Quyosh panelidan qo‘zg‘atiladigan sinxron generatorning dinamik rejimlarini tajriba yo‘li bilan aniqlash

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Dolzarbligi: ishning ahamiyati sinxron generatorlarning (SG) qo'zg'alish tizimlarini mustaqil manbalardan - quyosh panellaridan to'g'ridan-to'g'ri oqim bilan ta'minlashda zaruriy tadqiqotlarni o'tkazishdan iborat. Sinxron generatorlar uchun qo'zg'alish tizimlarini quyosh elektr panellaridan tok bilan ta'minlash SG ning ishlashi davomida sezilarli darajada energiya tejash imkonini beradi. Bunday holda, SG rejimlariga ta'sir qiluvchi quyosh energiyasining o'zgaruvchanligini hisobga olish va turli xil SG rejimlarining dinamikasini tahlil qilish kerak. Bu kabi tadqiqotlar respublikamizda bo‘lgani kabi ko‘plab mamlakatlar olimlari tomonidan ham olib borilmoqda; ularning natijalari quyosh energiyasidan elektr energiyasi ishlab chiqarishda foydalanishni kengaytirish uchun zarur.
Maqsad: mustaqil energiya manbai bo'lgan quyosh elektr panelidan qo'zg'alish oqimi bilan ta'minlashda sinxron generatorning rejimlarini o'rganish va tahlil qilish.
Usullari: elektr mashinalari nazariyasi va quyosh batareyasidan to'g'ridan-to'g'ri qo'zg'alish manbai bo'lgan sinxron generatorni ishga tushirish va ishlatish paytida parametrlarni qiyosiy tahlil qilish usullari qo'llanildi.
Natijalar: quyosh batareyasi tomonidan ishlab chiqarilgan doimiy kuchlanishdan foydalangan holda sinxron generatorning ishga tushirish va dinamik xususiyatlari o'rganildi; Oddiy ishga tushirish va qisqa tutashuv rejimlarida qo'zg'alish oqimi va hosil bo'lgan oqimning parametrlari o'rganildi.
Kalit so‘zlari: sinxron generator, quyosh panel, qo‘zg‘atish toki, dinamik rejim, tokning parametrlari, ossilograf, qisqa tutashuv jerimi, o‘lchash, grafik, texnik xarakteristika.

Экспериментальное определение динамических режимов синхронного генератора с возбуждением от солнечной панели

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Актуальность: важность работы заключается в проведении необходимых исследований режимов синхронных генераторов (СГ) при обеспечении систем их возбуждения постоянным током от независимых источников - солнечных панелей. Обеспечение систем возбуждения синхронных генераторов током от солнечных электрических панелей позволит экономить значительное количество энергии при эксплуатации СГ. При этом необходимо учитывать переменчивость солнечной энергии, влияющей на режимы СГ и сделать анализ динамики различных режимов СГ. Подобные исследования проводятся учёными многих стран, а также в нашей республике; их результаты необходимы для расширения использования солнечной энергии при производстве электроэнергии.
Цель: изучение и анализ режимов синхронного генератора при обеспечении его током возбуждения от солнечной электрической панели - независимого источника энергии.
Методы: использовались теория электрических машин и методы сравнительного анализа параметров при пуске и работе синхронного генератора с источником возбуждения постоянного тока от ФЭП.
Результаты: изучены пусковые и динамические характеристики синхронного генератора, использующего постоянное напряжение, вырабатываемое солнечной батареей; изучены параметры тока возбуждения и генерируемого тока при режимах нормального пуска и короткого замыкания.
Ключевые слова: синхронный генератор, солнечная панель, ток возбуждения, динамический режим, параметры тока, осциллограф, ток короткого замыкания, измерение, график, технические характеристики.

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Experimental determination of dynamic modes of a synchronous generator excited by a solar panel

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Relevance: the importance of the work lies in conducting the necessary studies of the modes of synchronous generators (SG) when providing their excitation systems with direct current from independent sources - solar panels. Providing excitation systems of synchronous generators with current from solar electric panels will save a significant amount of energy during SG operation. It is necessary to take into account the variability of solar energy affecting the SG modes and analyze the dynamics of various SG modes. Similar studies are carried out by scientists in many countries, as well as in our republic; their results are necessary to expand the use of solar energy in electricity generation.
Aim: study and analysis of the modes of a synchronous generator when providing it with excitation current from a solar electric panel - an independent energy source.
Methods: the theory of electrical machines and methods of comparative analysis of parameters during start-up and operation of a synchronous generator with a DC excitation source from a solar cell were used.
Results: the starting and dynamic characteristics of a synchronous generator using direct voltage generated by a solar battery were studied; The parameters of excitation current and generated current under normal start and short circuit conditions were studied.
Key words: synchronous generator, solar panel, excitation current, dynamic mode, current parameters, oscilloscope, short circuit current, measurement, graph, technical characteristics.

1. Kirish (Introduction)

Sinxron generatorlar har xil turdagi energiyani (issiqlik, quyosh, mexanik) elektr energiyasiga aylantirish uchun ishlatiladi. Ular oddiy ishlash prinsipi va ishonchli dizaynga ega. Sinxron generatorlar elektr stantsiyalari, transport vositalari, qurilish, qidiruv, konchilik va barqaror kuchlanish va elektr toki ishlab chiqarish talab qilinadigan boshqa sohalarda qo‘llaniladi [1-3].

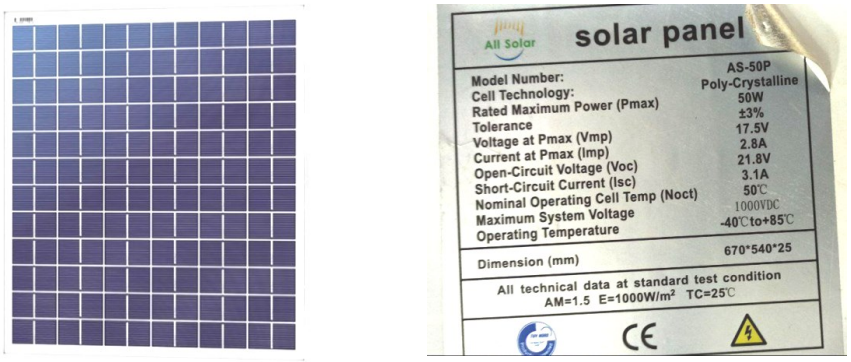
2. Materiallar va usullar (Methods and materials)

Sinxron generatorning dinamik ish rejimining o‘zgarishiga ta’sir qiluvchi parametrlar bilan belgilanadi. Adaptiv boshqaruv sinxron generatorning dinamik xususiyatlarini yaxshilash uchun ishlatiladi. Moslashuvchan boshqaruv algoritmlari Lyapunov funksiya usuli va moslashtirilgan model sxemasiga asoslananadi. Simulyatsiya natijalari sinxron generatorning dinamik xususiyatlarining sezilarli yaxshilanishini ko‘rsatadi.

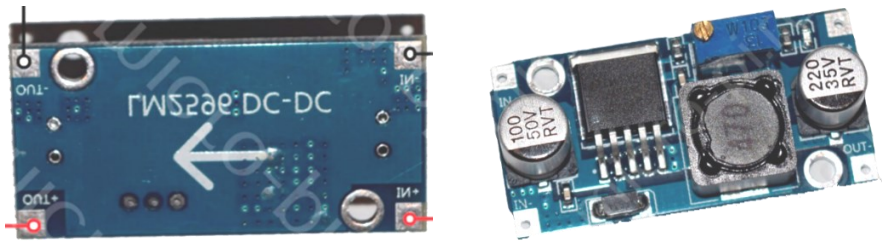
Quyosh panelidan qo‘zg‘atiladigan sinxron generatorning dinamik rejimi ish sharoitlariga qarab generatorning parametrlari masalan, rotor tezligi yoki elektr yuklama o‘zgarishi bilan tavsiflanadi. Generatorning dinamik ish rejimlarini o‘rganish metodi hisoblangan eksperimental laboratoriya stendidan foydalaniladi. Ular generatorning parametrlarini nazorat qilish va turli sharoitlarda uning ishlashini o‘rganish imkonini beradi. Bunday holda, turli xil ish rejimlarida generatorning dinamik xususiyatlarini bevosita kuzatish va o‘lchash, shuningdek, avtomatik qo‘zg‘atishni boshqarish samaradorligini baholash mumkin [10,11,12,13].

Toshkent davlat texnika universiteti Olmaliq filialida quyosh panelidan qo‘zg‘atiladigan sinxron generatorning dinamik rejimlarini o‘rganish uchun laboratoriya qurilmasi ishlab chiqildi va tajribalar olib borildi. Tajribada AS-50P tipidagi quyosh panel (1-rasm) orqali 21,8 V ishlab chiqarilgan maksimal o‘zgarmas kuchlanishni LM 2596 DC-DC konvertor orqali (2-rasm) qiymatini 12 V dan boshlab oshirib borish tartibida o‘zgartirib Г-273В tipidagi sinxron generatorning (3-rasm) qo‘zg‘atish cho‘lg‘amiga berildi. Г-273В sinxron generatorning texnik xarakteristikalari 1-jadvalda keltirilgan.

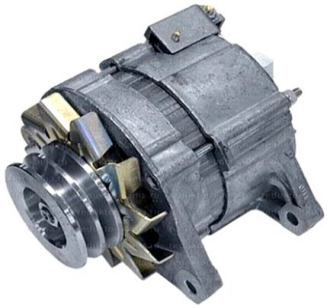
Г-273В sinxron generatori ishlab chiqargan o‘zgaruvchan elektr toki parametrlarini o‘lchash qurilmalari orqali o‘lchab o‘zgartiriladigan yuklamaga berildi. Г-273В sinxron generatorini quyosh paneli yordamida qo‘zg‘atish va ishlatish sxemasi (4-rasm) yig‘ilib, zanjirning har bir qismidagi elektr tokining parametrlarini qiymatlari o‘lchov qurilmalari voltmeter, ampermetrlar yordamida o‘lchanib, ossilogrammalari LECROY WAVERUNNER 64 Xi ossilograf yordamida ko‘rib chiqildi.



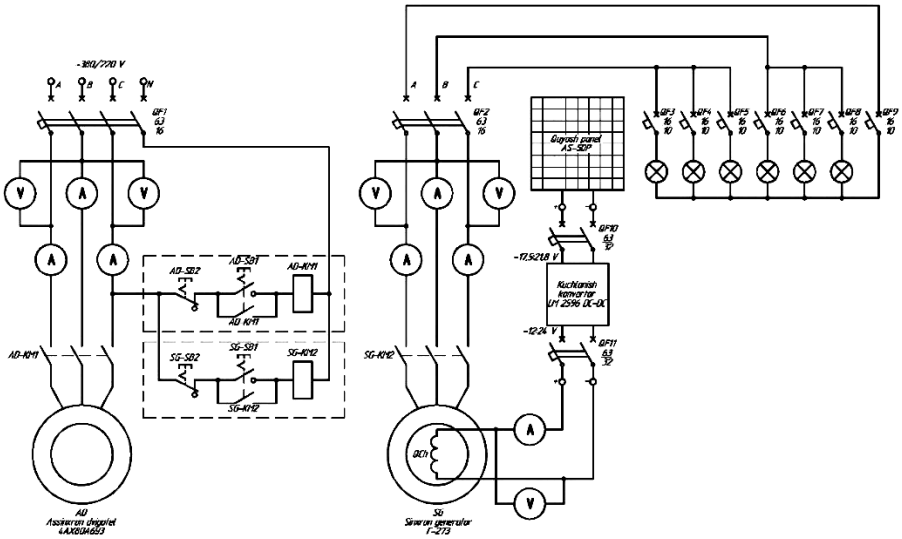
1-rasm. AS-50P quyosh panelining umumiy ko‘rinishi va parametrlari
Fig.1. Overview and parameters of the AS-50P solar panel



2-rasm. LM 2596 DC-DC konvertorining umumiy ko‘rinishi
Fig. 2. Overview of the LM 2596 DC-DC converter



3-rasm. Г-273В sinxron generatorining umumiy ko‘rinishi
Fig. 3. Overview of the Г-273В synchronous generator



4-rasm. Sinxron generatorni quyosh paneli yordamida qo‘zg‘atish va ishlatish sxemasi
Fig. 4. Scheme of excitation and operation of a synchronous generator using a solar panel

1-jadval. Г-273В sinxron generatorining texnik xarakteristikalari
Table 1. Technical characteristics of the Г-273В synchronous generator

Me'yoriy kuchlanish, V	28
Aylanish chastotasi (harorat 25 ± 10 °C, kuchlanish 28 V va mustaqil qo'zg'alishda), ayl/min, yuklama toki yuqori bo'lmaganda:	
10 A	1550
20 A	2100
Ishlab chiqarilgan tok kuchi, A	28
Qo'zg'atish toki, oshmaydi, A	3,4
Chotka prujinasidagi bosim kuchi (17,5 mm prujina qisilganda), rc	190-250
Stator cho'lg'ami	
O'tkazgich markasi	ПЭВ-2 yoki ПЭТВ
Cho'lg'am fazalari soni	3
» har bir fazadagi cho'lg'am	6
» cho'lg'amdagi o'ram	20
Harorat +20 °C bo'lganda faza qarshiligi, Ω	0,34...0,36
Rotor cho'lg'ami	
O'tkazgich markasi	ПЭВ-2 yoki ПЭТВ
O'ramlar soni	1200
Harorat + 20 °C cho'lg'am qarshiligi, Ω	16,0-17,0
To'g'rilagich bloki	
Turi	БПВ24-45
Maksimal qaytuvchi kuchlanish, V	150
Maksimal to'g'rilovchi tok kuchi, A	45
Kuchlanish tushuvi, oshmaydi, V	0,7
Kuchlanish tushuvi o'lchanayotganda tok kuchi, A	10

5-rasm. LECROY WAVERUNNER 64 Xi ossillografning umumiy ko'rinishi
Fig. 5. Overview of the LECROY WAVERUNNER 64 Xi oscilloscope

LECROY WAVERUNNER 64 Xi ossillografning umumiy ko'rinishi 5-rasmda ko'rsatilgan.

LECROY WAVERUNNER 64 Xi ossillografning texnik xarakteristikalari quyida keltirilgan:

2 ta kanal 600 MHz tarmoqli kengligi bilan.

4 ta kanal 400 MHz, 600 MHz, 1 GHz, 2 GHz tarmoqli kengligi bilan.

Namuna olish chastotasi 5 GHzli (kanallarni birlashtirishda 10 GHz, 44 Xi-A dan tashqari).

Har bir kanal uchun xotira hajmi 10 MB (kanallarni birlashtirganda 25 MB).

Yuqori ekranni yangilash tezligi - WaveStream texnologiyasi.

18 ta shartdan foydalangan holda uzoq yozuvdagi anomaliyalarni qidirish rejimi - WaveScan.

Avto va kursor o'lchovlari, matematik tahlil funksiyalari.

Intellektual sinxronizatsiya tizimi (CAN, I^2C, SPI avtobus signallari yordamida sinxronizatsiya va dekodlash opsiyasi).

MathCad, MatLab, Excel paketlari bilan integratsiya qilish imkoniyati.

Quvvat tahlili (PMA2), jitter tahlili (JTA2), raqamli filtrlash (DPF), telekommunikatsiya niqobi va ko'z diagrammasi tahlili (PMT va SDM) uchun dasturiy ta'minot variantlarini qo'llab - quvvatlaydi.

Uskuna variantlarini qo'llab - quvvatlash: MS - 32 mantiqiy analizatori va LeCroy problari.

WIN XP operatsion tizimiga asoslangan "Ochiq" platforma.

Kichik o'lchamli katta rangli LCD (26 sm).

O'lchamlari 260 × 340 × 152.

Og'irligi 7,26 kg.

Sinxron generatorlar yuqori ishonchlilik, barqaror chiqish kuchlanishi va chiziqli bo'lmagan

yuklamalar bilan ishlash qobiliyati kabi bir qator afzalliklarga ega bo‘lganligi sababli mikroGESlarda foydalanish maqsadga muvofiqdir.

3. Tadqiqod natijalari (Results)

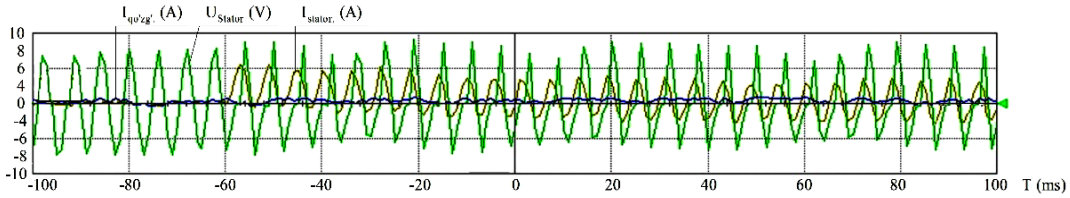
Г-273В sinxron generatorini quyosh paneli yordamida qo‘zg‘atish va ishlatish sxemasi yig‘ilib, quyosh panelidan ishlab chiqarilib, qo‘zg‘atish cho‘lg‘amiga berilayotgan qo‘zg‘atish toki, sinxron generator bir fazali qisqa tutashtirilgan rejimda ishlab chiqarayotgan stator tok kuchi va kuchlanish qiymatlari o‘lchanib, ossillogrammalari olindi. Natijada:

- qo‘zg‘atish toki - $I_{qo‘z.t.}$=0,3 A;
- qisqa tutashgan faza toki – $I_{qisqa.t.}$=6 A;
- qisqa tutashgan faza kuchlanishi – $U_{qisqa.t.}$=4 V.

Ushbu tajribada olingan ossillogramma 6-rasmda ko‘rsatilgan.

4. Munozara (Discussion)

Stator cho‘lg‘amlari qisqa tutashtirilgan Г273В sinxron generatorini quyosh paneli yordamida qo‘zg‘atish va ishlatish sxemasi (4-rasm) yig‘ilib, zanjirning har bir qismidagi elektr tokining parametrlarini qiymatlari o‘lchov qurilmalari voltmeter, ampermetrlar yordamida o‘lchanib, ossillogrammalari LECROY WAVERUNNER 64 Xi ossilograf yordamida ko‘rib chiqilganida, uning ko‘rinishi quyidagicha ifodalandi. (6-rasm).



6-rasm. Stator cho‘lg‘ami qisqa tutashtirilgan Г273В sinxron generatorni ossilograf yordamida o‘lchangan chiquvchi tok parametrlarining ossillogrammasi

Fig.6. Oscillogram of the output current parameters measured using an oscilloscope of a Г273В synchronous generator with a short-circuited stator winding

5. Xulosa (Conclusion)

Xulosa o‘rnida shuni aytish mumkinki, sinxron gneratorning qo‘zg‘atish cho‘lg‘ami quyosh paneli tomonidan ishlab chiqarilgan o‘zgarmas tok bilan to‘yintirilsa, uning dinamik xarakteristikalariga deyarli ta’sir ko‘rsatmaydi va doimiy tok manbasi sifatida foydalanilganda sinxron generator elektr energiya energiya manbaiga ega hisoblanadi. Ushbu ilmiy yangilik kichik, mikro va yuqori quvvatda ishlovchi gidroelektr stansiyalarda, issiqlik elektr stansiyalarda va boshqa elektr stansiyalarda qo‘llanilayotgan sinxron generatorlar uchun doimiy va mustaqil elektr manbai bilan ta’minlash imkonini beradi.

Lekin quyosh paneli uchun energiya manbai hisoblangan Quyoshning tabiat injiqliklari, kunning qorong‘u vaqtlarida, quyosh paneli yuzasiga turli iflosliklar tushishi natijada ishlab chiqarilayotgan elektr toki parametrlarining qiymatlari pastlashi natijasida sinxron generatorning qo‘zg‘atish cho‘lg‘ami yetarlicha to‘yinmasligi mumkin. Bunday kamchiliklarni bartaraf qilish uchun qo‘shimcha akkumulyator batareyalaridan foydalanish mumkin [7].

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