ad gragnil s, xol o sazomi xel sawyo (gal vanometri) miuerTdeba meoreul gragnil s. Kkvebis wyarosa da xel sawy-

CairTveba A, B, C momWerebTan, xol o ($_$) momWeri mudmivad meoreul i gragnil is nul - Tan.

batarea mimdevrobiT CairTveba AB, BC da CA momWerebze, batareis (+) momWeri am SemTxvevaSi mierTebul ia Sesabamisad A, B, C momWerebTan. wredis CarTvis dros, Tu gragnil is pol aroba sworia

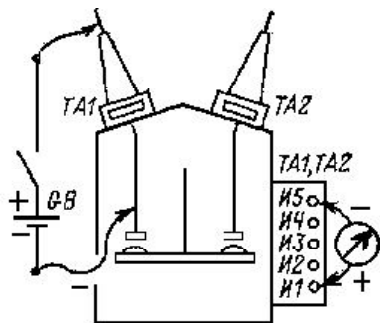


nax. 5.38. CaSenebul i denis transformatoris pol arobis gansazRvris sqema

os (+) momWerebi am dros unda mierTebul i iqnas im momWerebTan, roml ebic miCneul ia erTsaxel ad (Λ_1 da H_1). wredis CarTvisas xel sawyos isris marj vniv gada-xra amtkicebs aRniSvnis siswores (nax. 5.37)

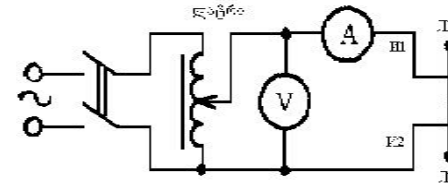
Camiwebul i denis transformatoris pol arobis gansazRvris sqema mocemul ia (nax.5.38)

CaSenebul i denis transformatoris Λ_1 ("zeviT") da Λ_2 ("qveviT") gamomyvanebi s gansazRvrisaTvis saWi roa CamrTvel ebis dayenebis win denis transformatoris fanj rebSi gavataroT sadeni, romel ic asrul ebs pirvel adi gragnil is rol s. gamtarTan CamrTvel is gavli iT kvebis wyaros (+) momWeri CairTveba denis transformatoris "zeviT" mxridan. Ggal vanometris (+) momWeri H_1 momWerTan, xol o (-) momWeriT muSa ganStoebasTan. Tu "zeviT" da H_1 erTsaxel aa, maSin wredis CarTvisas xel sawyos isari gadaixreba marj vniv.roca arsebobs eWvi CaSenebul i denis trans-



nax. 5.39. amomrTvel ze denis transformatoris dayenebis sisworis Semowmebis sqema

formatoris pol arobis gansazRvris sisworeSi, maSin mowmdeba meoreul i gragnil is pol aroba. rigrigobiT CairTveba xel sawyo yvel a ganStoebasTan $H_1 - H_2$; $H_1 - H_3$ da a.S. xel sawyos sworad arCeul i mdgomareobis dros did ganStoebebze gadasvl isas



nax. 5.40. denis transformatoris vol amperul i maxasiatebl is (damagnitebis) gadaRebis sqema

formatoris dayenebisa da meoreul i wredebis montaJis siswore.amisaTvis batareis (+) momWeri rigrigobiT CairTveba amomrTvel is gare Semyvanebis momWerebze, xol o (-) momWeri amomrTvel is uZrav kon-taqtze avzis SigniT, ise rogorc naCvenebia nax. 5.39-

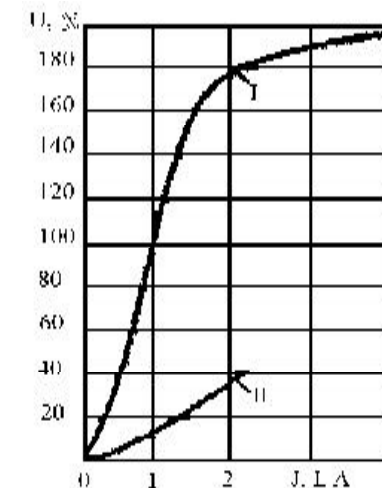
ze. xel sawyo CairTveba karadaSi ganl agebul meoreul i wredis momWerebze.

amiT mowmdeba ara marto denis transformatoris dayenebis adgili da siswore, aramed gamomyvanebis aRniSvnis sisworec.

personal is usafriTxoebis moTxovnebidan gamomdinare dauSvebel ia Semowmebis Catareba CarTul i

paral el urad izrdeba xel sawyos isris gadaxra.

amomrTvel ebis montaJis damTavrebis Semdeg zeTis Casxmamde saWi roa gakontrol des denis trans-



nax. 5.41. denis transformatoris damagnitebis maxasiatebl ebibi: I - wesivrul is; II - mokle SeerTul i xviebiT

amomrTvel is dros, misi TviTneburad gamorTvis Tavidan acil ebis mizniT.

Tu amomrTvel i avsebul ia zeTiT, maSin denis wya-ro unda CairTos mxol od gare momWerebze.

e) vol tmetrul i maxasiaTebel is gadaReba. vol tmetrul i maxasiaTebel i warmoadgens meoreul i gragnil is momWereze arsebul i Zabvis damokidebul e-bas masSi gamaval damamagnitebel denze. igi warmoad-gens ZiriTadi maxasiaTebel s, romel ic gansazRvravs denis transformatoris wesivrul obas.

vol tamperul i maxasiaTebel is gadasaRebi sqema naCvenebia nax. 5.40-ze.

am maxasiaTebel is SemcirebiT da misi daxril obis mixedviT vl indeba denis transformatoris yvel aze ufro gavrcel ebul i da saSiSi uwesivroba- meoreul gragnil Si xviaTaSorisi mokl edSerTva. rig SemTx-vevaSi maxasiaTebel i SeiZl eba gamoyenebul i iqnas transformatoris cdomil ebis Sesafasebl ad.

vol tamperul i maxasiaTebel is gadaRebisas ganrTu- l i pirvel adi gragnil is dros meoreul gragnil Si l laboratoriu l i avtotransforma- toris (l atri) saSual ebiT safexurebrivad vzrdi T Zabvis mniSvnel o- bas, roml is gasazomad gamoyenebul ia 0.5 sizustis kl a- sis el eqtromagnituri sistemis vol tmetri da Zabvis TiToeul i mniSvnel obisaTvis igive sistemisa da igive kl asis ampermetriT vzomavT denis mniSvnel obas. Aang- varad axal i CarTvis dros viRebT 10-12 wertil s da vagebT vol tamperul maxasiaTebel s (nax. 5.41)

gegmiuri Semowmebis dros viRebT 3-4 wertil s da vamowmebT mis damTxvevas adre gadaRebul maxasiaTe- bel Tan.

mokl ed SerTul i xviebis arsebobis dros maxasi- aTebel i mkveTrad ecema, rac naCvenebia nax. 5.41-ze. maxasiaTebel is dacema SeiZl eba SemCneul i iqnes misi adre gadaRebul i maxasiaTebel idan, an imave tipis de- nis transformatoris maxasiaTebel Tan SedarebiT.

5.14. mricxvel is CarTvis sisworis Semowmeba moqmed mierTebebze

a). mricxvel ebis CarTvis sisworis Semowme- ba 1000v zeviT danadgarebSi. Mmricxvel is CarTvis sisworis Semowmebis Sesaxeb SeiZl eba gavakeToT daskv- na, Tu mis momWerebze gadaRebul i veqtorul i diagra- ma emTxveva nax. 5.29-ze mocemul normal ur diagramas. amisaTvis saWiro da sakmaris pirobad iTvl eba: 1) Zabvis transformatoris meoreul i wredebis monta- Jisa da maTTan mricxvel is Zabvis gragnil ebis mi- erTebis siswore; 2) denis transformatoris meoreu- l i wredebis montaJisa da maTTan mricxvel is denis gragnil ebis mierTebis siswore.

amgvarad, mricxvel is CarTvis sisworis Semowmeba Sedgeba ori etapisagan: Zabvisa da denis wredebis Semowmebisagan (veqtorul i diagramis gadaReba).

Zabvis transformatoris meoreul i wredeb- is Semowmeba. Ees Semowmeba mdgomareobs fazebis marki rebis sisworesa da Zabvis wredebis wesivrobis SemowmebaSi. Semowmeba srul deba sxvadasxva Zabvis qveS. izomeba yvel a xazuri da TiToeul i fazis Zabva

“miwis” mimaT (fazuri Zabva), wesivrul wredebSi yvel a xazuri Zabva erTmaneTis tol ia da Seadgens 100-110 vol ts, xol o Zabvebis mniSvel oba fazasa da “miwas” Soris damokidebul ia Zabvis transformatoris CarTvis sqemaze da meoreul i wredebis Sesrul ebaze. Tu Zabvis ori erTfaza transformatori SeerTebuli ia Ria samkuTxediT an gamoyenebul ia Zabvis samfaza transformatori Camiwebul i faziT, maSin am fazis Zabva “miwis” mimaT nul is tol ia, xol o danarCeni fazebis Zabva tol ia xazuri Zabvisa.

Tu Zabvis samfaza transformatorSi meoreul i gragnil is neutral i Camiwebul ia, maSin yvel a fazis

Zabva miwis mimaT Sedgens daaxl oebiT $58v \left(\frac{100}{\sqrt{3}} \right)$.

fazebis dasaxel ebis sisworis Semowmebas viwyebT b faziT, romel ic mierTebul i unda iqnas mricxvel is Sua momWerTan. Ppirvel SemTxvevaSi igi advil ad SeiZl eba moiZebnos “miwis” mimaT Zabvebis gazomvis SedegebiT. Meore SemTxvevaSi ASeiZl eba moviqceT Semdegnairad: Zabvis transformatori gamovrToT orive mxridan. Zabvis ar arsebobisa da usafrTxoebis zomebis miRebis Semdeg amovi RoT maRal i Zabvis Sua fazis mcvel i. CavrToT Zabvis transformatori muSaobaSi. GgazvomoT meoreul i xazuri Zabvebi. gamorTul fazaze xazuri Zabva iqneba Semcirebul i (daaxl oebiT orjer), xol o gamourTvel fazebze xazuri Zabvebi ucvel ia. Nnapovni faza unda mivuerToT mricxvel is Sua momWeris Zabvis wreds, xol o danarCeni ori mivuerToT Sesabamisi markirebis kidura momWerebs.

Semdeg xel meored gamovrTavT Zabvis transformators, miviRebT usafrTxoebis zomebs, mcvel i Cayendeba Tavis adgil ze da Zabvis transformators CavrTavT muSaobaSi. DdanarCeni fazebi yvel a SemTxvevaSi ganisazRvreba fazomaCvenebl is daxmarebiT, roml is daniSnul ebaa samfaza wredSi fazebis Tanmimdevrobis dadgena.

SemowmebisaTvis fazomaCvenebl is markirebel i gamomyvanebi imave TanmimdevrobiT mivuerToT mricxvel is Zabvis gragnil is gamomyvanebs da davaWiroT Ril aks TiTi, davakvirdeT fazomaCvenebl is diskos brunvis mimaTul ebas. diskos brunva isris naCvenebl mimaTul ebiT gviCvenebs markirebis siswores da amasTanave gviCvenebs Zabvis gragnil is CarTvis siswores. winaaRmdeg SemTxvevaSi saWiroa gamovavl inoT fazaTa ukuTanmimdevrobis mizezebi: pirvel adi wredebis araswori markireba (fazebis Seferil oba) an Zabvis transformatoris meoreul i wredebis montajisas daSvebul i Secdomebi;

fazebis ukuTanmimdevrobiss mizezebis gamovl enis mizniT vamowmebT fazebis Tanmimdevrobas uaxl oesi Zabvis transformatoris momWerebze da vimeorebT Zabvis wredebis Semowmebas. Secdomis gamosworebis Semdeg fazebis Tanmimdevrobis Semowmebas vimeorebT.

markirebis sisworis gansazRvra mniSvel ovnad martivdeba, Tu am Zabvis transformatoriT ikvebeba sxva mricxvel i an rel euri dacvis mowyobil oebi, roml ebic winaswar arian Semowmebul i. Aam SemTx-

vevaSi sakmarisia movaxdinoT maTTan Sesamowmebel i mricxvel is fazireba.

ganvixil oT ramdenime Secdoma da uwesivroba romel ic vl indeba Zabvis wredebis Semowmebis dros, esenia: 1) meoreul wredebSi Zabvis wredebis denis gragnil ebTan SecdomiT CarTvis Sedegad gamowveul i mokl ed CarTviT mcvel is gadawva an avtomaturi amomrTvel is gaTiSva; 2) xazuri Zabvis Semcireba an ararseboba, roml ebic SeiZl eba gamowveul i iyos sxvadasxva mi zezebiT: sadenis gawyvetiT an mcvel is gada-wviT, Zabvis transformatoris uwesivrobiT, or momW-erze erTi da igive fazis mierTebiT, konkretul i mizezi gamovl indeba Zabvis transformatoris qsel - idan gamorTvis Semdeg Catarebul i Semowmebis Sede-gad.

Tu xazuri Zabvis gazomvis dros erTi maTgani iqneba daaxl oebiT 173v, maSin es niSnavs, rom erTi Zabvis transformatoris meoreul i gragnil i gadab-runebul ia meoreul i transformatoris meoreul i gragnil is mimarT. Secdomis gasworebis Semdeg ga-zomvebi unda ganmeordes.

**denis transformatoris meoreul i wredeb-
is Semowmeba.** Tu momWerebis kol ofze adgil ebs Sevucvl iT Zabvis wredis or kidura sadens, maSin simetriul i datvirTvis dros mricxvel is disko sworad CarTvis SemTxvevaSi unda gaCerdes (SesaZl oa mcire svl a nebismier mxares). Mmeore xerxiT Semowme-bis dros 1-3 mm dros Sual edSi iTvl eba aqtiuri energiis mricxvel is diskos brunTa ricxvi, Semdeg gamorTaven mricxvel is Zabvis wredis Sua fazis saden-

sa da drois igive Sual edSi aiTvl ian brunTa ricx-
vs. Tu mricxvel i CarTul ia sworad, maSin brunTa
ricxvi unda Semcirdes orjer.

b) mricxvel ebis CarTvis sisworis Semowmeba 1000v
qveviT danadgarebSi

Tu mricxvel i CarTul ia sworad, maSin nebismier
SemTxvevaSi uzrunvel yofil ia denisa da Zabvis erT-
saxel a fazebis SeuRI eba TiToeul mabrun el emen-
tSi.

mricxvel is CarTvis sisworis Semowmebis dros
izomeba fazuri da xazuri Zabvebi, agreTve gani sazRvre-
ba fazaTa Tanmimdevroba. Tu aris ukuTanmimdevroba,
maSin saWiroa adgil ebi Sevucval oT or nebismier
mabrun el ements da maT mkvebav denis transforma-
torebs. Semdeg rigrigobiT vamowmebT diskos brun-
vis mimarTul ebis siswores TiToeul i mabruni el e-
mentis moZrav sistemebze cal cal ke zemoqmedebis dros.
Semowmeba swarmoebs momWerebis kol ofSi zRudareb-
is rigrigobiT moxsnis gziT, am dros muSaobaSi rCe-
ba erTi mabruni el ementi, xol o danarCeni ori gamoy-
vanil ia muSa mdgomareobidan. zRudarebis CarTva-
gamorTva xdeba mxol od Zabvis moxsnis Semdeg.

Mmeore xerxis dros mierTebebi gamorTul ia Ti-
Toeul fazasTan xanmokl ed rigrigobiT CairTveba
xel ovnuri erTfaza datvirTva. datvirTvad SeiZl e-
ba gamoyenebul i iqnes 40-50 omi winaRoba simZl avriT
200vt, Tu mricxvel i sworad aris CarTul i, maSin Ti-

cxrili 5.1

SemaerTebel i sadenebis dasaSvebi kveTebi

gamtaris sigrZe, m	10-mde	10-15	15-25	25-35	35-40
spil enZis sadenis umciresi kveTi, mm ²	2.5	4	6	8	10

Toeul i el ementi daabrunebs diskos marj vniv. Ddiskos brunva sawinaaRmdego mimarTul ebiT gviCvenebs, rom mricxvel is denis gragnil Si deni gaedineba ukumimarTul ebiT da am Secdomis gamosaworebl ad saWiroa Sevucval oT adgil ebi am el ementTan mierTebul sadenebs.

E5.15. el eqtroenergiis gazomvis cdomil eba da moTxovnebi sazomi transformatorebisadmi

mricxvel ebis sizustis kl asis arCeva damokidebul ia mis daniSnul ebaze, CarTvis wessa da gasazomi energiis saxebaze (aqtiuri Tu reaqtul i). DdaniSnul ebis mixedvit mricxvel ebi iyofa saangariSo da teqnikuri aRricxvis kategoriebad, xol o CarTvis wesis mixedvit, rogorc zemoT avRniSneT uSual o an pirdapiri CarTvisa da iribi anu Zabvisa da denis transformatorebis saSual ebiT.

pirdapiri CarTvis aqtiuri energiis mricxvel is sizustis kl asi unda iyos 2,5-s, xol o reaqtul i energiisa – 3,0. sazomi transformatorebis saSual ebiT CarTul i aqtiuri da reaqtul i energiis saangariSo mricxvel ebis sizustis kl asi unda iyos 2,0, xol o teqnikuri aRricxvis mricxvel ebisaTvis- aranaki eb 2,0 da 2,5-s.

didi simZl avris gazomvis dros rekomendirebul ia gamoyenebul i iqnes aqtiuri energiis saangariSo mricxvel ebi aranaki eb 1,0 sizustis kl asisa, xol o reaqtul i energiis -aranaki eb 1,5-s. saangariSo mricxvel ebis dros denisa da Zabvis transformatorebs unda hqondes aranaki eb 0,5 sizustis kl asi (dasaSvebia gamoyenebul i iqnes 1,0 sizustis kl asis denis transformatori. im SemTxvevaSi Tu 0,4 omi winaRobiT datvirTvis SemTxvevaSi misi namdvil i cdomil eba ar aRemateba 0,5 kl asis denis transformatoris dasaSveb cdomil ebas); teqnikuri aRricxvis mricxvel ebisaTvis saWiroa visargebl oT aranaki eb 1,0 kl asis transformorebiT. sazomi transformorebis meoreul i wredebis datvirTva ar unda aRematebodes sizustis mocemul i kl asisaTvis dasaSveb nominal ur datvirTvas. Aaqedan gamomdinare saorientaciოდ მიღებულია transformatorის მეორეულ wredze mierTebul i SemaerTebel i sadenebis winaRoba araumetes 0.2 omisa, Aami tom qvemoT cxrili Si 5.1 moyvaniლი ia SemaerTebel i sadenebis dasaSvebi kveTebi.

pirdapiri CarTvis mricxvel ebi Cvenebs iZl evian uSual od kil ovatsaaTebSi an kil ovol tampersaaTebreaqtul Si.

sazomi transformorebis saSual ebiT CarTul i mricxvel ebis Cvenebs mravl deba koeficientze $K = K_i \times K_v$, sadac K_i da K_v Sesabamisad denisa da Zabvis transformorebis transformaciis koeficientebia.

mricxvel ebis transformatorebis saSual ebiT CarTvis dros kategoriul ad akrZal ul ia mvel ebis dayeneba sazomi transformatorebis meoreul wredebSi. rekomendirebul ia denisa da Zabvis transformatorebis meoreul i wredebis erTsaxel a momWerebiT Camiweba.

5.16. el eqtronul i mricxvel ebis Tanamedrove mdgomareoba

aqtiuri energiis induqciuri tipis el eqtromeqanikuri mricxvel i dRevandl amde iWers wamyvan adgil s moxmarebul i energiis aRricxvis sistemaSi ara marto saqarTvel oSi, aramed dsT-s qveynebsa da msofl ioSi.

saukuneze meti xnis ganmavl obaSi aseTi mricxvel ebis uzarmazari masStabebiT warmoebis Sedegad maTi konstruqcia da warmoebis teqnoL ogia damuSavebul ia uuvril manes detal ebamde.amJamad am tipis mricxvel ebi srul iad daxvewil ia, gaaCnia eqspl uataciis xangrZl ivi vada da SedarebiT dabal i Rirebul eba. amasTanave induqciur mricxvel ebs gaaCniaT rig SemTxvevaSi arasakmarisi sizuste da SezRudul i funqcional uri SesaZl ebl obani, rac mJRavndeba umartivesi ortarifiani sistemis Seqmnisa da mricxvel ebis Cvnebebis distanciuri Sekrebis organizaciis dros.



Nnax. 5.42. el eqtronul i mricxvel ebis saxe

moxmarebul i el eqtroenergiis aRricxvis avtomatizirebul i sistemis intensiurma ganviTarebam, mraVal -

tarifianobis SemoRebam da winaswarma gadaxdebma wina pl anze wamoswia ufro maRal i sizustis mqone axal i xel sawyos- el eqtronul i mricxvel is Seqmnis amocana.

el eqtronul i mricxvel ebis moqmedebis principi damyarebul ia aqtiuri simZl avris impul sebis sixSireSi gardaqmnaze, romel Ta aTvl a mTvl el i meqanizmiT iZl eva moxmarebul i el eqtroenergiis sidiides. impul sebis sixSire gamosavl el i simZl avris proporciul ia.

mowinave sazRvargareTul i firmebis („SIMENS“, „АББ“ da sxva) gamocdil ebis Seswavl am gviCvena rom el eqtronul ma mricxvel ebma myarad daiKaves adgil i sabazro seqtorSi, xol o maTi teqnikuri donisa da xarisxis asamaRl ebl ad samuSaoebi mimdinareobs sakmaod intensiurad.

Nnax. 5.42-ze warmodgenil ia Konzern „ЭНЕРГОМЕРА“-s el eqtronul i mricxvel ebi. Uunda aRiniSnos, rom el eqtroenergiis el eqtronul i mricxvel is damuSaveba warmoadgens sakmaod rTul samecniro-teqnikur amocanas, radganac man unda uzrunvel yos denis, Zabvisa da simZl avris koeficientis farTo dinamiuri diapazoni. damatebiTi SezRudvebia Zabvis wredebisa da el eqtromagnituri Tavsebadobis moTxovnebis mimarT. Mmkacri moTxovnebia momsaxureobis xangrZl ivi vada da Semowmebebs Soris didi inetrval i.

samfaza el eqtronul i mricxvel ebi gamoSvebul ia aqtiuri da reaqtul i energiisa da orive mimarTul ebiT energiis nakadis gasazomad.

dReisaTvis SegviZl ia gamovyot el eqtronul i mrocxvel ebis ganvitarebis Semdegi tendenciebi:

1. special izirebul i sazomi saSual ebebisa da mikroprocesorebis gamoyeneba saSual ebas izl eva erT mxriv avamaRI oT sizustis kl asi da saimedooba, xol o meore mxriv aparaturis danaxarj ebis gazrdis gareSe arsebitad gavzardoT mricxvel is funqcional uri SesaZl ebl obani. Magal iTad, davafiqsiroT moxmarebul i simZl avris maqsimumi, SevqmnaT „el eqtronul i arqivi“, vuzrunvel yoT winaswar gadaxdis al gorIT-mi da sxva;

2. induqciuri mricxvel ebis TandaTanobiTi Secvli a el eqtronul i saangariSo mowyobil obebiT;

3. denis transformatoris gul arebad, el eqtromagnituri fol adis nacvl ad al ternatiul i amorful i rkinis gamoyeneba;

4. hol is efeqtis safuzvel ze simZl avris gardamqmel ebiani erTfaza mricxvel is damzadebis SesaZl ebl oba;

5. kvebis modul uri bl okebis Seqmna, romel nic uzrunvel yofen maj amebel i mowyobil obis informaciis Senaxvas udeno mdgomareobaSi da qsel is gardamaval procesebSi;

6. kavSirgabmul obis modul uri bl okebis Seqmna, romel ic uzrunvel yofs informaciis gadacemas Zal ovani kabel iT. es saSual ebas gvaZl evs moxdes mricxvel is Cvenebebis distancieurad Sekreba;

7. teqniki saSual ebebis Seqmna, romel ic saSual ebas mogvcems Sei qmnas ufro efeqturi gaangariSebis sistema winaswari gadaxdisa da SeRavaTebisaTvis.

5.17. el eqtronul i mricxvel is Semowmeba

el eqtronul i mricxvel is Semowmeba induqciuri mricxvel is msgavsad iwyeba vizual uri daTval ierebiT. mricxvel s garedan ar unda emCneodes raime fizikuri Zal is zemoqmedebis niSani. amis Semdeg viwyebT mricxvel is Semowmebas TviTsvl aze.e datvirTvis wre-dis gaTiSvis dros, roca Zabva tol ia $1,15V_n$, maSin mricxvel is gamosaval i mowyobil oba Δt droSi ar qmnis erT impul sze mets, sadac Δt gamoiTvl eba formul iT:

$$\Delta t \geq \frac{R \cdot 10^6}{N \cdot m \cdot V_n \cdot I_{maqs}}$$

sadac N aris mudmiva (1 kvT.sT el energiis Sesabamisi impul sebis raodenoba),imp/kvt.sT;

m -sazomi el ementebis rixxvi;erTfaza mricxvel is SemTxvevaSi $m=1$,xol o samfaza mricxvel is SemTxvevaSi $m=3$.

V_n -nominal uri Zabva;

I_{maqs} -mricxvel is maqsimal uri deni;

R -koeficienti, romel ic 1.0 sizustis kl asis mricxvel ebisaTvis 600 tol ia,xol o 2.0 sizustis kl asisaTvis-480.

amis Semdeg mricxvel i unda SevamowmoT datvirTvis qveS \$5.3-is mixedviT.mricxvel Si gamaval i aqtiuri simZl avre pirdapiri CarTvis SemTxvevaSi gamoiTvl eba formul iT;

$$P_{mr} = \frac{3600 \cdot n}{N \cdot t} \text{kvT}$$

xol o denis transformatori T CarTvis SemTxvevaSi:

$$P_{mr} = \frac{3600 \cdot n}{N \cdot t} K, \text{ kvt},$$

sadac n - aris impul sebis raodenoba;

N - mudmiva, imp/kvt.sT;

t - dro, romelic Seesabameba n impul sebis raodenobas;

K - denis transformatoris transformaciis koeficienti.

erTi impul sis xangrZi ivobis Sesabamisi dro aiTvl eba impul sis or gamonaTebas Soris. magal iTad, Tu $n=5$, maSin dro unda aviTval oT 6 gamonaTebas Soris, xol o Tu $n=6$, maSin 7 gamonaTebas Soris da a.S.

denis marwuxis gamoyenebisas qsel Si gamaval i simZl avre erTfaza denis SemTxvevaSi gamoiTvl eba (5.4) formul iT, xol o samfaza denis SemTxvevaSi -(5.6) an (5.7) formul ebiT.

Tu gazomvis SedegebiT dakmayofil da piroba $P_{qs} \approx P_{mr}$, maSin mricxvel i sworad muSaobs.

5.18. mricxvel is Cvenebis sisworis Semowmeba sayofacxovrebo pirobebSi

el eqtromricxvel is Cvenebis mixedviT gamoiTvl eba daxarj ul i el eqtroenergiis safasuri. Tu gaCnda eWvi mricxvel is Cvenebis sisworis Sesaxeb, maSin is advil ad SegviZl ia SevamowmoT.

amisaTvis saWiroa pirvel rigSi gamovrToT qsel - idan binaSi arsebul i yvel a el eqtroenergiis momx-

marebel i xel sawyo da davrwmundeT imaSi, rom mricxvel is dasaTval ierebel fanj araSi disko ar brunavs.

Tu disko ganagrZobs brunvas es ni Snavs, rom sadRac darCa CarTul i xel sawyo da sanam disko ar gaCerdeba manam mricxvel s ver SevamowmebT. Tu yvel a xel - sawyo gamorTul ia da disko mainc ganagrZobs brunvas, maSin mricxvel s aqvs TviTsvl a da igi aucil ebl ad eqvemdebareba l laboratoriu l Semowmebas.

TiToeul i mricxvel is farze naCvenebia diskos ramdeni bruni Seesabameba. 1kvt.sT el eqtroenergiis, magal iTad, farze naCvenebia 400br/kvtsT. es ni Snavs, rom 1 kvtsT el eqtroenergiis Seesabameba diskos 400 bruni. Mmricxvel is Semowmebisatvis saWiroa agreTve vicodeT energiis ra raodenoba Seesabameba diskos erT bruns. Ees sidide aRiniSneba C asoTi da cxadia. rom Tu 1 kvtsT-s Seesabameba 400 bruni, maSin erT bruns Seesabameba

$$C = \frac{1}{400}.$$

Semowmebisatvis yvel aze kargia visargebl oT el - eqtrul i varvara naTurebiT. saWiroa CavrToT qsel - Si 1 naTura 100vt simZl avris da magal iTad, 5 wuTis

$\left(\frac{5}{60}\right)$ sT ganmavl obaSi daviTval oT diskos brunTa rixvi.

naTurebis mier daxarj ul i el energia gamoiTvl eba formul iT:

$$W_1 = \frac{5}{60} \cdot P \text{ (kvt.sT)},$$

sadac P CarTul i naTuris simZl avrea kvtsT-ebSi.

Cveul ebriv naTuris simZl avre naCvenebia naTuraze vatebSi. Aamitom is unda gadaviyvanoT kil ovatebSi. $100vt=0.1kvt$.

Mmricxvel is mier aRricxul i daxarj ul i el eqtroenergia gamoiTvl eba formul iT:

$$W_2 = C \cdot n \text{ (kvt.sT)},$$

sadac N - diskos brunTa ricxvia $5 \text{ wuTis } \left(\frac{5}{60}\right) \text{ sT}$ ganmavl obaSi.

Tu $W_1 = W_2$, maSin mricxvel i sworad muSaobs.

magal iTi. qsel Si CarTul ia ori naTura saerTo simZl avriT 150 vt. Mmricxvel is diskom sakontrol o Semowmebis dros 5 wuTSi gaakeTa $N=5$ bruni. mricxve-

l is farze naCvenebia, 400 br/kvt.sT. Aanu $C = \frac{1}{400} \text{ kvt.sT}$.

ganvsazRvroT naTurebis mier moxmarebul i energiis faqtiuri xarj i. naTurebis simZl avreP $P=150 \text{ vt} = 0,15 \text{ kvt}$. 5 wuTis ganmavl obaSi naTurebis mier moxmarebul i energiis raodenoba tol i iqneba

$$W_1 = \frac{5}{60} \cdot 1,15 = 0,0125 \text{ sT}.$$

imave drois ganmavl obaSi mricxvel is mier aRricxul i el eqtroenergia tol i iqneba

$$W_2 = \frac{1}{400} \cdot 5 = 0,0125 \text{ sT}.$$

anu $W_1 = W_2$.

e.i. mricxvel i sworad muSaobs.

el energiis mricxvel is cdomil ebis gan-sazRvra. Eel eqtroenergiis mricxvel is sizuste ganisazRvrebis sizustis kl asiT. sayofacxovrebo mricxvel ebisatvis dasaSvebia cdomil eba, romel ic ar aRemateba 4%-s. es niSnavs, rom srul iad wesrigSi myof mricxvel s SeuZl ia aRricxos nominal uri simZl avris 4%-iT meti an nakl ebi el eqtroenergia.

Tu W_1 da W_2 mniSvnel obebs Soris gansxvaveba 4%-ze metia, maSin mricxvel is Cveneba unda CavTval - oT arasworad.

magal iTad, ideal ur mricxvel s, romel ic gankuTvnil ia 220v Zabvaze da 10 a denze muSaobisatvis erT saaTSi SeuZl ia aRricxos $220 \cdot 10 = 2200 \text{ vt.sT} = 2,2 \text{ kvtsT}$. el eqtroenergia. magram mxedvel obaSi viRebT ra mricxvel is sizustis kl ass, wesivrul mdgomareobaSi SeiZl eba CaiTval os is mricxvel i, romel ic imave pirobeb-

Si aRricxavs $2,2 + \left(2,2 \cdot \frac{4}{160}\right) = 2,2 + 0,088 = 2,288 \text{ kvt. sT}$.

an $2,2 - \left(2,2 \cdot \frac{4}{160}\right) = 2,2 - 0,088 = 2,112 \text{ kvt. sT}$. el eqtroenergias.

wesivrul mdgomareobaSi myofma mricxvel ma sizustis kl asis sazRvrebSi unda imuSavos dasaSvebi gadatvirTvebis drosac. Mmcire datvirTvebis dros Cvenebis sizuste mcirdeba, xol o Zal ian mcire datvirTvebis dros diskom SeiZl eba arc ibrunos.

5.19. ra SeiZl eba ganisazRvros mricxvel iT garda el eqtroenergiis xarj isa

1. pirvel rigSi SeiZl eba ganisazRvros mocemul momentSi binaSi CarTul ia Tu ara naTurebi da sxva el eqtroxel sawyoebi. Tu mricxvel is disko brunavs, maSin CarTul ia, xol o Tu uZravia maSin yvel a gamorTul ia.

2. ra j amuri simZl avris datvirTva aris CarTu- l i mricxvel ze. visargebl oT saatIs wammzomiT da ganvsazRvroT ra droSi gaakeTebS magal iTad 20 bruns mricxvel is disko. es advil ad gasakeTebel ia radgan diskoze aris raime feris zol i, romel ic mkafiod Cans mricxvel is fanj araSi. davuSvaT 20 bruni mricx- vel ma gaakeTa 50 wm-Si. Semdeg mricxvel ze vkiTxu- l obT magal iTad 400 br/kvtsT. vadgenT proporcias:

Tu 1kvtsT=1000vt.3600 wm=3600000 vt.wm Sesabamisad srul deba 400 bruni, maSin X vt.wm-is Sesabamisad Ses- rul deba - 20 bruni. aqedan

$$X = \frac{3600 \times 40}{400} = 360000 \text{ vt.wm.}$$

FviciT ra, rom 3600000 vt.wm el eqtroenergia daxar- j ul ia 50 wm-Si advil ad SegviZl ia ganvsazRvroT mricxvel ze CarTul i xel sawyoebis j amuri simZl ave

$$\frac{360000}{50} = 7200 \text{ vt} = 7,2 \text{ kvT}$$

3. mricxvel Si gamaval i denis sidide. miRebul i simZl avres (7200vt) gavyofT qsel is nominal ur Zab- vaze (mag 220v) da mivi RebT

$$7200 : 220 = 32,73a$$

4. viciT ra mricxvel idan gamomaval i sadenebis kveTi da maTSi gamaval i denis xangrZl ivad dasaSve- bi mniSvnel oba (danarTi3) SeiZl eba gavigoT gada- tvirTul ia Tu ara qsel i. Mmagal iTad, sadenis dasaS- vebi denia 20 a. maSin 220 v Zabvis dros mas Seesabameba simZl avre $20a \times 220v = 4400vt$. mivceT dros raRac mniS- vnel oba. magal iTad, 30 wm da gavamravl oT miRebul simZl avreze $440030 = 132000$. davuSvaT mricxvel is dafaze aweria 400 br/kvtsT anu 1 kvtsT=3600000 vt.wm energias Seesabameba 400 bruni, xol o 132000 vt.wm Seesabameba

formul a $\frac{132000 \cdot 40}{3600000} = 15$ bruni.

anu Tu sadenebi gadatvirTul i ar aris, maSin mricxvel is disko naxevari wuTis ganmavl obaSi akeTebS ara umetes 15 brunisa.

5. gadatvirTul ia Tu ara TviTon mricxvel i. davuSvaT mricxvel ze daweril ia 5-15 a 220 v; 1kvtsT=1250 bruni. Mmaqsimal ur dens Seesabameba simZl avre $15 \times 220 = 3300vt$ el eqtroenergiis xarj i 30wm-is ganmav-

l obaSi tol ia $3300 \times 30 = 9900vtwm$ da $99000 - \frac{1250}{3600000} = 34$

bruni, e.i. Tu 30 wm is ganmavl obaSi disko akeTebS ara umetes 34 brunsa, maSin mricxvel i gadatvirTul i ar aris.

6. SeiZl eba gaviangariSoT ra raodenobis el eqt- roenergia daixarj a komunal uri binis saerTo far- Tobze. davuSvaT komunal ur binaSi aris ori saan- gariSo mricxvel i, romel Ta datvirTva daaxl oebiT Tanabrad aris ganawil ebul i. Ggarda amisa 5 oj axs

გააჩნია საკონტროლო მრიცხველები. ერთი ტვის განმავლობაში ერთმა საერთო მრიცხველმა აჩვენა 300 კვტს, ხოლო მეორემ 200 კვტს, ანუ მთლიანად დაიხარჯა $300+200=500$ კვტს. საკონტროლო მრიცხველმა კი აჩვენა $60+70+40+30+35=235$ კვტს. აქედან განისაზრვება, რომ საერთო ფაქტობრივად დაიხარჯა $500-235=265$ კვტს.

ლიტერატურა















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

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danarTi 1. pirobiTi grafikul i aRniSvnebi

cxril i 1 el eqtrul i wredis el ementebis pirobiTi grafikul i aRniSvnebi

parametri		grafikul i simbol o
el eqtrul i wi naRoba-R gamtaroba-G	mudmi vi	
	cvl adi Y	
induqci uroba-L urTierTi nduqci uroba-M	mudmi vi	
	cvl adi	
tevadoba-C	mudmi vi	
	cvl adi	
sazomi Sunt i		
srul i wi naRoba-Z srul i gamtaroba-Y		
mudmi vi Zabvis (emZ) wyaro		
mudmi vi da cvl adi Zabvis (emZ) wyaro		
mudmi vi da cvl adi deni s wyaro		
si nusoi duri emZ wyaro		
generatori		
Zabvi T marTvadi Zabvi s wyaro		

cxril i 2 el eqtrosazomi xel sawyoebis pirobiTi aRniSvnebi

parametri	grafikul i simbol o
ampermetri	
vol tmetri	
si xSi remzomi	
vatmetri	
si mZl avris koeficientis mzomi da fazometri	
aqtiuri energi is mri cxvel i	
reaqtiuri energi is mri cxvel i	

**AINO(ruseTi) da DIN (germania) standartebiT
miRebul i pirobiTi grafikul i aRniSvnebi**

cxril i 3

sakomutacio mowyobil obebis funqciebis pirobiTi
grafikul i aRniSvnebi

kontaqtis maxasiaTebel i	ГОСТ	DIN
kontaqtori		
amomrTveli		
gamTisi		
amomrTveli-gamTisi		
avtomaturi amuSavebis		
sabolo amomrTveli		
TviTdabrunebiT		
TviTdabrunebis gareSe		
rkal mqrobi		

**cxril i 4
sakomutacio mowyobil obebis kontaqtebis pirobiTi
grafikul i aRniSvnebi**

kontaqtis maxasiaTebel i	ГОСТ	DIN
normal urad Ria (nR) kontaqti		
normal urad Caketili (nC) kontaqti		
gadamrTveli kontaqtebi		
gadamrTveli kontaqtebi nei traluri mdgomareobiT		
gadamrTveli kontaqtebi gaTisvis gareSe		
normal urad Ria ormagi kontaqtebi		
normal urad Caketili ormagi kontaqtebi		monacemi ar aris
normal urad Ria kontaqtebi amuSavebis mysieri Caketv iT		
normal urad Ria kontaqtebi mysieri Caketv iT ukuqcevis dros		monacemi ar aris
normal urad Ria kontaqtebi mysieri Caketv iT amuSavebi sa da ukuqcevis dros		monacemi ar aris
normal urad Caketili kontaqtebi mysieri gaTisv iT amuSavebi sa dros		monacemi ar aris
normal urad Caketili kontaqtebi mysieri gaTisv iT ukuqcevis dros		monacemi ar aris
normal urad Caketili kontaqtebi mysieri gaTisv iT amuSavebi sa da ukuqcevis dros		monacemi ar aris
normal urad Ria kontaqtebi yvel aze adre amuSavebi T		


















cxriil is gagrZel eba

kontaqti s maxasi aTebel i normal urad Caketil i kontaqtebi yvel aze adre amuSavebi T	ГОСТ	DIN
normal urad Ria kontaqtebi yvel aze gvi an amuSavebi T		monacemi ar aris
normal urad Caketil i kontaqtebi yvel aze gvi an amuSavebi T		
normal urad Ria kontaqtebi ukuqcevis gareSe		
normal urad Caketil i kontaqtebi ukuqcevis gareSe		monacemi ar aris
normal urad Caketil i kontaqtebi Tvi Tdabrunebi T		
normal urad Ria kontaqtebi Tvi Tdabrunebi T		
gadmrTveli kontaqtebi neitral uri mdgomareobi T Tvi Tdabrunebi T marcxena mdgomareobi dan da Tvi Tdabrunebi s gareSe- marj venadan		monacemi ar aris
kontaqtoris(rel es) normal urad Ria kontaqtebi		
kontaqtoris(rel es) normal urad Caketil i kontaqtebi		
kontaqtoris(rel es) normal urad Ria kontaqtebi rkal Camqrobi T		monacemi ar aris
kontaqtoris(rel es) normal urad Caketil i kontaqtebi rkali Camqrobi T		monacemi ar aris
kontaqtoris(rel es) normal urad Ria kontaqtebi avtomaturi amuSavebi T		
amomrTvel is normal urad Ria kontaqtebi		















cxriil is gagrZel eba

kontaqti s maxasi aTebel i	ГОСТ	DIN
gamTisi normal urad Ria kontaqtebi		
amomrTvel -gamTisi s normal urad Ria kontaqtebi		
sabol oo amomrTvel is normal urad Ria kontaqtebi		
sabol oo amomrTvel is normal urad Caketil i kontaqtebi		monacemi ar aris
orj gufad bli okirebul i sabol oo amomrTvel i		
ganmrTvel is normal urad Ria moZravi kontaqtebi	monacemi ar aris	
normal urad Ria Camami webel i kontaqtebi	monacemi ar aris	
temperaturi sadmi mgrZnobi are normal urad Ria kontaqtebi		
temperaturi sadmi mgrZnobi are normal urad Caketil i kontaqtebi		monacemi ar aris
normal urad Ria kontaqtebi Senel ebi T gaTisvi sas		
normal urad Ria kontaqtebi Senel ebi T CarTvi sas		monacemi ar aris
normal urad Ria kontaqtebi Senel ebi T CarTva-gaTisvi sas		monacemi ar aris
normal urad Caketil i kontaqtebi Senel ebi T CarTvi sas		monacemi ar aris
normal urad Caketil i kontaqtebi Senel ebi T gaTisvi sas		

cxril is gagrZel eba

kontaqTis maxasiaTebel i	TOCT	DIN
gamTisSis kontaqtebi xel is bl oki rebiT	monacemi ar aris	
erTpol usa amomrTvel is normal urad Ri a kontaqtebi		monacemi ar aris
sampol usa amomrTvel is normal urad Ri a kontaqtebi		monacemi ar aris
sampol usa amomrTvel is normal urad Ri a kontaqtebi maqsimal uri denis avtomaturu amuSavebi T		monacemi ar aris
sampol usa gamTisSis normal urad Ri a kontaqtebi		monacemi ar aris
sampol usa amomrTvel - gamTisSis normal urad Ri a kontaqtebi		monacemi ar aris
Termul i Tvi Tregul irebadi amomrTvel is normal urad Caketil i kontaqtebi		
Termorel es normal urad Caketil i kontaqtebi		monacemi ar aris
normal urad Ri a kontaqtebi gaziT avebul bal onSi	monacemi ar aris	
dasalWeri Ri l aki ani amomrTvel is normal urad Ri a kontaqtebi avtomaturu dabrunebi T		
dasalWeri Ri l aki ani amomrTvel is normal urad Ri a kontaqtebi avtomaturu dabrunebi T meore dalWeri sas		monacemi ar aris
dasalWeri Ri l aki ani amomrTvel is normal urad Ri a kontaqtebi avtomaturu dabrunebi T gamovevi sas		monacemi ar aris
dasalWeri Ri l aki ani amomrTvel is normal urad Ri a kontaqtebi avtomaturu dabrunebi T Camoyris Ri l aki is daxmarebi T		monacemi ar aris
inerciul i amomrTvel is normal urad Ri a kontaqtebi		

cxril is gagrZel eba

kontaqTis maxasiaTebel i	TOCT	DIN
vercxl is swyl i ani gadamrTvel is kontaqtebi nei tral uri mdgomareobi T		
orpol usi ani gadamrTvel is kontaqtebi nei tral uri mdgomareobi T		monacemi ar aris
orpol usi ani gadamrTvel is kontaqtebi nei tral ur mdgomareobaSi dabrunebi T		monacemi ar aris
xel iT marTviT amomrTvel is kontaqtebi	monacemi ar aris	
Sexebaze mgrZnobi are amomrTvel is kontaqtebi	monacemi ar aris	
mi axl oebaze mgrZnobi are amomrTvel is kontaqtebi	monacemi ar aris	
magnit is mi axl oebaze mgrZnobi are amomrTvel is kontaqtebi	monacemi ar aris	
sampol usa avtomaturu kontaqtebi Termomagnituri amomrTvel iT dacvi T	monacemi ar aris	
dancavi gamorTvis sampol usa mowiyobil obis kontaqtebi	monacemi ar aris	
avtomaturu amomrTvel is kontaqtebi	monacemi ar aris	
amomrTvel is kontaqtebi, romel ic imyofeba vertikal ur mdgomareobaSi	monacemi ar aris	
mraval pozicuri gadamrTvel is kontaqtebi		






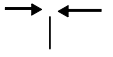
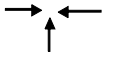






cxrili 5
SeerTebisa da maTi el ementebis pirobiTi
grafikul i aRniSvnebi

dasaxel eba	ГОСТ	DIN
sadenebis araganrTvadi SeerTeba		
kl emebis SeerTebis wertili (ganrTvadi SeerTeba)		
SemaerTebeli kal apoti		
SemaerTebeli kal apoti ganrTvadi da araganrTvadi kontaqtebi T		
sadenebis ganStoebis magali Tebi		
ori sadenis ganStoebis magali Ti		
sadenebis ganrTvadi SeerTeba		
SemaerTebeli kal apoti ganrTvadi kontaqtebi T		
erTpol usiani rozeti (bude)		
erTpol usiani Cangali (manWvali)		
rozetisa da Canglis SeerTeba		
maval pol usiani SeerTeba (Orive varianti tolmniSvnelovania)		
Stekeri (uZravi nawilii)	monacemi ar aris	
Stekeri (moZravi nawilii)	monacemi ar aris	
Stekerebi T SeerTeba	monacemi ar aris	
gaxsnili zRudari	monacemi ar aris	
SemaerTebeli zRudari		
orpol usa SeerTeba: manWvali da bude	monacemi ar aris	
Stirisa da ori budes SeerTeba		
SeerTeba adapteris daxmarebi T		
SeerTeba manStoebilis daxmarebi T		

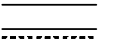

















cxrili 6
mcvel ebisa da ganmuxtvel ebis pirobiTi
grafikul i aRniSvnebi

dasaxel eba	ГОСТ	DIN
mcveli, ZiriTadi aRniSvna		
mcveli, gaferadebuli nawilini Snavs qsel TanmierTebis mxares		
mcveli megani kuri amuSavebi T (dar tyim T)		
mcveli damxmare sasignal kontaqti T		
ganomrTveli mcveli		
sampol usa megani kuri bl Okirebuli mcveli ganrTvadi kontaqtebi T mcvelis amoqmedebis dros		
mcveli -gamTisi		
anomrTveli -gamTisi mTavari mcveli T		
DDII, 10a tipis Casaxraxni mcveli		
00, 25a tipis mcveli danisebri kontaqtebi T		
mcveli signalizaciis damouki debel isqem T		monacemi ar aris
mcveli inerciuli dnobi T		monacemi ar aris

cxril is ggrZel eba

Znel dnoyadi mcvel i		monacemi ar aris
mcvel i swrafmoqmedi		monacemi ar aris
mcvel i-ganmuxtvel i		monacemi ar aris
orel eqtrodi ani naperwkl is Sual edi		
orel eqtrodi ani simetriul i naperwkl is Sual edi		monacemi ar aris
samel eqtrodi ani naperwkl is Sual edi		monacemi ar aris
ganmuxtvel i		
gaziT gavsebul i ganmuxtvel i		
vakuumuri ganmuxtvel i		monacemi ar aris
milisebri ganmuxtvel i		monacemi ar aris

cxril i 7
sidideebis simbol oebis da Camiwebis maxasiaTebi is pirobiTi grafikul i aRniSvnebi

simbol oebis daxasiaTeba	ГОСТ	DIN
mudmi vi Zabvis simbol oebi		
cvl adi erTfaza Zabvis simbol oebi	~50Γ _{II} 3N~50Γ _{II} 220/380E	~50Γ _{II} 3N~50Γ _{II} 220/380E
dabali sixSi ris Zabva		
saSual o sixSi ris Zabva		
maRal i sixSi ris Zabva		
mudmi vi Zabvis simbol o cvl adi mdgenel iT		
Camiweba		
uxmauro Camiweba		
damcavi Camiweba		
masa (korpusi)		

cxril i 8
sadenebis pirobiTi aRniSvna

dasaxel eba sadeni , sahaer o xazi	ГОСТ	DIN
sami sadeni		
Zabvisada sadenis kveTis aRniSvna		
dasagegmi sadeni	-----	-----
daumagrebeli sadeni		
ekrani rebuli sadeni		
sadenTa xveuli wvili		
sami sadeni erT kabel Si		
isrebi ucveneben sadenebs, gaerTianebuli s erT kabel Si		
koaqsial uri (ekrani rebuli) sadeni		
koaqsial uri sadeni CarTuli ekraniT		
SeuerTebeli sadeni		
SeuerTebeli izolirebuli sadeni		
sakabel o xazi	-----	-----
datvirTva		

cxril i 9
gadamtveli ebisa da amomtveli ebis pirobiTi grafikuli aRniSvnebi

dasaxel eba	ГОСТ	DIN
mraval poziciiani gadamtveli	monacemi ar aris	
amomtveli fiqsaciis gareSe(Rilaki)	monacemi ar aris	
amomtveli fiqsaciiT	monacemi ar aris	
sampoziciiani amomtveli fiqsaciiT	monacemi ar aris	
or j gufze	monacemi ar aris	
gadamtveli fiqsaciiT or mdgomareobaze	monacemi ar aris	
or j gufze da or mdgomareobaze	monacemi ar aris	














sinaTli is wyaroebis pirobiti grafikuli aRniSvnebi

Ddasaxel eba		ГОСТ	DIN
sinaTli is wneva	Ddabali	•	monacemi ar aris
	maRali	•	monacemi ar aris
	zemaRali	•	monacemi ar aris
impul suri gamosxiveba			monacemi ar aris
bal oni gavsebul ia gazi T	Nneoni	Ne	Ne
	Oqsenoni	Xe	Xe
	Nnatriumi	Na	Na
	vercxli iswyali	Hg	Hg
	iodi	I	J
bal oni amrekl i feni T	Si ga		monacemi ar aris
	Ggare		monacemi ar aris
rkal uri el eqtrodi			monacemi ar aris
ganaTebisa da signal izacii s varvara naTura			
sinaTli is signal izacii s impul suri naTura			
naTebis feri	wiTel i	C2	RD
	yviTel i	C4	YE
	Mwvane	C5	GN
	Lurji	C6	BU
	TeTri	C9	WH
orZafa varvarebis naTura	sami gamomyvani T		monacemi ar aris
	oTxi gamomyvani T		monacemi ar aris
ganaTebisa da sasi gnal o ai rganmuxtvis naTurebi ori gamomyvani T			monacemi ar aris















ganaTebisa da sasi gnal o ai rganmuxtvis naTurebi oTxi gamomyvani T

		monacemi ar aris	
dabali wnevis ai rganmuxtvis naTurebi	uel eqtrodo		monacemi ar aris
	mudmi vi denis martivi el eqtrodebi T		monacemi ar aris
	cvl adi denis martivi el eqtrodebi T		monacemi ar aris
	kombini rebuli el eqtrodebi T		monacemi ar aris
	kombini rebuli el eqtrodebi Ta da wi naswari gaxurebi T		monacemi ar aris
	mudmi vi da cvl adi denis kombini rebuli el eqtrodebi T		monacemi ar aris
	martivi el eqtrodebi T Tvi Tvarvarebadi kaTodi T		monacemi ar aris
	kombini rebuli el eqtrodebi T, wi naswari gaxurebi Ta da ul tra isferi gamosxivebi T		monacemi ar aris
	kombini rebuli el eqtrodebi Ta da Si ga amrekl i feni T		monacemi ar aris
	Txevadi kaTodi Ta da gare moki debi T		monacemi ar aris
maRali wnevis ai rganmuxtvis naTurebi	martivi el eqtrodebi Ta da gare moki debi T impul suri		monacemi ar aris
	kombini rebuli el eqtrodebi T, wi naswari gaxurebi Ta da Tvi Tvarvarebadi kaTodi T		monacemi ar aris
	kombini rebuli el eqtrodebi Ta da Si ga moki debi T		monacemi ar aris

cxril is gagZel eba

	martivi el eqtrodebiT		monacemi ar aris
	kombini rebul i el eqtrodebi Ta da wi naswari gaxurebiT		monacemi ar aris
zemaRal i wnevis airganmuxtvis naTurebi	martivi el eqtrodebiT		monacemi ar aris
	kombini rebul i el eqtrodebi Ta da Si ga moki debiT		monacemi ar aris
airganmuxtvis naTurebi s ti pebi	el eqtrol umi nescenci uri	EL	monacemi ar aris
	fl uoescenci uri	FL	monacemi ar aris
	varvara naTurebi infrawi Tel i gamosxi vebi T		monacemi ar aris
	varvara naTurebi i odis aRmdgenel i cikl iT		monacemi ar aris
	varvara naTura Si ga amrekl i feniT		monacemi ar aris
	rkal uri naTura		monacemi ar aris
	rkal uri naTura kuTxiT ganl agebul i el eqtrodebiT		monacemi ar aris
	l umi nescenci uri arakomutirebadi		monacemi ar aris
	komutirebadi cal mxrivi marTviT		monacemi ar aris
	komutirebadi ormxrivi marTviT		monacemi ar aris
airganmuxtvis naTurebi s gamSvi		monacemi ar aris	

cxril i 11 el eqtrogayvanil obis sqemebSi gamoyenebul i pirobiT grafikul i aRniSvnebi

Ddasaxel eba	ГОСТ	DIN
Camosaki di		monacemi ar aris
sanaTi varvaris naTuriT kedl is		monacemi ar aris
Seki dul i Weris		monacemi ar aris
sanaTi DPA naTuriT		monacemi ar aris
sanaTi l umi nescenci uri naTuriT, Camosaki di		monacemi ar aris
l umi nescenci uri naTuri s ganl agebis xazi		monacemi ar aris
Stefsel i, rozeti		monacemi ar aris
ormimarTul ebiani erTpol usa gadamrTvel i		monacemi ar aris
amomrTvel i erTpol usa		monacemi ar aris
orpol usa		monacemi ar aris
ganStoebis kol ofi		monacemi ar aris
gamanawil ebel i fari		monacemi ar aris
muSa ganaTebis jgufuri fari		monacemi ar aris
avariul i ganaTebis jgufuri fari		monacemi ar aris

cxril is pagrZel eba

el eqtrogayvani l Obi s aRni Svna, gayvani T	el gayvani l Obi s xazi	—	monacemi ar aris
	metal is mil ebSi	T	monacemi ar aris
	pl astmasis mil ebSi	II	monacemi ar aris
	metal is garsacmSi	Mp	monacemi ar aris
	izol atorebze	И	monacemi ar aris
	gvarI ze	Tc	monacemi ar aris
	daxurul i gayvani T	C	monacemi ar aris

**cxril i 12
transformatorebisa da avtotransformatorebis
pirobiTi grafikul i aRniSvnebi.**

dasaxel eba		aRni Svna	
		gamartivebul i	gaSili i
erTfaza transformatori	feromagnituri gul ar iT		
	feromagnituri gul ar iT da gragnil ebis Soris ekrani T		
diferencial uri transformatori			
erTfaza samgragnila transformatori feromagnituri gul ar iT			
samfaza transformatori feromagnituri gul ar iT	gragnil ebis SeerTeba "varskvl avi "- "varskvl avi " gamoyvani l i neitral uri vertil iT SeerTeba "samkuTxedi "- "varskvl avi " gamoyvani l i neitral iT		
	SeerTeba "varskvl avi "- "zigzagi " gamoyvani l i neitral iT SeerTeba "varskvl avi " erTi gragnil iT da ori "ukuvarskvl avi " neitral uri vertil iT da gamaTanabrebel i reaqtori T		
	samfaza samgragniliani transformatori feromagnituri gul ar iT, "varskvl avi " SeerTebi T, datvirTvis qveS regul irebi T. "samkuTxedi " da "varskvl avi " gamoyvani l i neitral iT		
avtotransformatori feromagnituri gul ar iT	erTfaza		

cxrili sagrZel eba

<p>samfaza, gragnilebis 'varskvava' SeerTebiT</p>		
<p>samfaza, cxragamoyvaniT</p>		
<p>erTfaza mesameuli gragnilit</p>		
<p>samfaza, gragnilebis SeerTeba "varskvavi" gamoyvani i neitralita da "sankuTxedad" SeerTebuli meoreuli gragnilit</p>		
<p>erTi meoreuli gragnilit</p>		
<p>erTigularitad ori meoreuli gragnilit</p>		
<p>ori gularitad ori meoreuli gragnilit</p>		
<p>sasalte, nulovani Tanmi mdevrobis damagnitebis kowiT</p>		

denis
transformatori

cxrili 13
el eqtruli manqanebis pirobiti grafikuli
arNisvnebi

dasaxel eba	arNisvna	gamartivebuli	gasilili
<p>cvladi denis samfaza generatori</p>			
<p>cvladi denis samfaza Zrava, romlis gragnilebis varskvavadarian SeerTebuli</p>			
<p>samfaza asinqronuli Zrava fazuri rotorit, romlis gragnili SeerTebuli a varskvavad, rotoris gragnili c SeerTebuli a varskvavad gamoyvani i neitraliT.</p>			
<p>samfaza el eqtruli manqanebis gragnilebis urTierTganlageba fazaTa Zvris gaTvaliswinebiT</p>			
<p>samfaza el eqtruli manqanebis gragnilebis ganlageba fazaTa Zvris gaTvaliswinebis gareSe</p>			
<p>mudmivi denis mdevrobiT agznebiani manqana</p>			
<p>paral el ur agznebiani mudmivi denis manqana</p>			
<p>Sereul agznebiani mudmivi denis manqana</p>			
<p>si nqronuli samfaza el manqana agznebis gragnilit, cxadpousiani rotoritad a varskvavad SeerTebuli statorit</p>			
<p>asinqronuli samfaza manqana mokled SerTuli rotorit da sankuTxedad SeerTebuli statorit</p>			
<p>si nqronuli samfaza manqana mudmivi magnitebis agznebiT a varskvavad SeerTebuli statoris gragnilit</p>			
<p>samfaza mabruni avtotransformatori, potencial- regulatori, wreebis SeerTebe ni Snavs statorisa da rotoris el eqtrul SeerTebe</p>			
<p>samfaza fazamabruni transformatori, fazoregulatori</p>			

danarTi 2.
trigonometriul i funqciebis
mniSvnel obebi

cxril i 1

Φ grad	cos Φ	sin Φ	tg Φ	Φ grad	cos Φ	sin Φ	tg Φ	Φ grad	Cos Φ	sin Φ	tg Φ
0	1,000	0,0000	0,0000	31	0,8572	0,5150	0,6009	62	0,4695	0,8829	1,88
1	0,9998	0,0175	0,0175	32	0,8480	0,5299	0,6249	63	0,4540	0,8910	1,96
2	0,9994	0,0349	0,0349	33	0,8387	0,5446	0,6494	64	0,4384	0,8988	2,05
3	0,9986	0,0523	0,0524	34	0,8290	0,5592	0,6745	65	0,4226	0,9063	2,14
4	0,9976	0,0698	0,0699	35	0,8192	0,5736	0,7002	66	0,4067	0,9135	2,25
5	0,9962	0,0872	0,0875	36	0,8090	0,5878	0,7265	67	0,3907	0,9205	2,36
6	0,9945	0,1045	0,1051	37	0,7986	0,6018	0,7536	68	0,3746	0,9272	2,47
7	0,9925	0,1219	0,1228	38	0,7880	0,6157	0,7813	69	0,3584	0,9336	2,60
8	0,9903	0,1392	0,1405	39	0,7771	0,6293	0,8098	70	0,3420	0,9397	2,75
9	0,9877	0,1564	0,1584	40	0,7660	0,6428	0,8391	71	0,3256	0,9455	2,90
10	0,9848	0,1736	0,1763	41	0,7547	0,6561	0,8693	72	0,3090	0,9511	3,08
11	0,9816	0,1908	0,1944	42	0,7431	0,6691	0,9004	73	0,2924	0,9563	3,27
12	0,9781	0,2079	0,2126	43	0,7314	0,6820	0,9325	74	0,2756	0,9613	3,49
13	0,9744	0,2250	0,2309	44	0,7193	0,6947	0,9657	75	0,2588	0,9659	3,73
14	0,9403	0,2419	0,2493	45	0,7071	0,7071	1,0000	76	0,2419	0,9703	4,01
15	0,9659	0,2588	0,2670	46	0,6947	0,7193	1,0355	77	0,2250	0,9744	4,33
16	0,9613	0,2756	0,2867	47	0,6820	0,7314	1,0724	78	0,2079	0,9781	4,70
17	0,9563	0,2924	0,3057	48	0,6691	0,7431	1,1106	79	0,1908	0,9816	5,14
18	0,9511	0,3090	0,3249	49	0,6561	0,7547	1,1504	80	0,1736	0,9848	5,67
19	0,9455	0,3256	0,3443	50	0,6428	0,7660	1,1918	81	0,1564	0,9877	6,31
20	0,9397	0,3420	0,3640	51	0,6293	0,7771	1,2349	82	0,1392	0,9903	7,11
21	0,9336	0,3584	0,3839	52	0,6157	0,7880	1,2799	83	0,1219	0,9925	8,14
22	0,9272	0,3746	0,4040	53	0,6018	0,7986	1,3270	84	0,1045	0,9945	9,51
23	0,9205	0,3907	0,4245	54	0,5878	0,8090	1,3764	85	0,0872	0,9962	11,4
24	0,9135	0,4067	0,4452	55	0,5736	0,8192	1,4281	86	0,0698	0,9976	14,3
25	0,9063	0,4226	0,4663	56	0,5592	0,8290	1,4826	87	0,0523	0,9986	19,1
26	0,8988	0,4384	0,4877	57	0,5446	0,8387	1,5399	88	0,0349	0,9994	28,6
27	0,8910	0,4540	0,5095	58	0,5299	0,8480	1,6003	89	0,0175	0,9998	57,3
28	0,8829	0,4695	0,5317	59	0,5150	0,8572	1,6643	90	0,0000	1,0000	----
29	0,8746	0,4848	0,5543	60	0,5000	0,8660	1,7320				
30	0,8660	0,5000	0,5774	61	0,4848	0,8746	1,8040				

danarTi 3.
sadenebisa da kabel ebis
standartul i kveTebi da
xangrZi ivad dasaSvebi datvirTvebi

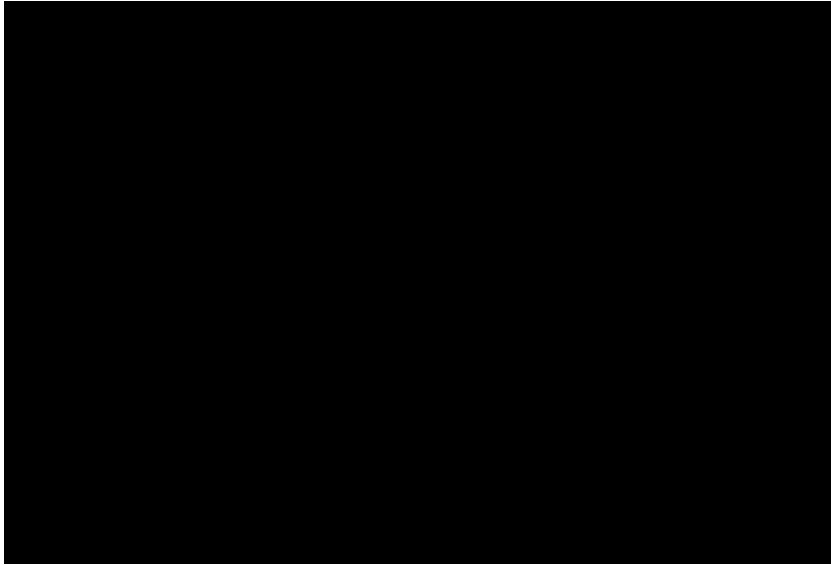
cxril i 1

ras aRniSnavs avtomaturi amomrTvel is tipi

tipi	daniSnul eba
AA	di di sigrZis el eqtrogayvani l obis wredebi T gaTi Svis a da naxebradgamtarul i mowyobil obebis dacvisaTvis.
B	saerTo daniSnul ebis ganaTebis qsel isaTvis.
C	ganaTebis wredebisa da zomeri gamSvi denebis mqone (Zravebi da transformatorebi) el eqtrodanadgarebis gaSvebisaTvis.
D	aqturi induqciuri dacvisaTvis, wredebisaTvis, agreTve di di gamSvi denebis mqone Zravebis datvirTvisaTvis.
K	inducuri datvirTvebisaTvis.
Z	el eqtronul i mowyobil obebisaTvis.

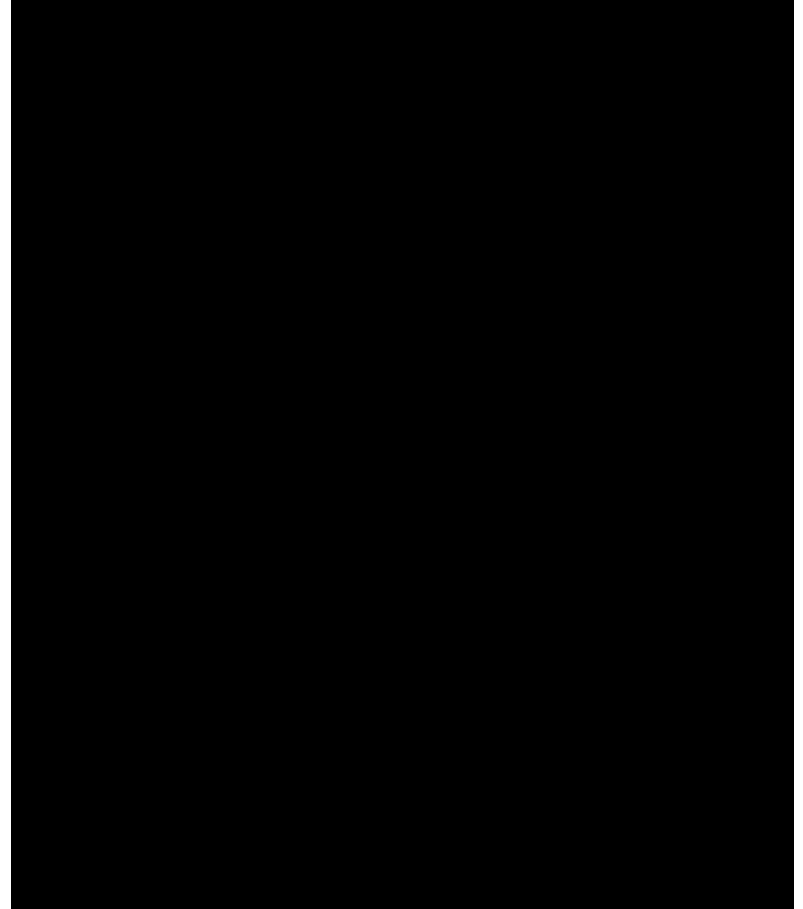
cxrili 5

metal is damcav garsacmSi moTavsebul i rezinis
izolaciis mqone sadenebisa da tyviis
,polivini qI oridis,rezinis garsacmis mqone
javSniani da araj avSniani kabel ebis xangrZi ivad
dasaSvebi deni.



cxrili 6

araizol irebul i sadenebis xangrZi ivad dasaSvebi
denuri



იბეჭდება ავტორთა მიერ წარმოდგენილი სახით

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08.06.2009. ქაღალდის ზომა 60X84 1/16. პირობითი ნაბეჭდი თაბახი 20,5.
ტირაჟი 300 ეგზ.

საგამომცემლო სახლი „ტექნიკური უნივერსიტეტი“, თბილისი,
კოსტავას 77

