Ksenia Kaplieva

SMART HOME INFRASTRUCTURE AND ECOSYSTEM

INNOVATIONS IN SMART HOME ENERGY AND WATER INFRASTRUCTURE

2025

Arrow Science & Technology

DOI: 10.29013/SHIE.KaplievaK.52.2025

Ksenia Kaplieva
Smart Home Infrastructure and Ecosystem. Innovations in Smart Home Energy and Water Infrastructure / K. Kaplieva, – Urbana, : Arrow Science & Technology, LLC – 2025. – 52 c.

ISBN 978-1-967596-17-1

This book examines innovative smart home infrastructure components, including power supply, backup energy storage, water supply systems, water purification, regeneration, and recycling, as well as clean air supply, regeneration, and oxygenation. Particular attention is paid to the complex issues of active monitoring and control of these components and their interactions in real time. For all the presented infrastructure elements and their interactions, descriptions of technical and software solutions are provided, corresponding to the optimized world level of technological and design innovation. These solutions enable the integration of artificial intelligence and artificial neural networks into smart home design and operation processes.

Preparing water for use in smart home systems, its purification, regeneration, and reuse are key to building a fully-fledged smart home. The book consists of several autonomous parts, each representing an original development that advances modern engineering and technology capable of creating a smart home. One of the areas covered in the publication is integrated innovation logistics, which includes issues of organizing the processes of generating innovative solutions within a smart home environment. The publication draws on the characteristics and classifications of existing technical solutions such as SMART HOUSE, SMART HOME INFRASTRUCTURE, and SMART BUILDINGS.

Keywords: *Smart home infrastructure components; smart mobile home ecosystem components; energy supply for smart home and smart mobile home infrastructure elements; water, its purification, regeneration and recycling; innovative smart home infrastructure components; original developments advancing those areas of modern engineering and technology capable of forming a smart home; world-class technological and design innovation.*

Subscribe to print 18/12/2025. Format 60×84/16.
Offset Paper. Arno Pro. Pec. liter. 14. Circulation of 300 copies.
Typeset in Arrow Science & Technology, LLC, USA.
Publishing by Arrow Science & Technology, LLC
805 Silver St., Urbana, IL 61801

ISBN 978-1-967596-17-1

Table of Contents

Introduction to innovative logistics of the smart home and its infrastructure elements

Developing a technical solution that is an invention and has commercial potential requires significant analytical preparation, comparative analysis, and identification of parameters capable of attracting investor attention and generating demand. Modern technical solutions increasingly require a comprehensive approach and consideration of the integration of various technologies with environmental, nature conservation, and social aspects. Without a systematic approach and a clear methodology, navigating this situation is difficult. First and foremost, it is important to evaluate the new technological solution, systematize its parameters, and compare it with existing successful developments. Market demands are often subjective, so it is necessary to balance subjective factors with objective conditions: equipment capabilities, material availability, cost, and manufacturing efficiency, while preserving the advantages of the future invention.

The remainder of the book examines innovative smart home infrastructure components that address all management and control tasks for supersystems and subsystems in autonomous mode, as well as their interaction with each other and with similar smart home systems in the surrounding area.

Particular attention is paid to cybersecurity and the use of the most functional mobile apps in smart home infrastructure systems.

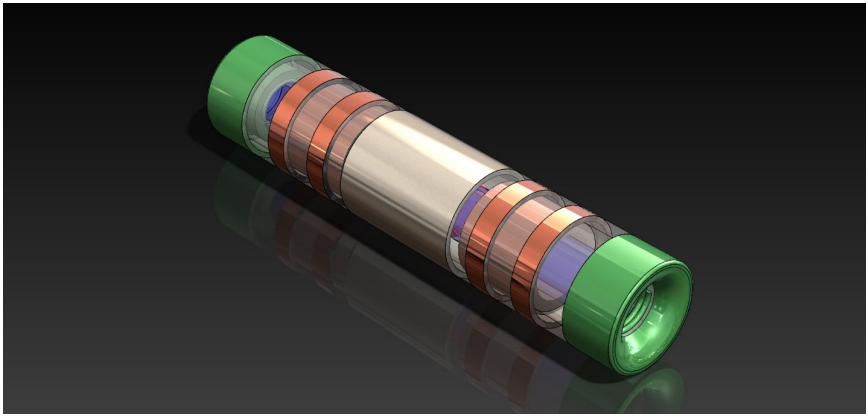

Figure 1.

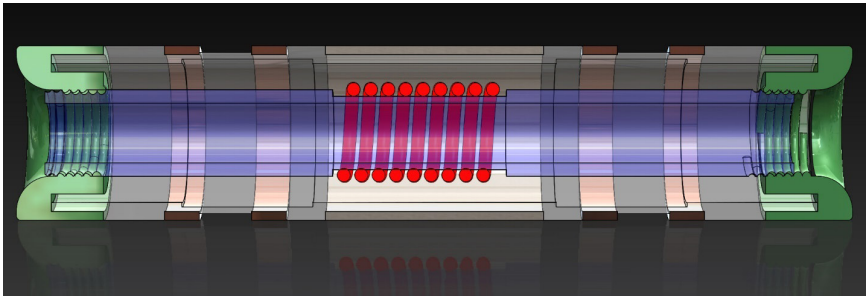

Figure 2.

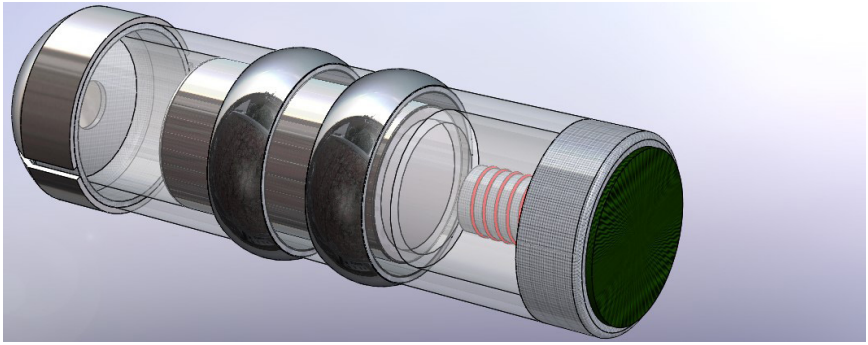

Figure 3.

The figures show 3D models of sensor modules for various types of online, contactless control and monitoring of water

flow and quality in smart home infrastructure elements in real time. These modules can also be used in similar systems within the infrastructure of smart home equivalents.

The primary instrument is an optical disc with a coding coating applied to the annular zone where no information is recorded. A microsensor integrated into the disc drive serves as an auxiliary instrument.

The signal from the microsensor is generated by measuring the coating thickness with an accuracy of 100 Å – the difference between each group of discs. The microsensor signal serves as a code for accessing data arrays located online.

Figure 4.

The figure shows a microsensor built into the drive.

The software identifies the microsensor signal and, if it matches the reference signal, grants access to the information. While downloading data, the system continues to monitor the signal's authenticity until the transfer is complete, preventing the disc from being replaced with an unlicensed one.

Counterfeiting such a disc is impossible, since the coating thickness is specified during manufacturing, and use is only possible with a microsensor tuned to a specific signal. Discs and sensors can be produced at any modern optical disc manufacturing facility. Series of 100–250 copies can have the same coding layer thickness and be equipped with the appropriate sensors.

The user can purchase one or more series and use them for online work. Programs and other data can be sent in a similar manner – in reverse order, ensuring complete confidentiality and protection from unauthorized messages and viruses. This solution relies on existing mechanical elements and requires software development, which could form the basis for further projects in this direction.

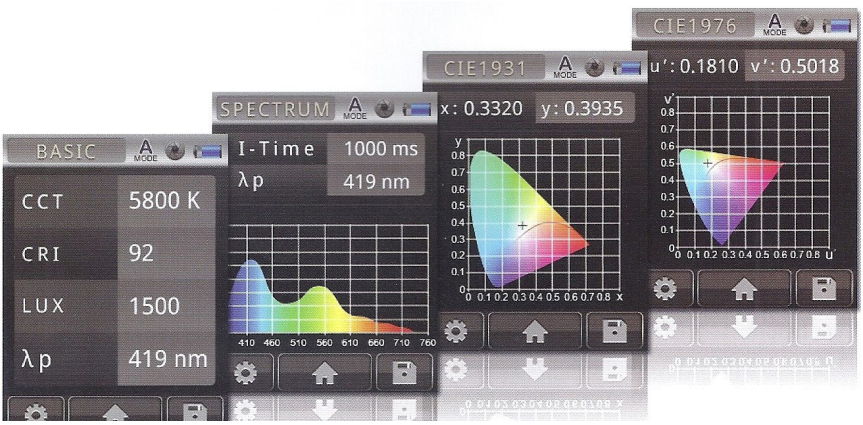

Figure 5.

The figure shows a hard magnetic disk for memory storage devices and personal computers in smart home systems.

The disk has a substrate made of a beryllium-based alloy and an electrolytic coating in the form of a sublayer beneath the ferromagnetic layer, produced using accelerated jet electrochemical processes.

1. Beryllium-based alloy production technology
    - Metallurgical part of the technology, including equipment, specialized source materials, and original processes.
    - Patent and licensing situation.
    - Possibility of autonomous use and implementation, forms of implementation.
    - Availability of finished samples and test reports.
    - Compliance with current standards.
    - Parameters that have the greatest impact on overall efficiency and their qualification according to technical documentation and standards.
2. Waste-free cutting technology for beryllium-based alloy rods to produce substrate blanks
    - Specialized process equipment, tooling, and tools.
    - Possibility of using the equipment and tools for cutting other materials with properties similar to beryllium-based alloys.
    - Patent and licensing status.
    - Compliance with current standards.
    - Non-standard parameters that positively impact process efficiency.
    - Availability of test reports and samples for presentation.

- Possibility of autonomous production and sales.
- Features of the production technology, application, storage, and adaptation to existing equipment.
- Cost of process components and finished products with unique characteristics, considered as a separate product.

3. Technology for highly efficient grinding and polishing of substrate blanks
   - Specialized process equipment, tooling, and tools.
   - Process flow charts, operation maps.
   - Availability of samples for presentation.
   - Compliance with standards.
   - Economic indicators and pricing.
   - Production and sales options, including stand-alone solutions.
   - Patent and licensing status.
4. Finished hard disk substrate blank
   - Product description and technical specifications.
   - Cost.
   - Availability of samples for presentation.
   - Compliance with current standards.
   - Storage conditions.
   - Process containers and packaging samples.
   - Special delivery terms.
   - Test methods and programs, test results.

The figure shows examples of disposable laser tools, each equipped with a coding system based on electromagnetic resonance spectroscopy.

The use of technologies based on electromagnetic resonance spectroscopy and magnetic resonance, in combination with

cutting-edge methods such as selective metal etching, for coding working tools and smart home infrastructure elements, as well as for active quality control of next-generation drives, is the most preferred solution at the current stage of equipping smart home structures.

Figure 6.

This technology enables comparative quality assessment between optical and magnetic resonance methods and facilitates the development of new integrative technologies that can become the basis for the production and implementation of smart home systems and next-generation memory storage devices, given the proliferation of quantum computers and their equivalents. Furthermore, these innovative technologies fully address the needs of smart home systems for the integration of artificial intelligence elements and artificial neural networks. The proposed technology is based on the principles of magnetic and electromagnetic resonance, as well as electromagnetic reso-

nance spectroscopy, implemented in sensors and infrastructure elements. It is based on a nanoscale composite material in the form of spherical capsules containing an amorphous iron core coated with a shell of rare earth metals or sequential shells of cobalt and aluminum. These capsules are used as magnetic tags.

During the production of the monolithic (two-layer) drive, magnetic tag material is placed in a predetermined area during the bonding process. Their presence is detected by a magnetic resonance sensor integrated into the drive structure.

Development of design and construction solutions for the application of this technology in smart home infrastructure is ongoing. Tested models and prototypes already demonstrate the feasibility of integration into new technical solutions. Given the specifics and operational characteristics of smart home infrastructure elements, contactless control and identification systems based on electromagnetic resonance spectroscopy represent one of the simplest and most promising areas for the development of cybersecurity technologies. These solutions can be applied both in smart home environments and at enterprises with complex production cycles. Based on the results of preliminary qualification testing of this method, the following conclusions and recommendations for its implementation in smart homes and their equivalents have been formulated.

Status of projects related to the secure coding of electronic devices, optical disks, and external digital storage media in smart home infrastructure

General information: In the current hierarchy of digital technologies and their commercial applications, secure coding is in demand not only in smart home systems but also in broader

segments such as smart buildings, smart cities, smart cars, and others. As an example of this scale, in the first quarter of 2021 alone, Samsung filed over 1,600 patent applications on this topic. All projects in this solution group are based on a single method: applying a coding coating or its technological equivalent to the protected object, followed by identification by measuring the coating thickness.

- Positive identification: the thickness matches the specified code, and the device's operating cycle continues.
- Negative identification: thickness mismatch, stopping or blocking equipment operation/data access.

This method has been tested in related areas – film thickness control in solar panels and semiconductor manufacturing.

Applicability in New Environments

The growth of the multilayer optical disc market using blue lasers has increased the need for protection, as the volume of data on media has increased, and leaks are becoming more critical.

Features:

- Coding is possible for each individual layer of a multilayer disc.
- Three-dimensional (layer-by-layer) local data coding is implemented, which is especially relevant for storing classified information.

Organization of corporate security systems

The technology enables the creation of a multi-level control system:

- Real-time monitoring of the status and location of each drive.
- Can be used with mobile external storage media with similar advantages.

- Can be expanded to military and specialized systems (army, navy, medicine, research institutes, state corporations).

Challenges of the optical media market

1. Existing security systems are easily circumvented.
2. Lack of quick identification by ownership; unauthorized removal or insertion of media is possible.
3. No protection when using media outside of a secure area.
4. The advent of PCs without hard drives and focused on cloud services requires new personalized methods.

Coding options

Advantages of the proposed technology

1. Multiple coating thicknesses – multiple unique codes.
2. 100% quality control directly on the production line.
3. Versatility in recording/reading formats.
4. Possibility of using the coating as a personal code.
5. Mobile sensors operating outside the drive (checkpoint monitoring, retail outlets).
6. Decoding independent of the drive's optical system, but with the ability to influence its operation.
7. Flexible algorithm, integration into hybrid media.
8. Use of the disk code as a password for accessing online resources.

Preliminary definition of the project's basic product:

1. The main market sector is corporate clients and users of super- and subsystems such as smart home, smart building, smart city, and smart car:

- Banks and financial companies;
- Industrial corporations;
- Research laboratories;
- Transportation companies, railway stations, airports, and seaports;
- Large retail chains;
- Municipal services;
- Government organizations and institutions;
- Large medical institutions;
- Insurance companies;
- Branches of the armed forces;
- Police and intelligence agencies.

2. Preliminary market size estimate:
   - The average price of a floppy disk drive with a built-in magnetic resonance sensor is $350;
   - The average price of a disk with an encoding ring is $5;
   - The average number of floppy disk drives required by one corporate client is 1,750; the price of floppy disk drives for this corporate client is $612,500;
   - The average number of disk drives required by one corporate client (as per point 1.1) is 17,500–10 disks per drive; the price of disk drives for this corporate client is $87,500;
   - The estimated number of corporate clients in accordance with paragraph 1.1 is over 10,000;
   - The estimated market size for corporate clients in accordance with paragraph 1.1 is at least $70,000,000 per year;

- The estimated annual market size for all categories of corporate clients may exceed $700,000,000 in the first stage.

3. Product Characteristics:
   - The project product is an optical disc with an encoding ring and a drive with an integrated sensor module, typically consisting of three microsensors;
   - The sensor module can be supplied without a drive if necessary;
   - The company leading the project can provide services for corporate clients to organize the implementation of a turnkey encryption and information security system.

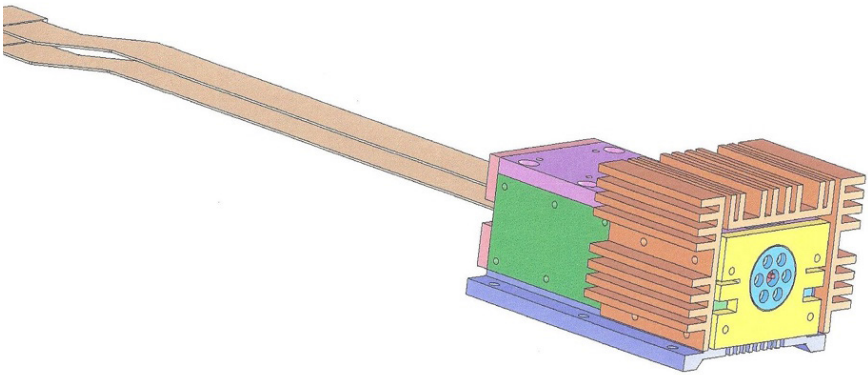

Figure 7.

The figure shows a model of part of a smart home lighting system based on powerful laser diodes, which ensures minimal energy consumption at high illumination levels.

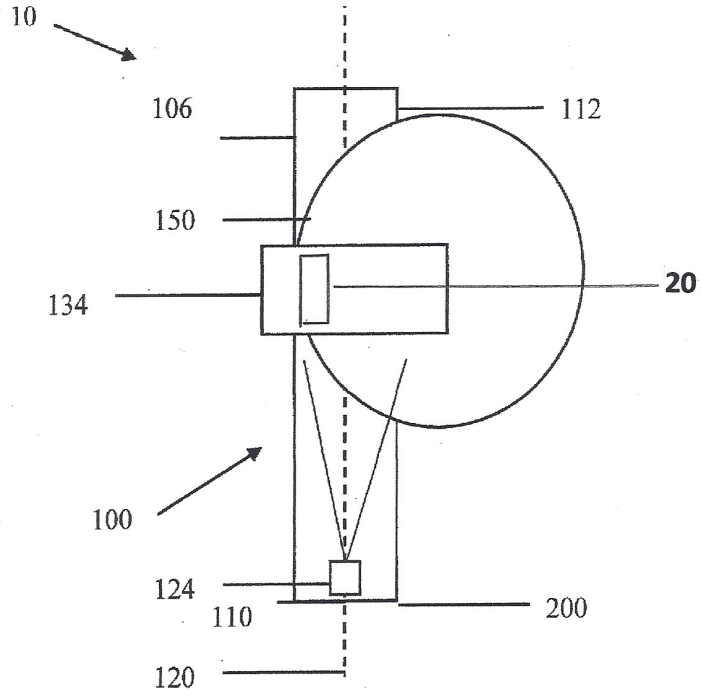

Figure 8.

The figure shows a schematic diagram of a brief description of the resonance method.

The method involves creating an alternating electromagnetic field in the space where the test sample is located. This field serves as an intermediary between the resonant circuit and the test sample.

On the one hand, the resonant circuit acts as an emitter of this field, and on the other, it acts as an acceptor (sensing element) for changes in the electromagnetic field caused by the test sample.

Even without a sample present, the alternating electromagnetic field generated by the solenoid is the sum of two electromagnetic fields changing in antiphase.

One field is generated by the change in the solenoid's magnetic induction and is accompanied by a vortex electric field (Maxwell-Faraday equation).

The other is caused by a change in the electric field created by the potential difference between the outermost turns of the solenoid (if the sample is placed inside the solenoid) or between the turn closest to the sample surface and the sample itself (if the sample is positioned opposite the end of the solenoid). This field is accompanied by a vortex magnetic field (Ampère's law of circulation with Maxwell's correction).

Under the influence of an external alternating electromagnetic field, the following electrical phenomena can be induced in the test sample, depending on its nature:

- linear and eddy conduction currents;
- linear and eddy displacement currents;
- linear and eddy ion currents (ordered movement of ions).

In accordance with the principle of superposition, these phenomena introduce distortions into the external alternating field, which are sensed by the solenoid of the resonant sensor. A resonant circuit containing a solenoid changes its behavior as if additional elements – a capacitor, inductor, and resistor – were added to it.

The sum of the additional capacitive, inductive, and active resistances constitutes the additional impedance introduced into the system by the test sample. This impedance is measured by the resonant sensor.

Changes in the parameters of the resonant circuit are reflected in its frequency response – the resonant frequency and oscillation amplitude change. By studying these changes, one can infer the impedance of the test sample.

Data Processing Principle of Resonant Sensors

A resonant sensor determines the total impedance of the sample at its operating frequency. This value alone is of little value, but using a set of sensors with different operating frequencies makes it possible to exploit a unique natural phenomenon – the change in the specific impedance of a substance depending on the frequency of the applied field. This change depends on the composition of the substance and is the basis of a rapidly developing field – resonance spectroscopy, or Electrochemical Impedance Spectroscopy (EIS).

EIS is a method for studying objects based on the analysis of impedance versus alternating current (AC) frequency. Different substances and processes have characteristic dependencies between active and reactive impedance, which allows for the inverse problem of determining the properties and composition of a substance based on its frequency response.

The change in impedance with frequency allows for the identification of the influence of each component on the overall impedance at different frequencies. Knowing the weighting factors for the influence of the components, the concentrations of the components can be determined from sensor readings by solving a system of linear equations.

Selection of Operating Frequencies and Noise Immunity

To improve accuracy, it is important to correctly select the operating frequencies of the sensors. Scanning over a wide range allows for the identification of the "characteristic" frequencies for each component, at which their response is maximal.

Traditional resonance spectroscopy uses an AC voltage source with contact with the sample, inducing a current in the

circuit. Its magnitude and phase are measured using Nyquist plots. However, such methods often have low sensitivity and accuracy.

The proposed method – impedance measurement using resonant circuits – is contactless and offers higher sensitivity and accuracy. Creating a circuit with a wide-bandwidth, tunable resonant frequency is technically challenging, so traditional spectroscopy is first used to find the "characteristic" frequencies. Then, by creating resonant sensors for these frequencies, a highly sensitive and accurate monitoring system is created.

Noise Immunity Features

"Mechanical" parameters of the medium, such as viscosity, density, transparency, and pressure (for incompressible media), do not affect the measured electrical parameters. Pipeline velocity and turbulence are too slow to affect megahertz impedance measurement processes. Stiffness is a chemical property determined by the composition of the substance. Temperature affects impedance, but its measurement and accounting are straightforward.

Application in smart home systems and energy equipment

The presented models feature a driver design with a swinging mechanism for feeding into the laser diode's operating zone and its stabilization and synchronization mechanisms.

The developments demonstrate the feasibility of such modernization for smart home systems, as well as their equivalents in solar panels and other energy equipment.

The following models show a variant of a computer memory unit capable of being part of a smart home infrastructure and an innovative quantum computer or its processor equivalent. For

operational efficiency, the unit is equipped with a swing arm with optical, laser, electronic, and mechanical subsystems that ensure the functions of all subsystems and minimize the time required for auxiliary movements of the actuators.

Furthermore, the supersystem has simple connections and limited movement time and distance, simplifying its integration into a smart home system. This allows for its widespread use in smart home systems and in projects to optimize process equipment in production systems across all industries, particularly in the control and monitoring of gas turbines and turbogenerators.

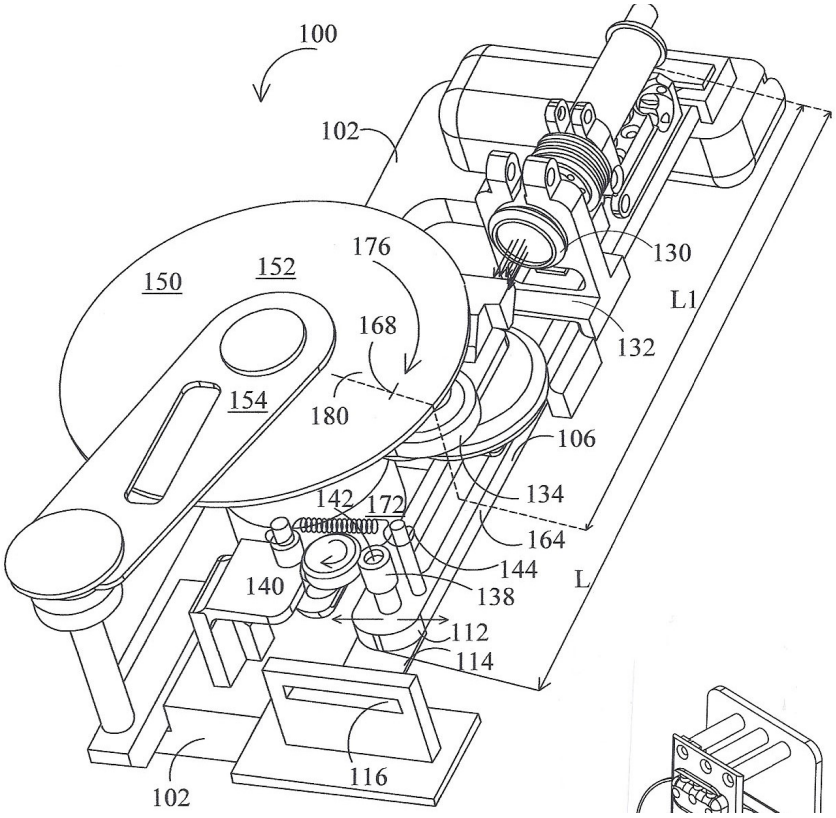

Figure 9.

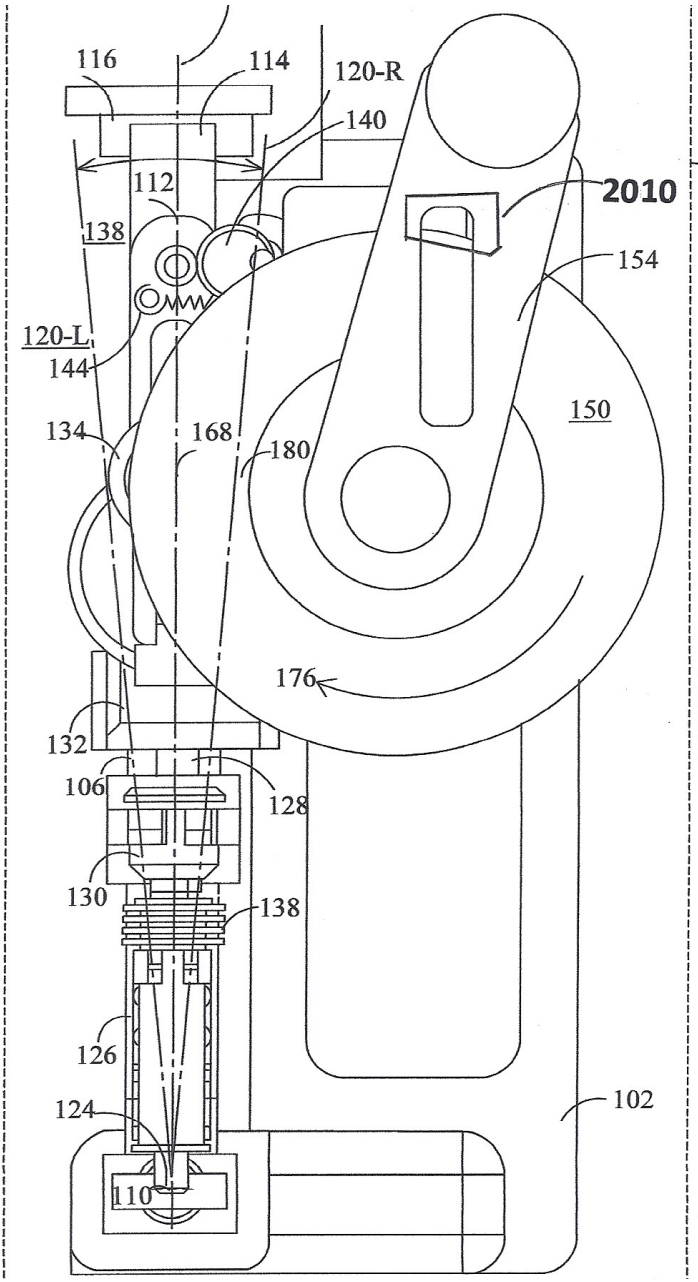
116
114
120-R
140
112
2010
138
154
120-L
144
150
134
168
180
176
132
106
128
130
138
126
124
102
110

Figure 10.

The figures 9 and 10 show a diagram of the application of a contactless control and identification system based on electromagnetic resonance spectroscopy in a smart home and its analogs.

This technology is one of the most promising areas for the development of cybersecurity tools at enterprises with complex production cycles.

Based on the results of preliminary qualification testing of the method, the following conclusions are offered.

1. Protective coding in a smart home infrastructure or its smart equivalents from the group – smart manufacturing, smart medical technology, smart vehicles, smart design, etc.

Fundamentals of protective coding of optical media or storage devices, primarily in the form of a disk transparent to the light flux emanating from the output optical system of a laser diode with a beam output as a single concentrated beam of light having standard dimensions – an outer diameter of 120 millimeters and a thickness of 1.2 millimeters.

The disk is glued together from two halves, each 0.6 mm thick; the coating is applied to one half of the disk on a ring with an outer diameter of 120 mm and an inner diameter of 118 mm. The coating thickness varies between 1 micron and 10 microns in 100 angstrom increments.

1.1. The conceptual foundations of coding are as follows: the coding signal is formed from the response of a sensor or group of sensors to the thickness of the annular coating on the disk, and a comparison of the resulting signal with a statistical standard of this signal – the equivalent of the resonant response of the sensors to the coating thickness, the specific properties of the coating material, the conductivity of the coating material,

the density of the coating material, and the electrical resistance of the coating material.

1.2. The servo-marking system of a formatted disk, which typically takes the form of group combinations of servo points on the disk's data tracks, is replaced by a signal from the decoding sensor of the security coding system. If the integrated signal from the three sensors matches the specified signal parameters, the drive's servo system begins to orient the laser beam's focus on the data track, thereby initiating the read or write process on the optical disc.

1.3. If the signal from the sensors does not match the statistical signal waveform in the drive's processor memory, the drive's servo system does not orient or stabilize the laser diode beam's focus on the data track, and reading or writing to the disc becomes impossible.

2. Disc Identification Options in the Drive:

2.1. Disc identification in the drive can be performed by measuring the coating thickness in real time, comparing the measurement results with the statistical value of this parameter stored in the drive's processor, and sending a signal to the comparator in the drive's processor.

2.2. The identification process can be performed during disc rotation or when the disc is inserted into the drive.

2.3. During identification when inserting a disc into a drive, negative identification results prevent the activation of any drive structure, while a positive identification signal activates the necessary drive structures.

2.4. Elements of the resonant encoding/decoding protective system can be integrated into any existing drive design, implementing all known optical memory technologies, without any design or circuit limitations.

2.5. Existing drives can also be modified to accommodate the microsensor system by embedding a sensor micromodule into the drive's supporting structure.

2.6. If necessary, the coating can be applied to existing discs.

3. Approximate process flow for manufacturing a disc with a coding coating, including for use in smart home digital systems and their innovative equivalents from smart technologies and processes:

3.1. Manufacturing an optical disc with a protective coding coating does not require special technologies or equipment.

3.2. Modernized technological equipment currently in use can be used for production.

3.3. Application of the coding coating can be combined with the production of a disc copy in a mold using a master disc with an identification dot in a formatted servo-marking system, which will thus be imprinted on each information track – of which a typical optical disc has over 37,000.

4. Options for using discs with a protective coating in optical memory systems for corporate clients, which equally applies to systems at all levels in smart home infrastructure components and its technological and design equivalents:

4.1. An approximate scheme for using discs with protective coding/decoding for corporate clients includes the production of For each such client, a specific number of disks with thickness parameters and micro-sensor coordinates unique to that client are provided.

4.2. The design and technical characteristics of the sensor micromodule can also be upgraded based on the client's wishes, but in accordance with the control parameters of the protective coding coating on the disks.

5. Use cases for disks with protective coding in consumer electronics and microelectronics systems within the supersystems and subsystems of digital smart home infrastructure structures and their equivalents:

5.1. Disks with protective coding can be used in Blu-Ray and HD DVD systems; in addition, the protective coding system can be applied in new developments and technologies of optical digital memory, including disks with extremely high recording density, multilayer disks, and monolithic optical disks with a memory capacity of 1 terabit or more.

5.2. During disk manufacturing, the necessary indications can be added to the servo-marking during the pressing process. The disk drive's servo motor begins to orient the laser beam's focal point only when the coding signal from the coding and decoding system matches. This signal is generated by a system of three micro-sensors. Using magnetic resonance methods, these micro-sensors compare the coating thickness with a reference. If the signal parameters match the reference for at least two sensors, the resulting signal is added to the system of symbols and marking points of the servo-marking system. By reading these signals, the disk drive's servo motor begins to stabilize the laser's focus on the required track on the disc's recording surface.

6. Applications for discs with protective coating in personal computers, including those installed in infrastructure elements of digital smart home systems and their equivalents:

6.1. The manufacturing technology for discs for personal computers is similar to the manufacturing technology for such discs for other optical memory options.

6.2. The methodology for using securely encrypted disks is determined by the type of computer, its complexity and power, performance, etc.

6.3. The ability to use securely encrypted technology in hybrid disks, which combine a hard drive with an optical drive, is becoming especially important.

Given that smart home technologies and their equivalents are in an active phase of development and implementation, various questions may arise that must be answered during the current development process to avoid more complex issues and even problems in later stages of development and optimization.

In smart home infrastructure, the ability to monitor water consumption, quality, and contamination levels online, in real time and with a sufficiently high degree of accuracy, is crucial in supersystems and subsystems related to water use. Current standards for water used in residential buildings require strict limits on contaminants of various levels and origins, which in turn necessitates continuous, strict monitoring without interrupting the water flow and the transfer of samples to a laboratory for analysis.

Therefore, continuous monitoring of the key parameters of water used is a key requirement for the operation of smart home systems.

The following five figures show commercially available water meters with a built-in control and monitoring system that operates precisely under the required conditions.

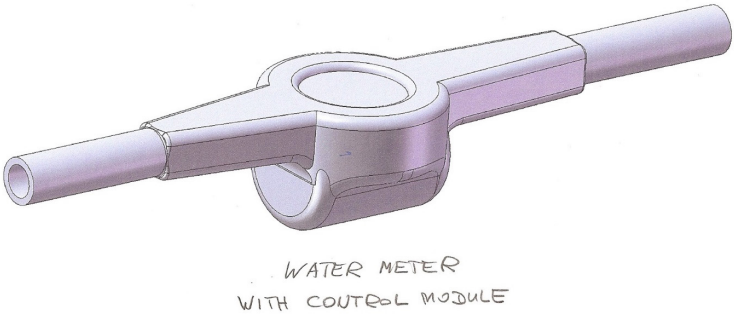

Figure 11.

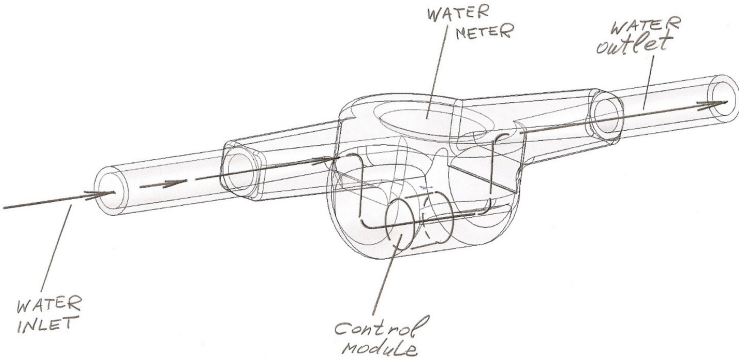

Figure 12.

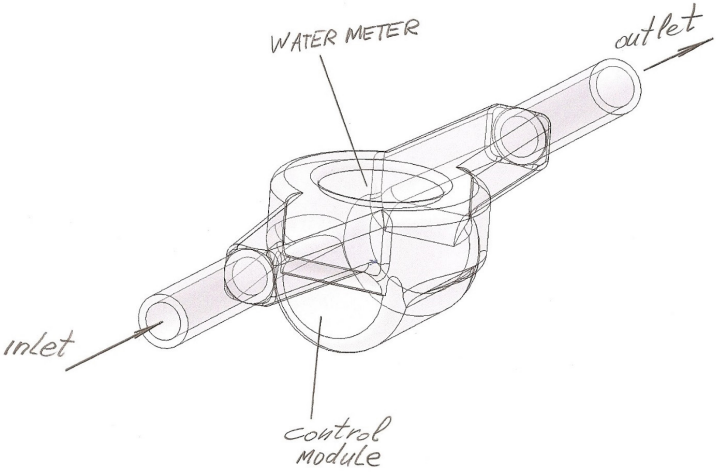

Figure 13.

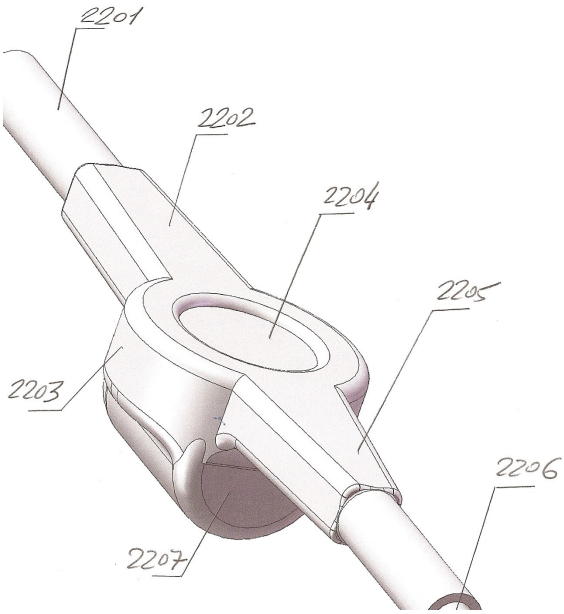

Figure 14.

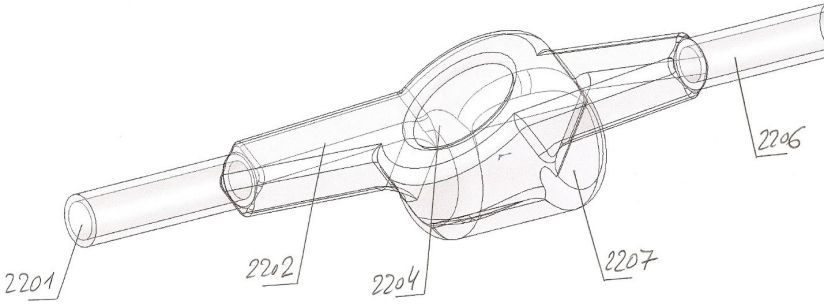

Figure 15.

Models of commercially available linear water meters from ARAD served as the basis for comparison. These models demonstrate the feasibility of integrating the proposed contactless monitoring system, based on electromagnetic resonance spectroscopy, into the meter housing without redesigning any of the basic components. Models of commercially available linear

water meters from ARAD also served as the basis for comparison. hese models demonstrate the feasibility of integrating the proposed contactless monitoring system, based on electromagnetic resonance spectroscopy, into the meter housing without redesigning any of the basic components. Thus, this and subsequent series of tests conducted in a smart home infrastructure environment provide a comprehensive understanding of the transformation of the tested technology into a compact supersystem for monitoring and identifying the parameters of liquids, mixtures, emulsions, and aerosols, as well as for selecting the strongest signals in terms of amplitude, enabling measurement and reliable identification of results within milliseconds.

It should be noted that such high performance enables approximately 1000 measurement cycles within 30 seconds at a given signal frequency and enables the identification of parameters with high amplitude and repeatability.

The transition to a microformat control and analytical module opens the possibility of creating an ultra-compact design, significantly expanding the scope of application of the technology and sensor modules.

Compact functionality, size, and signal energy parameters enable the efficient integration of these systems into mobile communications systems and the gradual migration of the monitoring and control software to mobile applications. This is especially relevant for specialized sensor modules for blood sugar monitoring with signal processing within the capabilities of the corresponding mobile applications and their future modifications.

Conducted tests have demonstrated a broader range of application for this technology than previously anticipated.

Based on the nature of interaction with the monitored object, the following methods are distinguished:

1. transmitted radiation;
2. reflected radiation;
3. scattered radiation;
4. resonant.

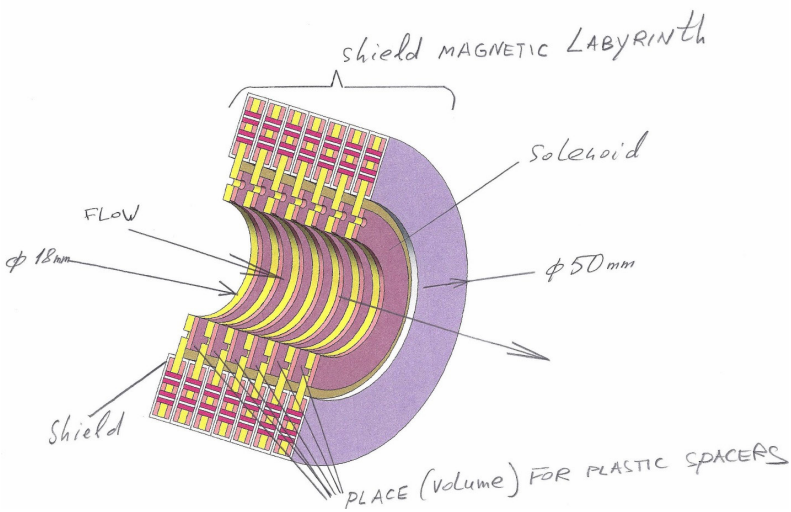

Figure 16.

Modern smart home infrastructure equipment and its equivalents require the latest innovative solutions not only in terms of design and construction, but especially in the management and control of all processes, including the supply of energy, water, and air, as well as optimal thermal and cooling stabilization.

This requirement becomes especially relevant when using alternative fuels in smart home units that provide backup energy or energy resources, such as fuel mixtures and composites – for example, fuel emulsions.

The photo shows an example of a sensor module model that controls and monitors in real time a smart home backup diesel

generator set using a fuel emulsion of diesel fuel and water (with a 50% water content in the emulsion).

In this case, fuel supply parameters, as well as proportional control and monitoring of air supply, require high flexibility of the control and monitoring system, which is ensured by the sensor module shown.

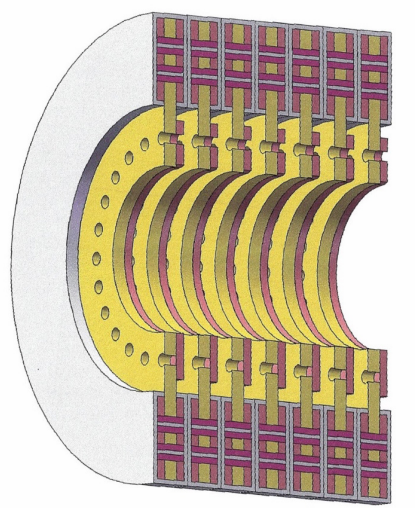

Figure 17.

Potential Applications of Non-Contact Measurement Techniques Based on the Principles of Electromagnetic Resonance Spectroscopy with Elements of Artificial Intelligence and Artificial Neural Networks in Smart Home Systems and Their Equivalents.

Potential Applications of Electromagnetic Resonance Spectroscopy in Multifunctional Sensor Technology in Medicine and Biology, Taking into Account Smart Home Infrastructure Conditions.

• Measuring the Concentration and Composition of Components in Liquids.

This category includes both solutions and dispersed systems: emulsions, suspensions, as well as biological fluids (blood, milk, lymph, urine, etc.).

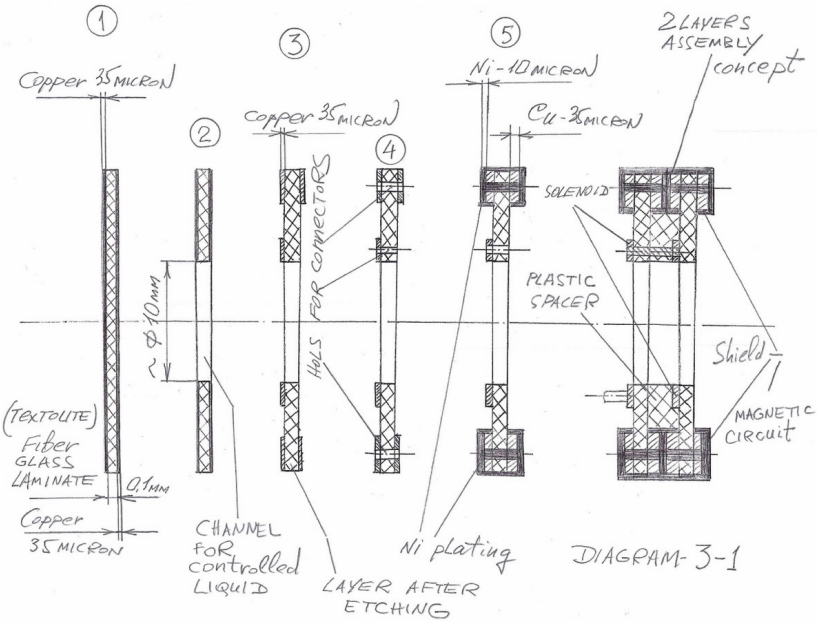

Figure 18.

Due to the high sensitivity of the proposed sensor designs, this technology can be widely applied in the following areas:

1. In the pharmaceutical industry – in drug production processes;

2. For laboratory and field analysis of biological fluids: blood, milk, urine, and others;

3. In medical, technical, and food microbiology – for monitoring microorganism concentrations and the presence of viruses, including coronaviruses.

Measurement of the electromagnetic impedance of biological tissues.

Currently, measuring the impedance of biological tissues at different alternating current frequencies is widely used in diagnostics, as well as in biological and medical research.

For example, a significant increase in tissue impedance at low frequencies allows for the detection of inflammation in the early stages. Some thyroid diseases are diagnosed by changes in the phase angle between current and voltage.

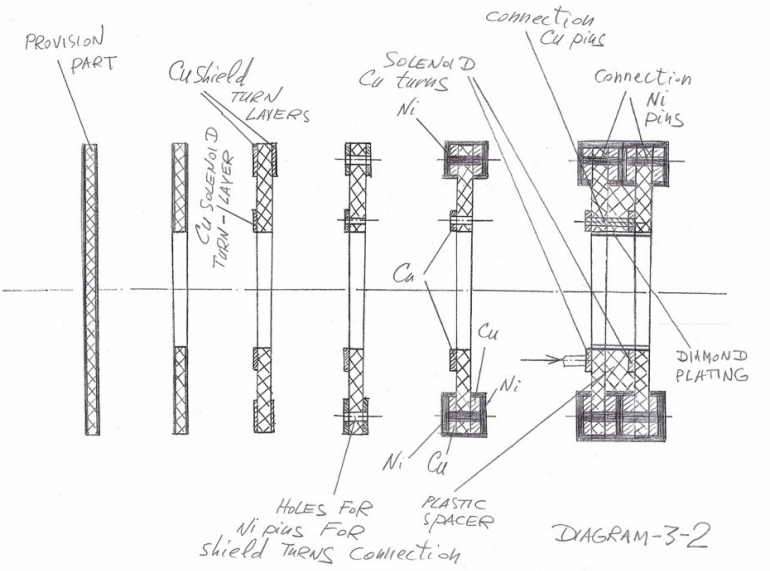

Figure 19.

Based on electromagnetic resonance spectroscopy, so-called electromagnetic resonance spectrometric mammography is an effective method for the early detection of breast cancer.

Skin impedance measurements help diagnose skin diseases, such as identifying unstained malignant melanoma, and identifying coronavirus-contaminated areas on the hands.

Endoscopic impedance measurements can be used to detect internal organ pathologies.

Noninvasive blood tests, such as those used to detect high blood sugar levels, and lymphatic fluid analysis are also used.

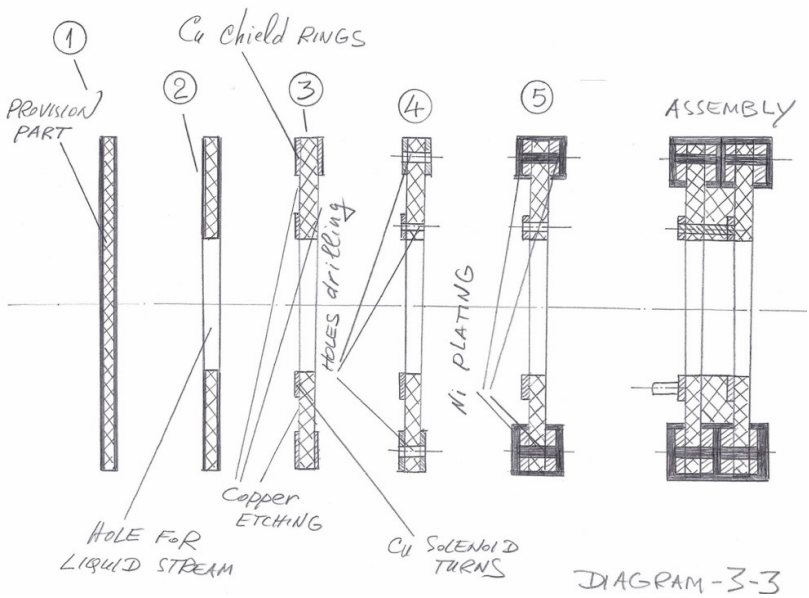

Figure 20.

In all the above-mentioned applications of electromagnetic resonance spectrometric measurements, electromagnetic spectroscopy technology can significantly increase the sensitivity of such measurements. Furthermore, the use of these sensors allows for the detection of coronaviruses in the human throat in the early stages of infection.

Use of Electromagnetic Resonance Spectroscopy Methods and Technologies in Biosensors

The term "biosensor" generally refers to a device in which biological material (enzymes, tissues, bacteria, yeast, antigens/antibodies, organelles, receptors, DNA, viruses, including coronaviruses) directly responds to a signal from the proposed sensor

and generates a resonant signal associated with the presence and concentration of this component. The proposed device implements a fundamentally new method for obtaining information about the chemical composition of solutions, which determines the successful application of such methods in infrastructure components and smart home elements, as well as their functional and design equivalents.

This book examines a systems analysis of the conceptual framework of innovative storage media used in smart home systems. To integrate such a storage device into a smart home infrastructure, a significant increase in storage capacity is required. A preliminary analysis of such a system is proposed.

The first and most important area of control and management is the monitoring and analysis of all materials and their combinations involved in smart home processes.

It is known that the following operating parameters are regulated and monitored at the process input:

- energy and fuel consumption;
- fuel injection pressure;
- specific energy and fuel consumption;
- stoichiometric air volume relative to energy and fuel consumption;
- additional air volume relative to total energy and fuel consumption.

Since the efficiency of energy equipment in a smart home primarily depends on the air volume, this dependence is monitored and precisely adjusted throughout the entire operating cycle, which requires significant processing power from the control processors and computers.

References, patent, and licensing information:

APPENDIX 4–1
United States Patent Application 20210105734
Kind Code A1
XU, Lixiang et al., April 8, 2021
METHOD AND APPARATUS FOR DATA TRANSPORT CONTROL BETWEEN WIRELESS NETWORK SYSTEMS
Abstract:

A communication method and system for integrating a 5G system supporting higher data rates with Internet of Things (IoT) technology is disclosed. It is applicable to intelligent services such as smart homes, smart buildings, cities, automobiles, healthcare, digital education, retail, security, and others. The method includes determining whether a condition is met by a node and transmitting commands and equipment information when the condition is met.

APPENDIX 4–3
United States Patent Application 20210105780
Kind Code A1
JIN, Seungri et al., April 8, 2021
METHOD AND APPARATUS FOR SUPPORTING SIMULTANEOUS TRANSMISSION AND RECEPTION TO MULTIPLE TRANSMISSION AND RECEPTION POINTS IN A NEXT-GENERATION MOBILE COMMUNICATION SYSTEM
Abstract:

A method and system for supporting simultaneous transmission and reception to multiple points in a 5G IoT-enabled

system, applicable in smart cities, homes, healthcare, and other applications.

APPENDIX 4–4
United States Patent Application 20210105828
Kind Code A1
AGIWAL, Anil et al., April 8, 2021
METHOD AND APPARATUS FOR RANDOM ACCESS PROCEDURE
Abstract:
Method and apparatus for random access procedures in 5G IoT-enabled systems used in smart homes, cities, and other intelligent services.

APPENDIX 4–5
United States Patent Application 20210105677
Kind Code A1
JANG, Jaehyuk et al., April 8, 2021
METHOD AND APPARATUS FOR CONFIGURING CARRIER AGGREGATION FOR SERVING CELLS HAVING DIFFERENT START TIME POINTS IN A FRAME IN A WIRELESS COMMUNICATION SYSTEM
Abstract:
A method for configuring carrier aggregation with different frame start points in 5G networks supporting IoT to increase data rates.

APPENDIX 4–6
United States Patent Application 20210105665
Kind Code A1

BENNETT, Andrew et al., April 8, 2021

APPARATUS AND METHOD FOR NETWORK CONFIGURATION

Abstract:

A method for monitoring and configuring a 5G network, including collecting data from user equipment and managing the network based on the analysis of this data.

APPENDIX 4–7

United States Patent Application 20210101679

Kind Code A1

HAN, Yoonseon et al., April 8, 2021

APPARATUS AND METHOD FOR MOBILITY MANAGEMENT OF UNMANNED AERIAL VEHICLE USING FLIGHT MISSION AND ROUTE IN MOBILE COMMUNICATION SYSTEM

Abstract:

A method and system for managing the mobility of an unmanned aerial vehicle in 5G IoT-enabled networks, applied in intelligent services.

APPENDIX 4–8

United States Patent Application 20210098137

Kind Code A1

CARROLL; Brian; et al.

April 1, 2021

SMART MEDIA DEVICE

Abstract

Increasingly, multiple users and multiple network devices are connecting to or requesting access to and/or from network

resources. Users are increasingly expanding the number of network devices connected to a network. For example, a Home Network Environment (HNE) can have multiple networked devices connected to a single network. Each network device has its own interface, and each network device is controlled via this interface, which is generally located at the network device. A smart media device (SMD) can provide centralized control for the multiple network devices and access to and/or from the multiple network resources. The SMD can provide control of one or more Internet of Things devices communicatively coupled to the SMD.

APPENDIX 4–9
United States Patent Application 20210105609
Kind Code A1
PARK; Jonghan; et al.
April 8, 2021
METHOD AND APPARATUS FOR REINSTALLING SIM PROFILE IN WIRELESS COMMUNICATION SYSTEM

Abstract

The present disclosure relates to a communication method and system for converging a 5th-Generation (5G) communication system for supporting higher data rates beyond a 4th-Generation (4G) system with a technology for Internet of Things (iot). The present disclosure may be applied to intelligent services based on the 5G communication technology and the iot-related technology, such as smart home, smart building, smart city, smart car, connected car, health care, digital education, smart retail, security and safety services.

APPENDIX 4–10

United States Patent Application 20210100042

Kind Code A1

AGIWAL; Anil; et al.

April 1, 2021

SYSTEM AND METHOD OF IDENTIFYING RANDOM ACCESS RESPONSE

Abstract

A communication method and system for converging a 5th-Generation (5G) communication system for supporting higher data rates beyond a 4th-Generation (4G) system with a technology for Internet of Things (iot) is provided. The communication method and system include intelligent services based on the 5G communication technology and the iot-related technology, such as smart home, smart building, smart city, smart car, connected car, health care, digital education, smart retail, security and safety services. A method includes transmitting a random access preamble on a physical random access channel (PRACH) transmission occasion from a base station, identifying a random access radio network temporary identifier (RA-RNTI) for receiving random access response (RAR) information based on a time-related parameter, a frequency-related parameter and an uplink carrier-related parameter, and receiving scheduling assignment information scheduling a physical downlink shared channel (PDSCH) on a physical downlink control channel (PDCCH) based on the identified RA-RNTI from the base station.

APPENDIX 4–11
United States Patent Application 20210100010
Kind Code A1
YOON; Suha; et al.
April 1, 2021
METHOD AND APPARATUS FOR TRANSMITTING SCHEDULING REQUEST IN MOBILE COMMUNICATION SYSTEM

Abstract

The present disclosure relates to a communication technique that fuses a 5G communication system supporting a higher data transmission rate following a 4G system with iot technology and a system therefor. The present disclosure can be applied to intelligent services (e.g., smart homes, smart buildings, smart cities, smart cars or connected cars, health care, digital education, retail, security and safety related services, etc.) On the basis of 5G communication technology and iot related technology. A method for transmitting a scheduling request (SR) of a terminal according to the present invention comprises the steps of: receiving SR configuration information; performing channel sensing of an unlicensed band in case that the SR is triggered in the unlicensed band; and waiting for SR transmission in case that a channel is occupied as a result of the channel sensing.

APPENDIX 4–12
United States Patent Application 20210099954
Kind Code A1
AGIWAL; Anil; et al.
April 1, 2021

METHOD AND APPARATUS FOR MONITORING WAKE UP SIGNAL

Abstract

The disclosure relates to a communication method and system for converging a 5th generation (5G) communication system for supporting higher data rates beyond a 4th generation (4G) system with a technology for Internet of Things (iot). The disclosure may be applied to intelligent services based on the 5G communication technology and the iot-related technology, such as smart home, smart building, smart city, smart car, connected car, health care, digital education, smart retail, security and safety services. A method and apparatus for monitoring wakeup signal and method and apparatus for securing unicast V2X communication are provided.

APPENDIX 4–13

United States Patent Application 20210100024

Kind Code A1

BANG; Jonghyun; et al.

April 1, 2021

METHOD AND DEVICE FOR TRANSMITTING/RECEIVING UPLINK CONTROL INFORMATION IN WIRELESS COMMUNICATION SYSTEM

Abstract

The disclosure relates to a communication technique for convergence of a 5th generation (5G) communication system for supporting a higher data transmission rate beyond a 4th generation (4G) system with an iot technology, and a system therefor. The disclosure may be applied to intelligent services (e.g., smart homes, smart buildings, smart cities, smart cars or

connected cars, health care, digital education, retail business, security and safety-related services, etc.) On the basis of 5G communication technology and iot-related technology. The disclosure relates to a method and device for transmitting or receiving uplink control information in a wireless communication system. The disclosure relates to a method for configuring and generating uplink control information in an unlicensed band. The disclosure proposes a method for adding generated uplink control information to an uplink data channel.

APPENDIX 4–14
United States Patent Application 20210099496
Kind Code A1
SHAH; Sapan Pramodkumar; et al.
April 1, 2021
METHOD AND SYSTEM FOR HANDLING MISSION CRITICAL DATA (MCDATA) COMMUNICATIONS USING PRE-ESTABLISHED SESSION

Abstract

The present disclosure relates to a communication method and system for converging a 5th-Generation (5G) communication system for supporting higher data rates beyond a 4th-Generation (4G) system with a technology for Internet of Things (iot). The present disclosure may be applied to intelligent services based on the 5G communication technology and the iot-related technology, such as smart home, smart building, smart city, smart car, connected car, health care, digital education, smart retail, security and safety services. Example embodiments initiate a Mission Critical data (mcdata) communication using a pre-established session. A participating mcdata server receives at least one pre-

established session setup request from an originating mcdata client device. The pre-established session setup request comprises the pre-established session indication advising the participating mcdata server of initiation of at least one pre-established session. The participating mcdata server initiates the at least one pre-established session with the originating mcdata client device based on the pre-established session indication. The participating mcdata server sends at least one mcdata-communication-state message to the originating mcdata client device.

APPENDIX 4–19

United States Patent Application 20210068141

Kind Code A1

YEO; Jeongho; et al.

March 4, 2021

METHOD AND APPARATUS FOR DECODING DOWNLINK CONTROL SIGNAL IN WIRELESS CELLULAR COMMUNICATION SYSTEM

Abstract

The present disclosure relates to a communication technique for converging iot technology with a 5G communication system for supporting a higher data transmission rate beyond a 4G system, and a system therefor. The present disclosure may be applied to intelligent services (for example, a smart home, a smart building, a smart city, a smart car or connected car, healthcare, digital education, retail business, security and safety related services, or the like) on the basis of 5G communication technology and iot related technology. The present invention relates to a wireless communication system and, specifically, to a method and apparatus for decoding a downlink control signal.

APPENDIX 4–20

United States Patent Application 20210067276

Kind Code A1

WANG; Yi; et al.

March 4, 2021

METHOD AND APPARATUS FOR TRANSMITTING HYBRID AUTOMATIC REPEAT AND REQUEST INFORMATION IN A WIRELESS COMMUNICATION SYSTEM

Abstract

The present disclosure relates to a communication method and system for converging a 5th-Generation (5G) communication system for supporting higher data rates beyond a 4th-Generation (4G) system with a technology for Internet of Things (iot). The present disclosure may be applied to intelligent services based on 5G communication technology and iot-related technology, such as smart home, smart building, smart city, smart car, connected car, health care, digital education, smart retail, security and safety services. The present invention provides a method of a base station for supporting an inter-system handover from an evolved packet system (EPS) to a 5th generation (5G) system. The present application provides a method for transmitting HARQ-ACK information, including steps of: detecting, by a UE, a PDCCH and receiving a PDSCH scheduled by the PDCCH; for one slot of one carrier, determining, according to a configured slot pattern and a configured PDCCH monitoring occasion, the HARQ-ACK occasion and the number of HARQ-ACK bits occupied by the one slot; and generating, by the UE, a HARQ-ACK codebook according to the HARQ-ACK occasion and the number of HARQ-ACK bits occupied by the one slot, and transmitting

HARQ-ACK information. By the method of the present invention, the number of HARQ-ACK bits to be fed back within each slot is reduced, and the feedback overhead is reduced; moreover, the number of bits of the generated HARQ-ACK codebook changes semi-statically, so that confusion between a base station and a UE is avoided.

APPENDIX 4–21

United States Patent Application 20210068168

Kind Code A1

KIM; Soeng Hun; et al.

March 4, 2021

METHOD AND APPARATUS FOR TRANSMITTING AND RECEIVING DATA USING PLURALITY OF CARRIERS IN MOBILE COMMUNICATION SYSTEM

Abstract

The present disclosure relates to converging a 5th-Generation (5G) communication system for supporting higher data rates beyond a 4th-Generation (4G) system with a technology for Internet of Things (iot), and may be applied to intelligent services, such as smart home, smart building, smart city, smart car, connected car, health care, digital education, smart retail, security and safety services. A method according to disclosed aspects includes receiving a first control message including a first random access response window for a first cell group, receiving a second control message for adding a second cell group, including information on a second random access response window size for the second cell group, transmitting, on a cell of the second cell group, a random access preamble, and monitoring, on the cell of the second cell group, a random access response

based on the second random access response window size for the second cell group.

APPENDIX 4–22
United States Patent Application 20210060404
Kind Code A1
WANKE; Todd; et al.
March 4, 2021
SYSTEMS, DEVICES, AND METHODS EMPLOYING THE SAME FOR ENHANCING AUDIENCE ENGAGEMENT IN A COMPETITION OR PERFORMANCE

Abstract

This document presents devices, systems, and their methods of use for content generation, engagement, and distribution by which a user can interact with collected content in a variety of different manners. Generally, a content engagement platform is provided, where the platform may be implemented on one or more computing devices, such as one or more of: a remote server, a desktop computer, a tablet computer, a handheld mobile computing device, for instance, a mobile phone or personal digital assistant, a smart accessory, such as a watch or eyeglasses, and the like. The platform allows a user to annotate and distribute video content.

APPENDIX 4–23
United States Patent Application 20210058848
Kind Code A1
BAEK; Youngkyo; et al.
February 25, 2021

METHOD AND APPARATUS FOR TERMINATING CELLULAR NETWORK CONNECTION OF UNAUTHENTICATED TERMINAL

Abstract

A method and apparatus for terminating a cellular network connection of a terminal that is connected without authentication are provided. The disclosure relates to a communication technique and a system for converging a 4th generation (4G) system and a 5th generation (5G) communication system to support higher data rates, subsequent to the 4G system, with Internet-of-things (iot) technology. The disclosure may be applied to intelligent services (e.g., smart home, smart buildings, smart cities, smart cars or connected cars, healthcare, digital education, retail business, security and safety related services, or the like) based on 5G communication technology and iot-related technology.

APPENDIX 4–24

United States Patent Application 20210084534

Kind Code A1

KIM; Donggun; et al.

March 18, 2021

METHOD AND DEVICE FOR IMPROVED COMMUNICATION PERFORMANCE IN WIRELESS COMMUNICATION SYSTEM

Abstract

Disclosed are a communication technique for merging iot technology with a 5G communication system supporting a data transmission rate higher than that of a 4G system, and a system therefor. The present disclosure can be applied to intelligent

services (for example, smart home, smart building, smart city, smart car or connected car, health care, digital education, retail, security, and safety related services, and the like) based on 5G communication technology and iot-related technology. Disclosed is an operating method of a terminal, comprising the steps of: receiving, from a base station, a radio resource control (RRC) message including information indicating whether to use uplink data compression (UDC); receiving data from an upper application layer of the terminal; compressing the data and encoding the compressed data; generating an uplink data compression (UDC) header and a service data adaptation protocol (SDAP) header together; generating a block to which the UDC header and the SDAP header are bonded in the encoded data; and transmitting the block to a lower layer of the terminal.

APPENDIX 4–25

United States Patent Application 20210058805

Kind Code A1

JI; Hyoungju; et al.

February 25, 2021

METHOD AND APPARATUS FOR INDICATING BEAM FAILURE RECOVERY OPERATION OF TERMINAL IN WIRELESS COMMUNICATION SYSTEM

Abstract

The disclosure relates to a communication scheme and system for converging iot technology and a 5G communication system supporting a higher data transfer rate beyond a 4G system. The disclosure may be applied to intelligent services (e.g., smart home, smart building, smart city, smart car or connected car, health care, digital education, smart retail, and security and

safety services), based on 5G communication technology and iot-related technology. A method of a terminal according to an embodiment includes: receiving information on a reference signal set for beam failure detection from a base station; identifying the reference signal set for beam failure detection based on the information; identifying whether a beam failure is detected based on the reference signal set; and if the beam failure is detected for the reference signal set, triggering a beam failure recovery procedure.

APPENDIX 4–26

United States Patent Application 20210099913

Kind Code A1

LEE; Wonbo; et al.

April 1, 2021

METHOD AND APPARATUS FOR CONTROLLING TRAFFIC OF NETWORK DEVICE IN WIRELESS COMMUNICATION NETWORK

Abstract

The present disclosure relates to a communication technique for combining a 5G communication system with iot technology to support a higher data transmission rate than a 4G system, and a system thereof. The present disclosure can be applied to 5G communication and iot related technology-based intelligent services (for example, smart homes, smart buildings, smart cities, smart cars or connected cars, health care, digital education, retail business, security and safety related services, etc.). The present invention relates to a method and apparatus for a first network device in a wireless communication network to control traffic of a terminal, and the method comprises the steps of: the first

network device detecting a first flow in a second network device connected to the first network device after a particular point of time; confirming whether the detected first flow is associated with a first terminal connected to the second network device after that point of time; and controlling traffic for the flow of the terminal on the basis of the confirmation result.

APPENDIX 4–27
United States Patent Application 20210099870
Kind Code A1
MOON; Sangjun; et al.
April 1, 2021
METHOD AND APPARATUS FOR PERFORMING AUTHORIZATION FOR UNMANNED AERIAL SYSTEM SERVICE IN WIRELESS COMMUNICATION SYSTEM

Abstract

Disclosed are a communication scheme and system for converging iot technology and a 5G communication system supporting a high data transmission rate beyond a 4G system. The disclosure can be applied to intelligent services (e.g., services related to smart home, smart building, smart city, smart car, connected car, health care, digital education, retail business, security, and safety) based on 5G communication technology and iot-related technology. Disclosed is a method of performing authorization related to an unmanned aerial system (UAS) service in a wireless communication system.

APPENDIX 4–28
United States Patent Application 20210076347
Kind Code A1

PARK; Jungshin; et al.

March 11, 2021

METHOD FOR SUPPORTING EFFICIENT PDU SESSION ACTIVATION AND DEACTIVATION IN CELLULAR NETWORKS

Abstract

A communication method and system converges a 5G communication system for supporting higher data rates beyond a 4G system with an IoT technology. The system and method may be applied to intelligent services based on 5G communication technology and IoT-related technology, such as smart home, smart building, smart city, smart car, connected car, health care, digital education, smart retail, security and safety services. Embodiments provide a scheme for efficiently operating a user plane (UP) connection of a session in cases where a terminal has a plurality of sessions in a mobile communication system, such as a 5G system, having a network structure in which an AMF for mobility management and an SMF for session management are separated from each other. A terminal (UE) can optimize a non-access stratum (NAS) signaling message and perform data transmission/reception with low latency.