



Introduction to Nanotechnology in Control Communications

Deman Najat Najm Aldeen, Suha Suliman Mardan, Saba F. Jaf

College of Engineering, University of Kirkuk, Kirkuk, Iraq.

ARTICLE INFO

*Received: 13 Oct 2024,
Revised: 23 Oct 2024,
Accepted: 25 Oct 2024,
Online: 15 Dec 2024*

Keywords:

Nanotechnology, Molecular Nano Technology (MNT), Nano Material, Nanoscale Chemical Sensors, Nanoelectromechanical Systems (NEMS), Data Link Control network (DLC)

ABSTRACT

These days, nanotechnology is among the most cutting-edge studies and active research topics in a variety of disciplines, including materials science, chemical [1], electronic, medical [2], as well as civil engineering. Nanotechnology is seen by contemporary science as the next industrial revolution that can open up larger possibilities beyond our wildest dreams in a variety of disciplines. Nanotechnology can offer practical solutions for human-machine interface, memory extension, sensing, and energy-efficient computing in communications engineering. Additionally, manufacturers can use nanotechnology in communications systems to create computer chips and sensors that are far faster, smaller, more energy-efficient, and less expensive to produce than their present modules. An overview of several challenges of nanotechnology in communication systems will be covered in this paper. Additionally, a brief discussion of the potential applications of various nanotechnology advancements in communication systems, as well as the possibility of further research that could improve communication systems.

1. Introduction

1.1 Background on Nanotechnology

At the atomic, molecular, and supramolecular scales where special phenomena allow for novel applications, nanotechnology is the manipulation and control of matter. Because of quantum mechanics and an enhanced surface area to volume ratio [4], materials display distinct properties at the nanoscale (between 1 and 100 nanometers) [3]. New materials, tools, and systems that have applications in a variety of industries, including electronics, energy, healthcare, and more, have resulted from this.

2. Nanotechnology Fabrication Techniques

Nanotechnology relies on specialized fabrication techniques, for example:

2.1 Lithographic techniques

With the use of stiff materials for the fabrication process, lithographic techniques have been used to produce features with a resolution of less than 200 nm. To achieve this downsizing, several specialized lithographic processes have been developed and will be covered in the upcoming sections [5].

Corresponding author:

E-mail addresses: deman.n@uokirkuk.edu.iq (Deman), suhasuliman@uokirkuk.edu.iq (Suha), saba.eng81@uokirkuk.edu.iq (Saba)

doi: [10.5281/figshare.2024.14475458](https://doi.org/10.5281/figshare.2024.14475458)

2523-9376/© 2024 Global Scientific Journals - MZM Resources. All rights reserved.



This work is licensed under a Creative Commons Attribution Share Alike 4.0 International License.
<https://creativecommons.org/licenses/by-sa/4.0/legalcode>

2.1.1 Electron beam lithography

This method forms the required pattern on a material by scanning it with an electron beam. The beam is focused via magnetic lenses. Thermionic emitters and thermal field emitters are often utilized electron sources, with outputs ranging from 1 to 200 keV, while they are most frequently utilized in the 50–100 keV range [5]. This kind of lithography's resolution is highly dependent on the size of the beam point. The appropriate nanoscale resolution is obtained by electronically controlling the beam properties and specimen position. The primary disadvantage of electron beam lithography is the system's acquisition and maintenance costs [6].

2.1.2 Focused ion beam lithography

This kind of lithographic method patterns a resistance by using ions rather than electrons. Ions are produced from a liquid metallic tip that contains elements like gallium. The ions are then "filtered" so that only a specific kind of ion may interact with the resist, and they are focused using electrostatic lenses on the surface of the material [5].

2.1.3 Colloid monolayer lithography

Self-organized one- or two-dimensional colloidal systems are used as layers for nanofabrication in this lithographic technique. This technology can still create nanoscale patterns and is a more cost-effective substitute for conventional electron or ionic lithographic techniques. Colloidal monolayers can be generated through a number of self-assembly processes. For example, colloidal particles can be deposited on the surface of the substrate in solution before evaporation of the solvent, or through electrophoresis, or spin coating. [7].

2.2 Molecular self-assembly

An alternative technique to lithographic techniques to fabricate features and structures at the nanometer scale. It is based on thermodynamically favored interactions of molecules such as peptides, proteins, and DNA, and other organic or inorganic molecules [8]. Molecules are spontaneously brought together to

energetically stable conformations favored by noncovalent forces including hydrophobic, electrostatic interactions, and hydrogen bonding. This technique has advantages such as the ability to fabricate three-dimensional structures and the potential for molecular control of the material.

2.3 Electrically induced nanopatterning

These techniques utilize electrostatic interactions between a thin dielectric material liquid film and an electric field gradient to produce nanometer scale lateral patterns and structures [9].

2.4 Rapid prototyping

Rapid prototyping combines various nanofabrication techniques for the generation of complex geometrical patterns, multi-layered structures, and structures with chemical functionality [10]. Compared to conventional lithographic approaches, this technique has the benefit of being able to resolve features smaller than 100 nm, incorporating a variety of functions into the materials, and—most importantly—cutting the production time down from hours to seconds.

2.5 X-ray lithography

This method uses electromagnetic radiation with wavelengths between 0.5 and 4 nm, also referred to as "soft X-rays," to transfer a pattern from a mask to a substrate [5]. With this method, lithography may be carried out at a mask-to-wafer distance of several microns. Nevertheless, the obtainable resolution decreases proportionately with higher gap distances [11].

2.6 Ion projection lithography

The foundation of ion projection lithography is subjecting a wafer to ions of hydrogen or helium. Ion projection lithography, like photolithography, employs a mask to shield a portion of the substrate from ion exposure. But in this instance, the ion-absorbing substance in the masks stops ions from projecting onto the substrate beneath the absorbing pattern.

3. Applications of Nanotechnology in Communications

Through its application in next-generation networks, components, and devices, nanotechnology is also revolutionizing communications [12]. Materials can be designed at the nanoscale to achieve larger bandwidth, faster processing, and more effective information transfer. For instance, terahertz communications with data speeds of more than one terabit per second are being developed because of nanomaterials [13]. Also, they can be used to improve energy-efficient transistors, antennas, photonic circuits and memory for 5G networks and beyond.

4. Motivation and Objectives

Integration between Nanotechnology and control communication networks to enhance the network efficiency and management.

5. Introduction to Nanotechnology in Control Communications

Nanotechnology revolutionize the control communications field, enable unprecedented precision, efficiency, and adaptability in a wide range of applications. Materials and devices exhibit unique physical [14], chemical, and electrical properties at the nanoscale, and this can be used to produce innovative communication systems. This introduction discusses the integration of nanotechnology into control communications networks and the remote input and output cards emergence, unlocking new possibilities for industrial automation, and smart infrastructure [15].

6. Advantages of Nanotechnology in Control Networks

Nanotechnology has juttred out as a revolutionary force in control communication networks [16]. This evolving field holds potential to improve the efficiency, reliability and capabilities of these critical systems. It also paves the way for a new era of advanced communications [17]. In this paper, we will explore the exciting applications of nanotechnology in the control of communications networks, delve into the benefits, challenges and

latest developments in this fast evolving landscape.

7. Nanotechnology in Control Communications Networks

The integration of nanotechnology into control communication networks has opened up a world of possibilities [18]. At the nanoscale, engineers can design precisely material and devices that allow the development of high compact, high efficient, and responsive components that are essential in modern communications systems. Nanosensors can detect the slightest variations in network performance, while nanoactuators can quickly respond to changes. So, nanotechnology changes the way control communications networks operate [19]. Nanomaterials unique properties such as enhanced electrical, optical, and mechanical properties, create innovative communication protocols, signal processing algorithms, and data transmission methods [20]. Integration between nanotechnology and control communication networks paves the way for new levels of efficiency, reliability, and flexibility in critical infrastructure [21], industrial automation, and smart city applications [22].

8. Benefits of Nanotechnology Integration

8.1 Improved Efficiency

Nanotechnology enabled components and devices to improve the overall control communications networks efficiency due to faster speeds, less power consumption, and less heat generation [23].

8.2 Enhanced Reliability

Nanoscale systems precision and robustness improved the reliability and flexibility of control communications networks, reducing the failures risk and ensuring uninterrupted operations.

8.3 Increased Functionality

Nanomaterials unique properties enable the development of multifunctional devices and systems, allowing for the integration of advanced sensing, processing, and actuation capabilities within a compact form factor.

8.4 Reduced Size and Cost

Nanotechnology-based components and devices can be miniaturized, leading to smaller and more cost-effective control communications network solutions, particularly in critical infrastructure and industrial automation applications.

9. Challenges in Nanotechnology Implementation

9.1 Scalability and Integration

It is still very difficult to scale up the manufacture of nanoscale components and integrate them seamlessly into the control communications network architecture that is now in place. This requires improvements in system-level integration and manufacturing processes.

9.2 Reliability and Durability

For nanotechnology-based devices to be widely adopted in control communications networks, they must be guaranteed to be durable and reliable over an extended period in demanding working environments, like those seen in industrial settings.

9.3 Cost reduction

Market share will not be gained by new technologies unless they can be competitively priced with current ones. Since there is a clear demand for replacement technologies, the commercialization obstacles of novel technologies in RF electronics are less severe than in digital electronics.

9.4 Regulatory and Safety Concerns

The proper deployment of nanotechnology in control communications networks requires addressing safety and regulatory concerns about the possible effects of nanomaterials on the environment and human health [24].

10. Nanomaterial-based Sensors

Incorporate nanoscale sensors into the control system to collect data in real-time on variables like humidity, pressure, and temperature.

Nanowires or nanoparticles with particular detecting properties can be used to create these sensors [25]. For example, pressure measurements can be obtained with extreme precision using carbon nanotube-based pressure sensors.

10.1 Nanomaterial

Working with materials and structures at the nanoscale, which is generally between 1 and 100 nanometers, is the focus of nanotechnology [26]. Nanomaterials can be used in control and communication systems to improve their performance. Here are some commonly used nanomaterial:

10.1.1 Nanowires and Nanotubes

Ultra-thin structures at the nanoscale diameter [27], possess excellent electrical conductivity and can be employed to integrate components in control networks and improve signal transmission efficiency.

10.1.2 Graphene

Graphene is a carbon atoms single layer organized in a hexagonal lattice [28]. It has exceptional mechanical strength, flexibility, and electrical conductivity. Graphene-based components, such as graphene transistors and antennas, can be integrated into control systems to enhance their performance.

10.1.3 Nanocomposites

Nanocomposites are material which consist of matrix filled with nanoparticles. By incorporating nanoparticles, such as metal oxides or carbon nanotubes into the matrix, the resulting nanocomposite can exhibit improved properties such as strength, conductivity, and sensing capabilities. These material can be used in robust control and communication devices construction.

10.1.4 Quantum Dots

Quantum dots are very tiny semiconductor particles with unique optical properties [29]. These particles can release light at particular wavelengths when an external energy source

stimulates them. These particles are superior to traditional materials because of their size-dependent characteristics, quantum dots are employed in displays, sensors, and optical communication systems.

10.2 Nanosensors and actuators

By nanotechnology, extremely sensitive and accurate sensors and actuators development for control and communication systems became possible. For example:

10.2.1 Nanoscale Chemical Sensors

Chemical compounds can be detected and analyzed with high sensitivity by nanosensors. They can be employed in environmental monitoring, industrial process control, and medical applications to measure parameters such as gas composition, pH levels, and biomarkers [30].

10.2.2 Nanomechanical Sensors

Physical quantities such as force, pressure [31], and mass can be detected and measured by nanoscale mechanical sensors, such as nanocantilevers or nanoresonators,. These sensors can be applied in many fields such as structural health monitoring, robotics, and touch-sensitive interfaces.

10.2.3 Nanoelectromechanical Systems (NEMS)

Electrical and mechanical operations at nanoscale can be combined by these devices. They can act as sensors or actuators which offer precise control over mechanical movements or generating electrical signals based on mechanical inputs. NEMS technology holds promise for a range of applications like telecommunications, data storage, and biomedical devices [32].

11. Nanotechnology Revolution

Nanotechnology can lead to revolution in various fields such as control communications networks and remote input and output (I/O) systems. By using nanoscale material and devices, it becomes possible to enhance the performance,

functionality, and miniaturization in nanoscale domains.

11.1 Integration of Nanotechnology and Control Communications networks

The integration of nanotechnology into control communications networks is still a new field. There are numerous notable advancements and promising researches in this field [33]. Here are some examples of nanotechnology devices that can be integrated into control communications networks and remote I/O cards:

11.1.1 Nanoscale Antennas

Nanotechnology has been utilized to develop nanoscale antennas for wireless communication systems. These antennas were made from nanomaterial such as carbon nanotubes or grapheme and offering advantages such as miniaturization, improved bandwidth, and enhanced signal reception. To facilitate wireless communication between devices, sensors, and actuators with lower size and power requirements, they can be incorporated into control communications networks [34].

11.1.2 Nanophotonics devices

The future of pharmaceutical technology is represented by nanophotonic devices, which are setting the standard for innovation in healthcare diagnostics and practice [35]. In an attempt to realize the "future of biosensors," undetectable devices that are worn on a regular basis and continuously monitor hormone levels, drug intake, the presence of toxins and viruses, and other biomarkers, have been made possible by nanotechnology. These devices are known as nanophotonics. In turn, these gadgets can help doctors treat their patients more effectively by enabling patients to take better care of themselves at home. This is because patients will be able to detect problems at home before ever considering seeing a doctor. Therefore, the technology's greatest contribution to healthcare may lie in its ability to avert several unexpected fatalities.

11.1.3 Nanoscale switching

These devices have the potential to improve the efficiency of control communications networks in several ways [36]. Here are a few examples:

11.1.3.1 Improved Routing and Switching

Nanoscale switching devices such as nanoelectromechanical systems (NEMS) or nanoscale transistors can facilitate more effective signal routing and switching. Due to their quick switching rates, low power consumption, and compact forms, these devices can lead to more responsive and nimble network operations. Also, they can optimize signal routing in response to current conditions and demands, resulting in decreased latency and increased network efficiency by enabling the dynamic reconfiguration of network pathways.

11.1.3.2 Reduced Power Consumption

Compared to conventional macro-scale counterparts, nanoscale switching devices typically operate at low power levels. It becomes possible to reduce the overall power consumption of the network by integrating these devices into control communications networks. This is particularly critical in energy-constrained environments or for battery-powered devices, where minimize the power consumption.

11.2 Nanotechnology-based Input Cards

The integration of nanotechnology into input cards in control communications networks improved the way these important interfaces are handled. Nanotechnology programmable logic controllers (PLC) global market represents a thriving sector at the intersection of nanotechnology and industrial automation [37]. PLCs have long played an important role in controlling various industrial processes, providing reliability, flexibility, and programmability. With advances in nanotechnology, the incorporation of nanocomponents into PLCs improved the industrial automation by enhancing efficiency, reducing footprint, and increasing processing power. Nano PLCs exploits nanomaterials and nanoelectronics to miniaturize components, enabling the development of compact, robust

controllers that offer significant advantages over traditional programmable logic controllers (PLCs), like high speed, lower power consumption, and accuracy improvement. Also, their small size allows for seamless integration into diverse industrial applications, from manufacturing and automotive to aerospace and healthcare.

11.2.1 Nanoscale Sensors and Actuators

Nanotechnology can lead to the development of highly sensitive and miniaturized sensors and actuators. These devices can be integrated into control systems physical quantities detection and manipulation such as temperature, pressure, and acceleration. Nanosensors can provide real-time data for monitoring and feedback control, while nanoscale actuators can facilitate precise and responsive control actions.

11.2.2 Nanoelectronics

Nanotechnology can lead to nanoscale electronic components fabrication such as transistors, resistors, and capacitors. These nanoelectronic components can be used in control communications networks and remote I/O cards to achieve higher integration density, lower power consumption, and faster operation.

12. Future Trends and Opportunities

Utilization of nanoscale switching devices in smart grid systems can lead to several potential benefits such as:

12.1 Enhanced Grid Reliability

Nanoscale switching devices can contribute to enhance the reliability in smart grid systems. These devices provide quicker fault isolation and detection, which speeds up grid disturbance reaction times like power outages or equipment failures. Nanoscale devices' high-speed switching capabilities enable effective grid reconfiguration, reducing downtime and improving overall grid reliability.

12.2 Efficient Power Routing

In smart grid systems, power routing can be optimized via nanoscale switching devices. Precise

control over power flow is made possible by these devices, which can also dynamically modify the grid to monitor weather and power line temperature. This information can then be utilized to determine the carrying capacity of the line and boost the power flow of already-existing transmission lines. [38]

12.3 Energy Storing Devices

Energy storage technologies, particularly those that use ion insertion techniques like Li battery technology, are expected to progress significantly with the help of nanotechnology. Nanotechnology can stabilize electrode materials against swelling-induced damage from ion absorption, release electrical energy, and improve the efficiency of storage devices. [39]

12.4 Smart Grid Communication Infrastructure and Cybersecurity

The interchange of data and information amongst all components of the power system is the primary means by which smart power grids operate. An effective smart grid relies on its communication infrastructure. It is anticipated that the infrastructure supporting smart grid communication will be intelligent, safe, dependable, and efficient [40]. The deployment of the smart grid is anticipated to be impacted by the usage of integrated nanocircuits in silicon chips, which shrinks the size of the CPUs.

13. The practical part (Practical example incorporating nanotechnology in control communications networks and remote I/O cards)

Assume you are employed at a manufacturing plant where numerous processes are monitored and managed by a sophisticated control system.

You want to use nanotechnology to improve the system's responsiveness and efficiency. Here are some more specifics about how nanotechnology is included in remote I/O devices and control communications networks.

13.1 Medium voltage grid control center at the power company

When a malfunction or voltage change happens, it is used to monitor and control medium voltage networks by indicating the network's state momentarily in time, so that it may be seen on the screen for monitoring.

13.2 Description of existing project

- The project was initially delivered in 2020 and finally delivered in 2023
- Three switchboards were added, new switches were added, five new switchboards were refurbished, and output feeders were transferred to the control center.

13.3 The purpose of the practical part

To achieve electrical supply quality and continuity by:

- Fast and precise fault detection can reduce removal time.
- Monitor and control medium voltage grid. (Transformer, stations)
- Monitoring measurements of electrical quantities.
- Surveillance of events on external sites which analyzes events with high accuracy.
- Recording of technical data that contributes to various reports and statistics (Daily, monthly, annual, or on demand) which help specialists to work on millennium studies.

- Improving the performance and planning.

13.4 Develop communications and introduce new methods capable of speedily transporting

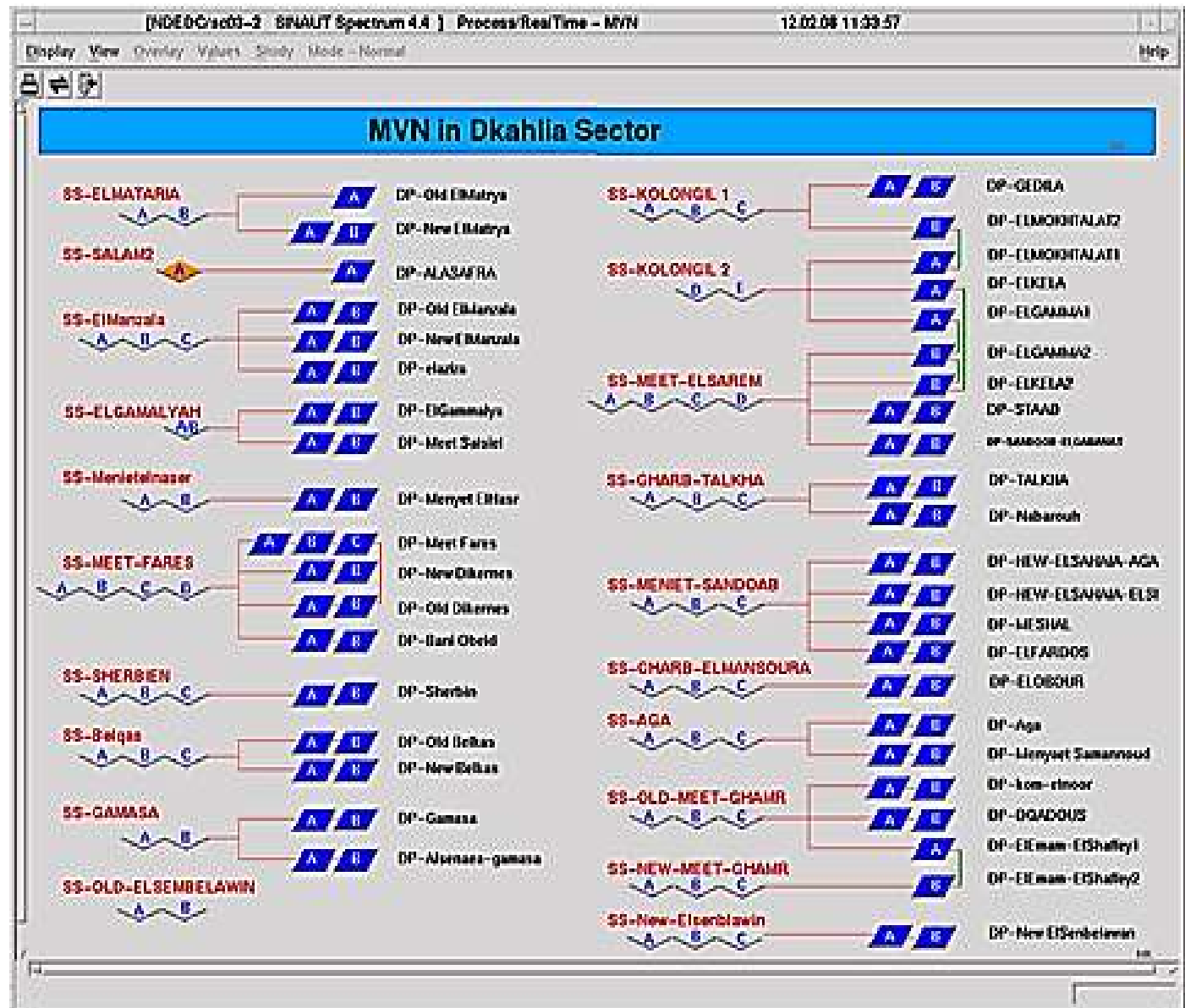


Fig 1. MVN Dkahlia Sector

those data to the control center

- The communication system currently used for the control project RF DLC.Y
- Due to the nature of the DLC network and problems with system

- Work on the use of modern systems to transfer signals and data from different locations to the control center to ensure fast and control center to ensure fast and continuous data access. There has been a recent surge in GSM and GPRS communication. Such as their use in kiosks.

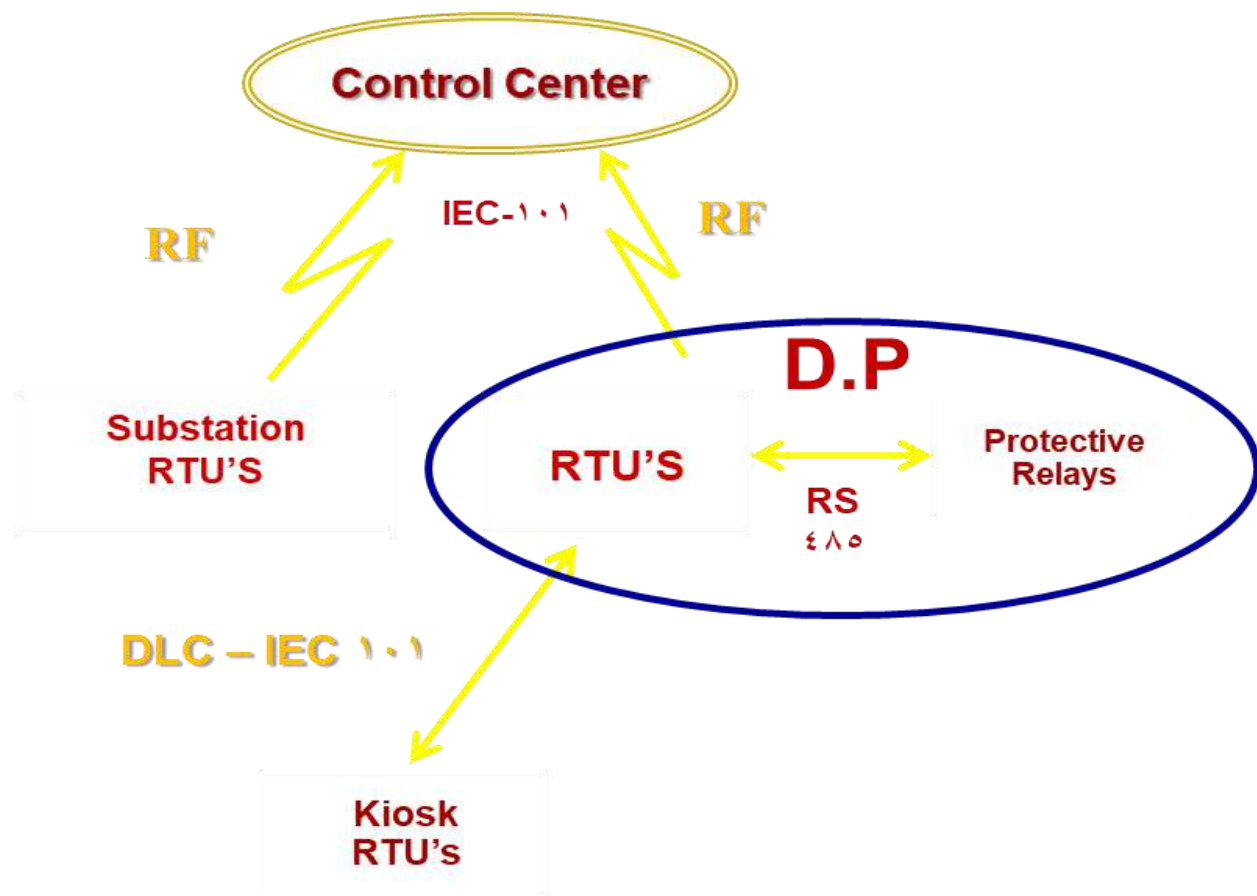


Fig 2. Communication system between Control center and Kiosk RTUs

Table 1. Substation Signals

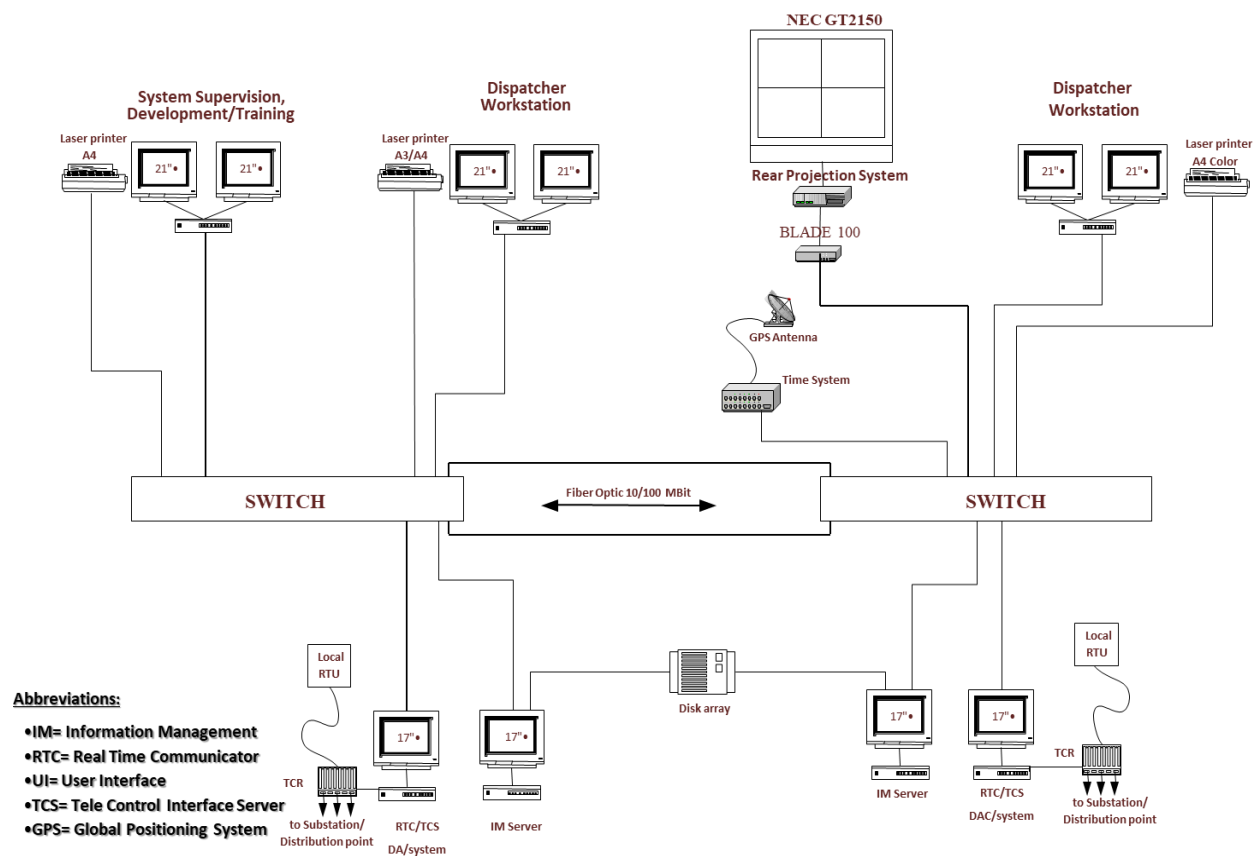
	Incoming	Outgoing	Bus Tie	Bus Bar
Status Indication	*C.B: On/Off * C.B: Test Position *Earth Switch Indication	*C.B: On/Off * C.B: Test Position *Earth Switch Indication	*C.B: On/Off * C.B: Test Position	* B.B live
Protection Alarms	*O/C *Directional O/C * E/F *Directional E/F *MCB DC Loss	*O/C * E/F *UFLS *MCB DC Loss	*O/C *MCB DC Loss	
Alarms	*RTU DC Charger failure *Low Voltage of RTU Battery * Battery Charger failure * Battery Under Voltage * 220 V AC Loss *RTU failure *RTU Door Open * RTU Switch Remote/Local *Communication Equipment failure			
Analog measurements	* 3 phase current	*Single phase current		*Bus Bar Voltage 11 KV
Pulse Accumulation	KWH of 11KV side of Transformers	KWH		

Table 2. Distribution Point Signals

	Incoming	Outgoing	Bus Tie	Bus Bar
Status Indication	*C.B: On/Off * C.B: Test Position *Earth Switch Indication	*C.B: On/Off * C.B: Test Position *Earth Switch Indication	*C.B: On/Off * C.B: Test Position	
Protection Alarms	*O/C *Directional O/C * E/F *Directional E/F *MCB DC Loss	*O/C * E/F *UFLS *MCB DC Loss	*O/C *MCB DC Loss	
Alarms	*RTU DC Charger failure *Low Voltage of RTU Battery * Battery Charger failure * Battery Low Voltage * 220 V AC Loss *RTU failure *RTU Door Open * D.P Door Open * RTU Switch Remote/Local *Communication Equipment failure * Fire Alarm			
Analog measurements	* 3 phase current * KV * MW * PF *MVAR * Freq	*1 phase current		11 KV B.B Voltage
Pulse Accumulation	*KWH	*KWH		

Table 3. Kiosk Signals

	Incoming	Outgoing	Bus Bar
Status Indication	* Isolator: Open/ Close	* Isolator: Open/ Close	
Protection Alarms	* E/F Indication		
Alarms	*RTU DC Power Supply failure * Battery Charger failure *Communication Equipment failure		
Analog measurements	*phase current on Low Voltage of Transformer(3 phase) *KV for Low Voltage		

**Fig 3. Major station Components**

North Sector	South Sector
DP-AZIZA	DP-AGA
DP-BNIBD	DP-DQDOS
DP-GAMAS	DP-FRDOS
DP-GMLYA	DP-GAMAH
DP-MNNSR	DP-GDILA
DP-ASFRA	DP-KELA
DP-SNGMS	DP-MKHTL
DP-MTFRS	DP-MSHAL
DP-MTSLS	DP-MSMND
DP-NBLQS	DP-NBROH
DP-NDKRN	DP-NSENA
DP-NMNZL	DP-NSNAG
DP-OBLQS	DP-NSNBL
DP-ODKRN	DP-SHFEY
DP-OMNZL	DP-SNDGB
DP-OMTRY	DP-STAAD
DP-SHRBN	DP-TLKHA
DP-MDRUA	DP-NTLKHA

Fig 4. North and south distribution boards in control center

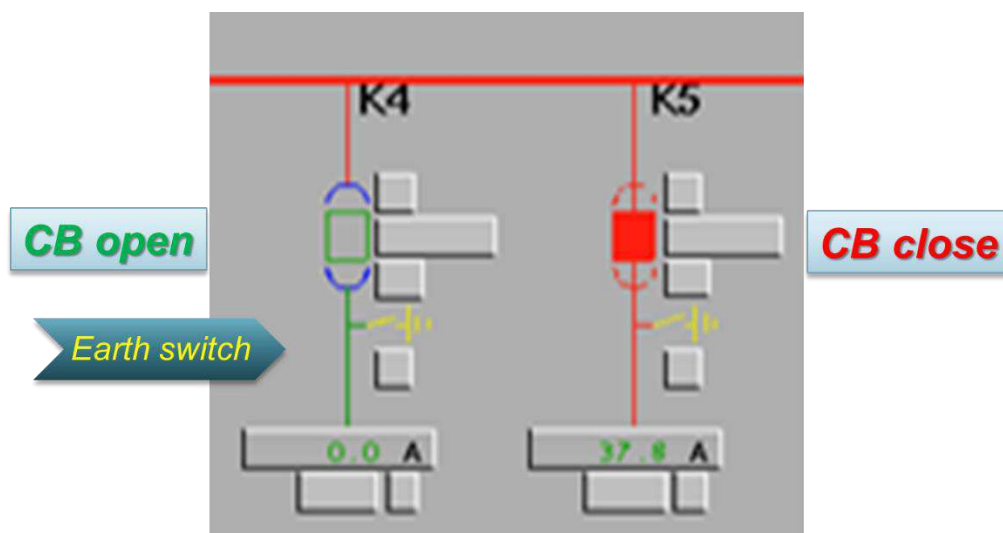


Fig 5. SCADA system with components

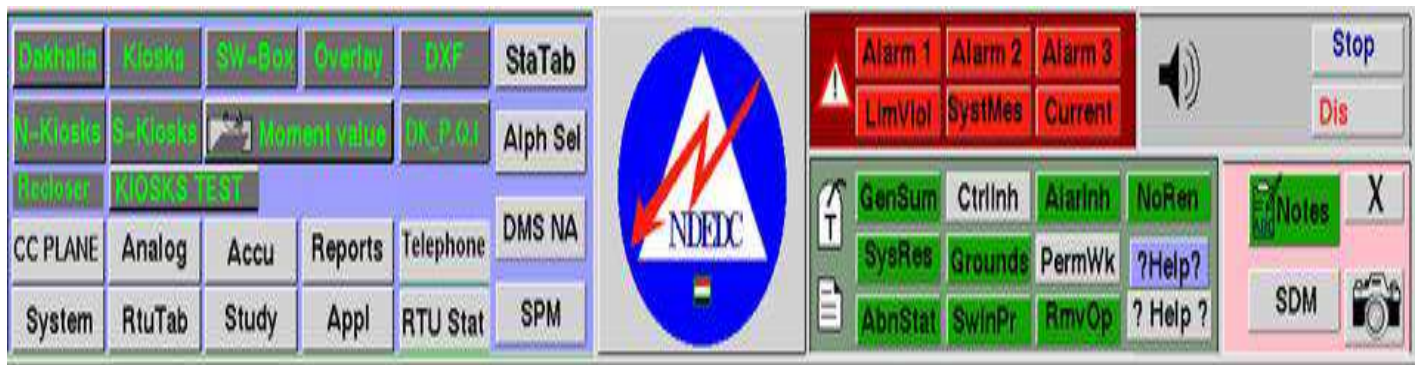


Fig 6. The master

From the output of the control center and control and data aggregation

- The system stores the data momentarily and extracts it with reports
- The reports are used to conduct studies to develop electrical grid components
- The recorded data is used to find the maximum load for the total company and the maximum load for the four sectors of the company for each sector

The monitor is the main engine of the control system, where we open and review all alarm reports and displays from outside locations.

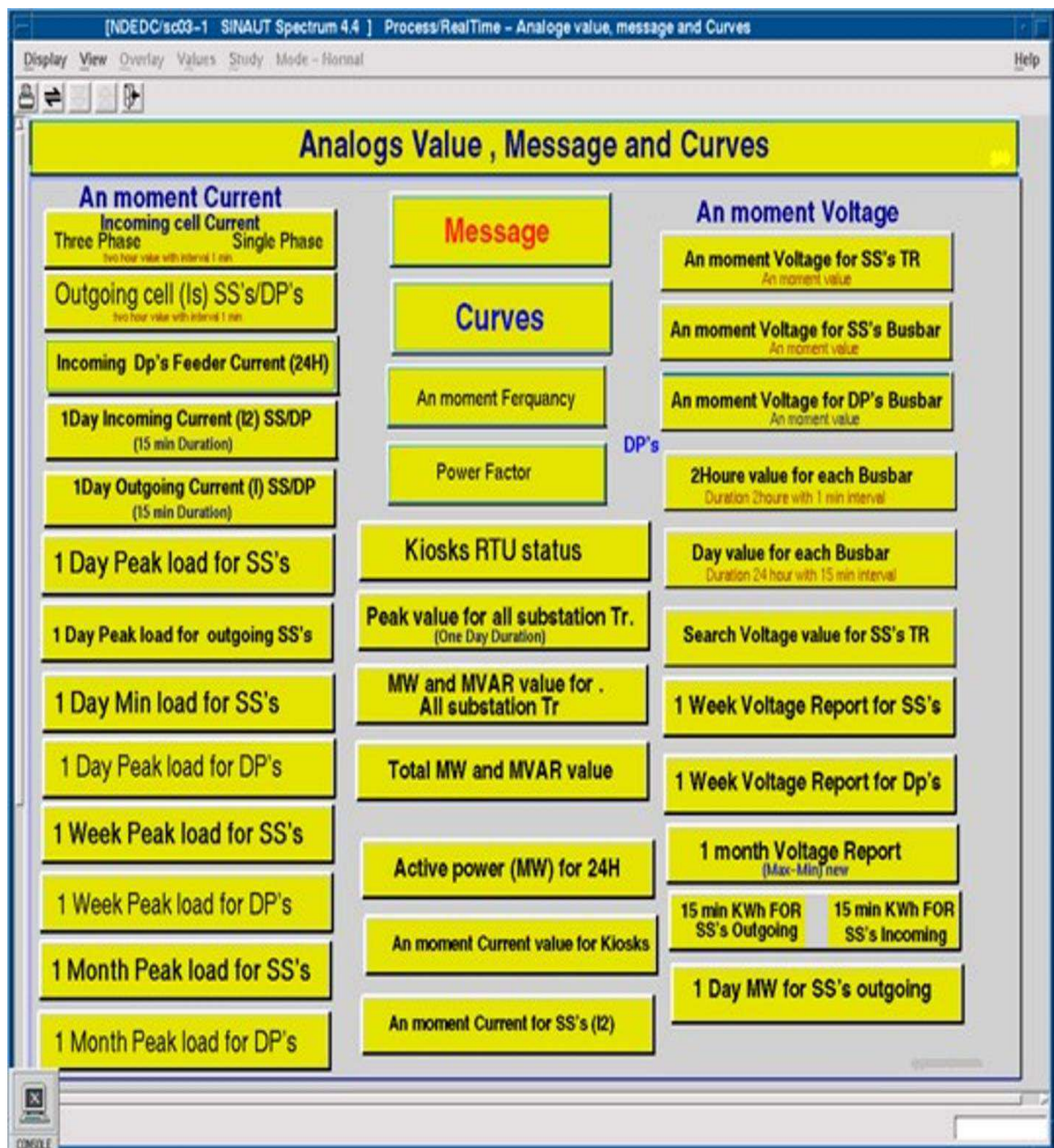


Fig 7. The main engine of the control system report

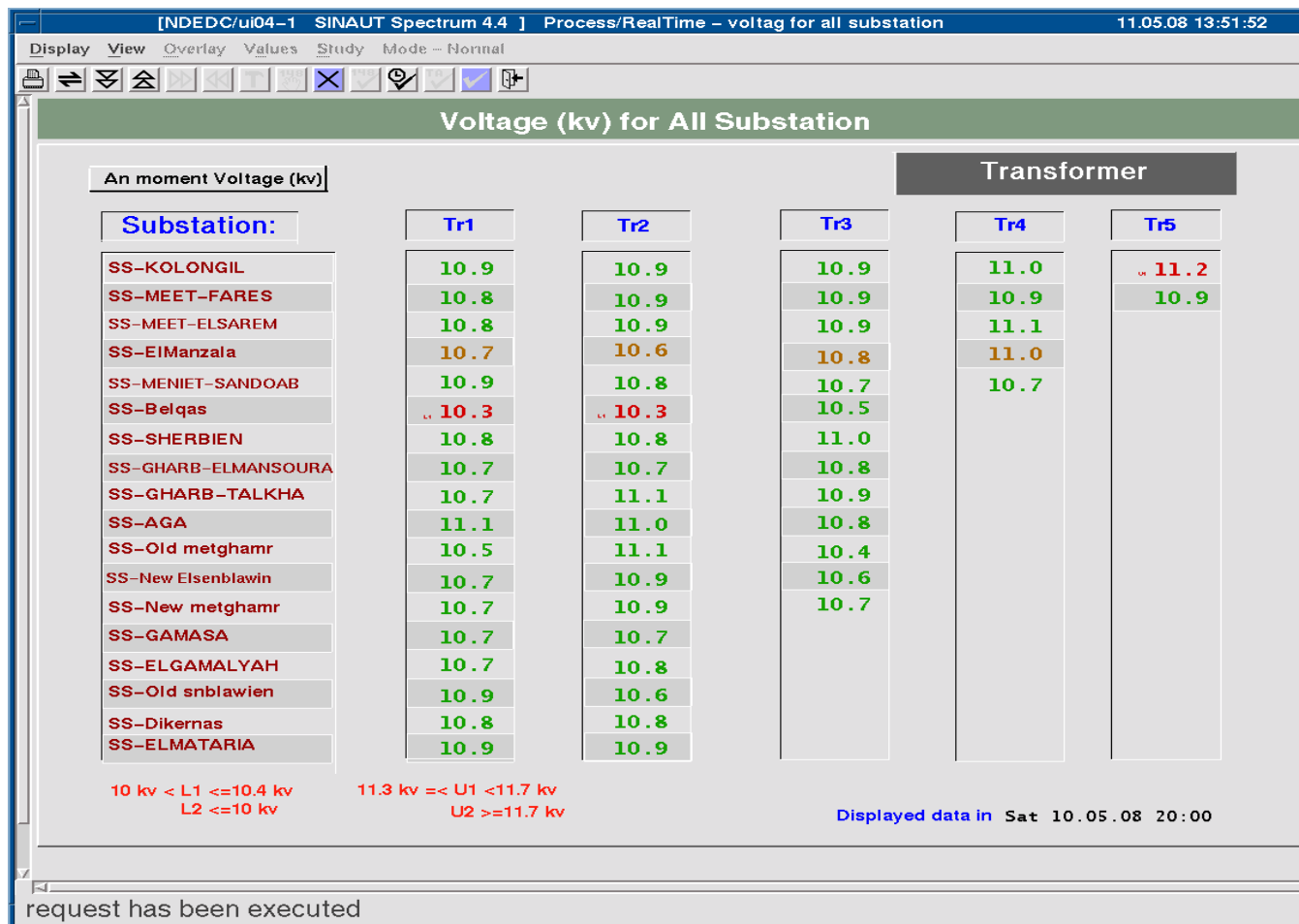


Fig 8. Voltage for all

MVN RTU Status Overview								
North Sector	L/R	RTU		South Sector	L/R	RTU	Substation	RTU
DP-AZIZA	R			DP-AGA	R		SS-AGA	
DP-BNIBD	R			DP-DQDOS	R		SS-BLQAS	
DP-GAMAS	R			DP-FRDOS	R		SS-GMLIA	
DP-GMLYA	R	RTU		DP-GAMAH	R		SS-GMS	
DP-MNNSR	R			DP-GDILA	R		SS-GTLKH	
DP-ASFRA	R			DP-KELA	R		SS-KOLNG	
DP-SNGMS	R			DP-MKHTL	R		SS-MNN	
DP-MTFRS	R			DP-MSHAL	R		SS-MNZLA	
DP-MTSLs	R			DP-MSMND	R		SS-MSND	
DP-NBLQS	R			DP-NBROH	R		SS-MTFRS	
DP-NDKRN	L			DP-NSENA	R		SS-MTRYA	
DP-NMNZL	R	RTU		DP-NSNAG	R		SS-MTSRM	
DP-OBLQS	R			DP-NSNBL	R	RTU	SS-NGHMR	
DP-ODKRN	R			DP-SHFY	R		SS-NSNBL	
DP-OMNZL	R			DP-SNDGB	R		SS-OGHMR	
DP-OMTRY	R			DP-STAAD	R		SS-SHRBN	
DP-SHRBN	R			DP-TLKHA	R		SS-WMANS	
DP-MDRUA	L			DP-NTLKHA	L		SS-OSNBL	
RTU Local	L			RTU Remote	R		RTU Dist	D
							RTU Fail	RTU

Fig 9. The connectivity between the distribution boards and switch stations

An Moment Ferquancy value for : DP-Aga /11 /Incoming 3							
08:00 49.9	08:15 50.3	08:30 49.7	08:45 49.7	09:00	09:15	09:30	09:45
08:01 50.1	08:16 50.3	08:31 49.7	08:46 49.6	09:01	09:16	09:31	09:46
08:02 50.1	08:17 50.3	08:32 49.7	08:47 49.6	09:02	09:17	09:32	09:47
08:03 50.1	08:18 50.3	08:33 49.7	08:48 49.6	09:03	09:18	09:33	09:48
08:04 50.1	08:19 50.1	08:34 49.7	08:49 49.6	09:04	09:19	09:34	09:49
08:05 50.1	08:20 50.1	08:35 49.7	08:50 49.8	09:05	09:20	09:35	09:50
08:06 50.1	08:21 50.1	08:36 49.7	08:51 49.8	09:06	09:21	09:36	09:51
08:07 50.1	08:22 50.1	08:37 49.7	08:52 49.7	09:07	09:22	09:37	09:52
08:08 50.1	08:23 50.0	08:38 49.6	08:53 49.7	09:08	09:23	09:38	09:53
08:09 50.2	08:24 50.0	08:39 49.6	08:54 49.6	09:09	09:24	09:39	09:54
08:10 50.2	08:25 49.9	08:40 49.6	08:55 49.6	09:10	09:25	09:40	09:55
08:11 50.2	08:26 49.8	08:41 49.7	08:56 49.7	09:11	09:26	09:41	09:56
08:12 50.3	08:27 49.8	08:42 49.7	08:57 49.7	09:12	09:27	09:42	09:57
08:13 50.3	08:28 49.7	08:43 49.7	08:58 49.7	09:13	09:28	09:43	09:58
08:14 50.3	08:29 49.7	08:44 49.7	08:59 49.8	09:14	09:29	09:44	09:59

L1: 49.8
 L2: 49.6
 U1: 50.2
 U2: 50.4

Fig 11. The frequency values every minute of a two-hour feed

An Moment curent value for DP-ELMOKHTALA/11 /MAKTAB-ALAMAL							
11:00 45.0	11:15 45.0	11:30 44.9	11:45 45.8	12:00 47.6	12:15 49.1	12:30 49.2	12:45 0.0
11:01 44.7	11:16 45.0	11:31 45.5	11:46 46.4	12:01 47.3	12:16 49.5	12:31 49.2	12:46 0.0
11:02 45.4	11:17 45.9	11:32 44.7	11:47 46.4	12:02 47.7	12:17 48.6	12:32 48.2	12:47 44.8
11:03 45.2	11:18 45.2	11:33 45.4	11:48 46.9	12:03 49.3	12:18 48.8	12:33 48.7	12:48 46.5
11:04 44.7	11:19 44.8	11:34 45.5	11:49 46.1	12:04 49.0	12:19 49.9	12:34 49.0	12:49 48.1
11:05 45.6	11:20 44.7	11:35 46.1	11:50 45.9	12:05 49.1	12:20 49.1	12:35 48.4	12:50 49.3
11:06 44.5	11:21 44.2	11:36 47.0	11:51 46.3	12:06 49.2	12:21 48.2	12:36 48.4	12:51 50.4
11:07 44.5	11:22 45.6	11:37 46.6	11:52 46.5	12:07 49.0	12:22 47.4	12:37 48.7	12:52 50.9
11:08 45.1	11:23 44.8	11:38 46.1	11:53 46.8	12:08 49.3	12:23 48.5	12:38 48.7	12:53 51.0
11:09 45.8	11:24 44.4	11:39 45.7	11:54 47.3	12:09 49.8	12:24 49.1	12:39 49.2	12:54 51.6
11:10 45.5	11:25 44.7	11:40 45.7	11:55 47.3	12:10 49.2	12:25 49.1	12:40 48.8	12:55 51.3
11:11 45.6	11:26 44.1	11:41 46.3	11:56 47.8	12:11 49.0	12:26 49.2	12:41 49.7	12:56 50.7
11:12 44.9	11:27 44.8	11:42 45.4	11:57 48.0	12:12 48.1	12:27 49.7	12:42 0.0	12:57 50.2
11:13 45.4	11:28 45.8	11:43 45.7	11:58 48.0	12:13 48.0	12:28 49.1	12:43 0.0	12:58 50.2
11:14 45.8	11:29 44.9	11:44 45.7	11:59 47.7	12:14 49.1	12:29 50.8	12:44 0.0	12:59 52.2

Fig 12. The current values every minute of a two-hour feed

14. Conclusion

A comprehensive overview of nanotechnology has been covered in this paper which will help researchers and professionals from various fields to delve more deeply into the applications of nanotechnology in their respective fields of interest. The applications of nanotechnology are enormous and have entered all medical, chemical, engineering, agricultural, and also industrial fields. In this research, we reviewed the integration of nanotechnology with control and communications networks and how to benefit from this technology in developing and improving connectivity and communications between control networks and each other in the electricity network. However, more work still needs to be linked and carefully verified so that more solutions can be identified. In addition, more developments should be made and carefully evaluated at the nanoscale for the future world, so that we are aware of this huge technology.

15. References

1. Anselmo A.C., Mitragotri S. Nanoparticles in the clinic: An update. *Bioeng. Transl. Med.* 2019;4:e10143. doi: 10.1002/btm2.10143. [[PMC free article](#)] [[PubMed](#)] [[CrossRef](#)] [[Google Scholar](#)] [[Ref list](#)]
2. McNeil S.E. Nanotechnology for the biologist. *J. Leukoc. Biol.* 2005; 78:585–594. doi: 10.1189/jlb.0205074. [[PubMed](#)] [[CrossRef](#)] [[Google Scholar](#)] [[Ref list](#)]
3. 1. Mansoori G., Fauzi Soelaiman T. Nanotechnology—An Introduction for the Standards Community. *J. ASTM Int.* 2005;2:1–22. [[Google Scholar](#)] [[Ref list](#)]
4. De Charles P.P., Jr., Owens F.J. *Introduction to Nanotechnology*. John Wiley & Sons; Hoboken, NJ, USA: 2003. [[Google Scholar](#)] [[Ref list](#)]
5. Chen Y, Pepin A. Nanofabrication: conventional and nonconventional methods. *Electrophoresis.* 2001;22:187–207. [[PubMed](#)] [[Google Scholar](#)] [[Ref list](#)]
6. Gates BD, Xu Q, Stewart M, et al. New approaches to nanofabrication: molding, printing and other techniques. *Chem Rev.* 2005;105:1171–96. [[PubMed](#)] [[Google Scholar](#)] [[Ref list](#)]
7. Burmeister F, Badowsky W, Braun T, et al. Colloid monolayer lithography-a flexible approach for nanostructuring of surfaces. *Applied Surface*

- Science. 1999;144–155. 461–6. [[Google Scholar](#)] [[Ref list](#)]
8. Rajagopal K, Schneider J. Self-assembling peptides and proteins for nanotechnological applications. *Curr Opin Struct Biol.* 2004;14:480–6. [[PubMed](#)] [[Google Scholar](#)] [[Ref list](#)]
9. Schäffer E, Thurn-Albrecht T, Russell TP, et al. Electrically induced structure formation and pattern transfer. *Nature.* 2000;403:874–7. [[PubMed](#)] [[Google Scholar](#)] [[Ref list](#)]
10. Fan H, Lu Y, Stump A, et al. Rapid prototyping of patterned functional structures. *Nature.* 2000;405:56–60. [[PubMed](#)] [[Google Scholar](#)] [[Ref list](#)]
11. Chen Y, Rousseaux F, Haghir-Gosnet A, et al. Proximity X-ray lithography as a quick replication technique in nanofabrication : recent progress and perspectives. *Microelectronic Engineering.* 1996;30:191–4. [[Google Scholar](#)] [[Ref list](#)]
12. Salamanca-Buentello F, Persad D.L., Court E.B., Martin D.K., Daar A.S., Singer P.A. Nanotechnology and the developing world. *PLoS Med.* 2005;2:e97. doi: 10.1371/journal.pmed.0020097. [[PMC free article](#)] [[PubMed](#)] [[CrossRef](#)] [[Google Scholar](#)] [[Ref list](#)]
13. Akyildiz, J.A., Jornet, J.M. and Han, C. (2014) Terahertz Band Frontier for Wireless Communications. *Physical Communication*, 12, 14-32. <http://dx.doi.org/10.1016/j.phycom.2014.01.006>
14. M. Saif Islam and Logeeswaran V. J., Nanoscale Materials and Devices for Future Communication Networks. *IEEE Communications Magazine*, June 2010.
15. Silva G.A. A New Frontier: The Convergence of Nanotechnology, Brain Machine Interfaces, and Artificial Intelligence. *Front. Neurosci.* 2018;12:843. doi: 10.3389/fnins.2018.00843. [[PMC free article](#)] [[PubMed](#)] [[CrossRef](#)] [[Google Scholar](#)] [[Ref list](#)]
16. Bongomin O., Ocen G.G., Nganyi E.O., Musinguzi A., Omara T. Exponential disruptive technologies and the required skills of industry 4.0. *J. Eng.* 2020;2020:4280156. doi: 10.1155/2020/4280156. [[CrossRef](#)] [[Google Scholar](#)] [[Ref list](#)]
17. Jeon J.-C. Designing nanotechnology QCA-multiplexer using majority function-based NAND for quantum computing. *J. Supercomput.* 2021;77:1562–1578. doi: 10.1007/s11227-020-03341-8. [[CrossRef](#)] [[Google Scholar](#)] [[Ref list](#)]
18. Görmüş A. *International Congress on Social Sciences (INCSOS 2019) Proceeding Book*. Volume 1. Atlantis Press; Dordrecht, The Netherlands: 2019. Future of work with the industry 4.0; pp. 317–323. [[Google Scholar](#)] [[Ref list](#)]
19. Maghirang JCG, Uy RL, Borja KVA, Pernez JL. QCKer-FPGA: An FPGA implementation of Q-gram counting filter for DNA sequence alignment, In 2019 IEEE 11th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM). 2019;1-6.
20. Silva G.A. A New Frontier: The Convergence of Nanotechnology, Brain Machine Interfaces, and Artificial Intelligence. *Front. Neurosci.* 2018;12:843. doi: 10.3389/fnins.2018.00843. [[PMC free article](#)] [[PubMed](#)] [[CrossRef](#)] [[Google Scholar](#)] [[Ref list](#)]
21. Salari M. Applications of nanotechnology in construction: A Short Review. *Adv. Appl. NanoBio-Technol.* 2022;3:82–86. [[Google Scholar](#)] [[Ref list](#)]
22. Hanus M.J., Harris A.T. Nanotechnology innovations for the construction industry. *Prog. Mater. Sci.* 2013;58:1056–1102. doi: 10.1016/j.pmatsci.2013.04.001. [[CrossRef](#)] [[Google Scholar](#)] [[Ref list](#)]
23. Talebian S., Rodrigues T., Neves J., Sarmento B., Langer R., Conde J. Facts and figures on materials science and nanotechnology progress and investment. *ACS Nano.* 2021;15:15940–15952. doi: 10.1021/acsnano.1c03992. [[PubMed](#)] [[CrossRef](#)] [[Google Scholar](#)] [[Ref list](#)]
24. Sharma P.K., Dorlikar S., Rawat P., Malik V., Vats N., Sharma M., Rhyee J.S., Kaushik A.K. Nanotechnology and its application: A review. *Nanotechnol. Cancer Manag.* 2021;1–33. [[Google Scholar](#)] [[Ref list](#)]
25. Tsaramiris G., Kantaros A., Al-Darraj I., Apostolopoulos D.P.C., Pavlopoulou A., Alrammal M., Ismail Z., Buhari S.M., Stojmenovic M., Tamimi H. A modern approach towards an industry 4.0 model: From driving technologies to management. *J. Sens.* 2022;2022:5023011. doi: 10.1155/2022/5023011. [[CrossRef](#)] [[Google Scholar](#)] [[Ref list](#)]
26. Hulla J., Sahu S., Hayes A. Nanotechnology: History and future. *Hum. Exp. Toxicol.* 2015;34:1318–1321. doi: 10.1177/0960327115603588. [[PubMed](#)] [[CrossRef](#)] [[Google Scholar](#)] [[Ref list](#)]
27. Xu X., Ray R., Gu Y., Ploehn H.J., Gearheart L., Raker K., Scrivens W. A Electrophoretic Analysis and Purification of Fluorescent Single-Walled Carbon Nanotube Fragments. *J. Am. Chem. Soc.* 2004;126:12736–12737. doi: 10.1021/ja040082h. [[PubMed](#)] [[CrossRef](#)] [[Google Scholar](#)] [[Ref list](#)]
28. Novoselov K.S., Geim A.K., Morozov S.V., Jiang D.-e., Zhang Y., Dubonos S.V., Grigorieva I.V., Firsov A.A. Electric field effect in atomically thin carbon films. *science.* 2004;306:666–669. doi: 10.1126/science.1102896. [[PubMed](#)] [[CrossRef](#)] [[Google Scholar](#)] [[Ref list](#)]
29. Tang X., Ackerman M.M., Shen G., Guyot-Sionnest P. Towards infrared electronic eyes: Flexible colloidal quantum dot photovoltaic detectors enhanced by resonant cavity. *Small.* 2019;15:1804920. doi: 10.1002/smll.201804920. [[PubMed](#)] [[CrossRef](#)] [[Google Scholar](#)] [[Ref list](#)]
30. Geng Y., Ren Y., Wang X., Li J., Portilla L., Fang Y., Zhao J. Highly sensitive and selective H₂S sensors with ultra-low power consumption based on flexible printed carbon-nanotube-thin-film-transistors. *Sens. Actuators B Chem.* 2022;360:131633. doi: 10.1016/j.snb.2022.131633. [[CrossRef](#)] [[Google Scholar](#)] [[Ref list](#)]
31. Duan Y., He S., Wu J., Su B., Wang Y. Recent progress in flexible pressure sensor arrays. *Nanomaterials.* 2022;12:2495.

- doi: 10.3390/nano12142495. [[PMC](#)] [[free article](#)] [[PubMed](#)] [[CrossRef](#)] [[Google Scholar](#)] [[Ref list](#)]
32. Kumar V., Lee G., Choi J., Lee D.-J. Studies on composites based on HTV and RTV silicone rubber and carbon nanotubes for sensors and actuators. *Polymer*. 2020;190:122221. doi: 10.1016/j.polymer.2020.122221. [[CrossRef](#)] [[Google Scholar](#)] [[Ref list](#)]
33. de Luis B., Morellá-Aucejo Á., Llopis-Lorente A., Godoy-Reyes T.M., Villalonga R., Aznar E., Sancenón F., Martínez-Máñez R. A chemical circular communication network at the nanoscale. *Chem. Sci*. 2021;12:1551–1559. doi: 10.1039/D0SC04743K. [[PMC](#)] [[free article](#)] [[PubMed](#)] [[CrossRef](#)] [[Google Scholar](#)] [[Ref list](#)]
34. Mansor M., Rahim S., Hashim U. A CPW-fed 2.45 GHz wearable antenna using conductive nanomaterials for on-body applications; Proceedings of the 2014 IEEE Region 10 Symposium; Kuala Lumpur, Malaysia. 14–16 April 2014; pp. 240–243. [[Google Scholar](#)] [[Ref list](#)]
35. Koenderink AF, Alù A, Polman A. Nanophotonics: shrinking light-based technology. *Science* 2015;348:516–21. [[PubMed](#)] [[Google Scholar](#)] [[Ref list](#)]
36. Ju JH, Jang SK, Son H, Park J-H, Lee S. High performance bi-layer atomic switching devices. *Nanoscale* 2017;9: 8373–8379. doi: 10.1039/C7NR01035D. [[PubMed](#)] [[CrossRef](#)] [[Google Scholar](#)] [[Ref list](#)]
37. Silva G.A. A New Frontier: The Convergence of Nanotechnology, Brain Machine Interfaces, and Artificial Intelligence. *Front. Neurosci*. 2018;12:843. doi: 10.3389/fnins.2018.00843. [[PMC](#)] [[free article](#)] [[PubMed](#)] [[CrossRef](#)] [[Google Scholar](#)] [[Ref list](#)]
38. V. K. Jain, and G. Chapman, "Enhanced Defect Tolerance through Matrixed Deployment of Intelligent Sensors for the Smart Power Grid," Proceedings of IEEE International Symposium on Defect and Fault Tolerance in VLSI Systems, Vancouver, BC, Canada, 3–5 October 2011.
39. G. G. Amatucci, and F. Badway, —Nanotechnology— Enabler of Next Generation Energy Storage,|| 37th Intersociety Energy Conversion Engineering Conference (IECEC '02), Washington, DC, 29–31 July 2002.
40. S. Rahman, —Smart Grid Expectations: What will Make it a Reality,|| IEEE Power & Energy Magazine, Vol. 7, no. 5, pp. 84 – 85, 88, September/October 2009.
41. Fali, M. A., Ali, N. G., Shakir, W. M. R. (2022). Lorawan Protocol Data Communication in Internet of Things. *Journal of Global Scientific Research*. 7:(5), 2279-2282.