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EVALUATION OF ELECTROMAGNETIC FIELD EXPOSURE IN MODERN RESIDENTIAL BUILDINGS

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Abstract: The rapid development of electrical, electronic and wireless technologies in residential buildings has led to an increased presence of electromagnetic fields (EMF) in indoor environments. Electrical installations, household appliances, wireless communication systems and building automation generate electromagnetic fields with different frequencies and intensities. This paper analyzes the main indoor EMF sources, the types of electromagnetic fields encountered in buildings, assessment methods, regulatory limits and technical solutions for exposure reduction. A case study based on in-situ measurements in a residential building is also presented.

Key words: electromagnetic fields, residential buildings, EMF exposure, indoor environment, civil engineering.

1. INTRODUCTION

Modern residential buildings integrate an increasing number of electrical and electronic systems intended to improve comfort, safety and energy efficiency. As a consequence, occupants are continuously exposed to electromagnetic fields (EMF) generated by power supply systems, household appliances, information technology equipment and wireless communication devices [1].

From the perspective of civil engineering, indoor environmental quality has become a key design criterion, alongside thermal comfort, acoustic performance and indoor air quality. Electromagnetic exposure is now considered an additional factor influencing occupants' well-being and long-term health [2].

2. SOURCES OF ELECTROMAGNETIC FIELDS IN BUILDINGS

Electromagnetic fields in residential buildings originate from a wide range of sources operating at different frequencies. Low-frequency fields are mainly produced by electrical power systems, while higher frequencies are associated with wireless communication technologies.

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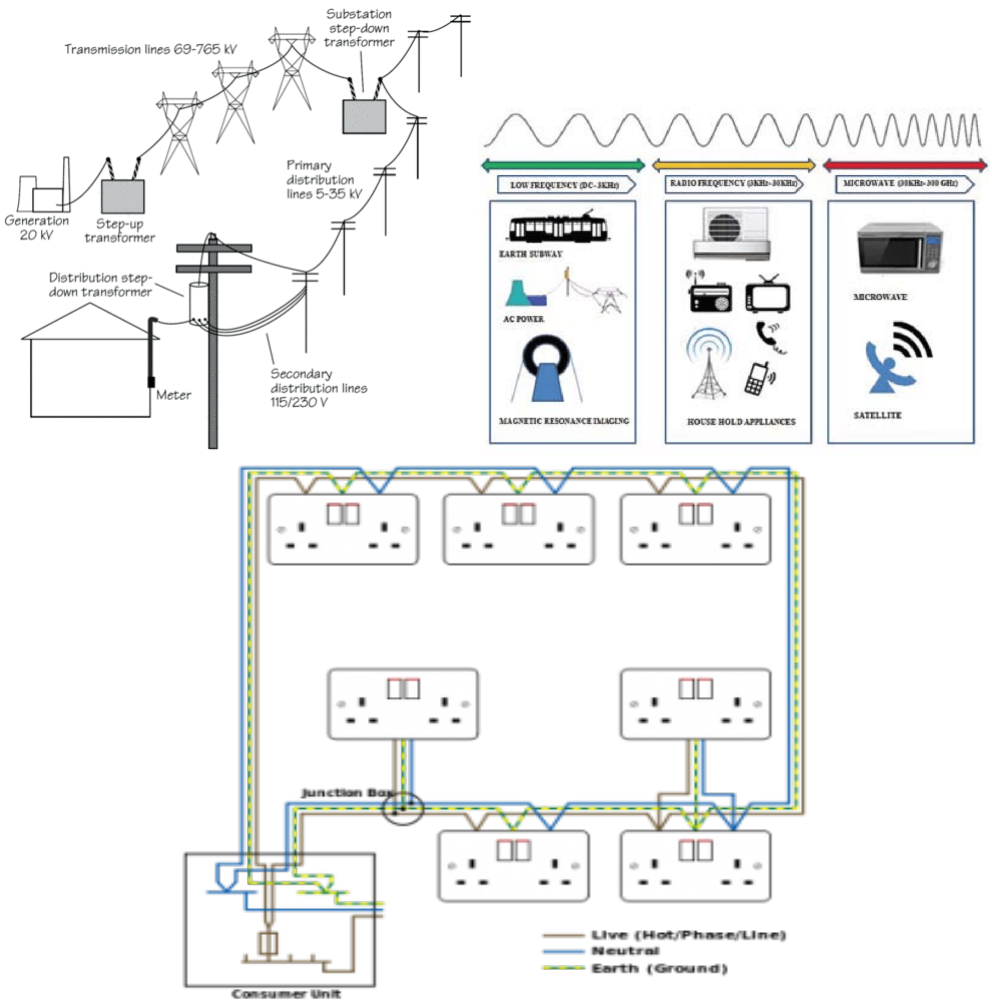

Fig.1. Typical indoor sources of electromagnetic fields in a residential building

As shown in Fig. 1, The most common indoor EMF sources include electrical power supply networks operating at 50 Hz, electrical distribution boards, household appliances, IT equipment, wireless communication systems and building automation installations [3]. The cumulative effect of these sources leads to a complex electromagnetic environment that varies spatially and temporally.

3. TYPES OF ELECTROMAGNETIC FIELDS

3.1. Extremely Low Frequency Fields (ELF)

Extremely low frequency electromagnetic fields are generated by alternating current electrical installations and devices connected to the power grid. These fields are characterized by frequencies up to 300 Hz and are mainly associated with electric and magnetic components around cables and equipment [4].

3.2. Radiofrequency Fields (RF)

Radiofrequency electromagnetic fields are produced by wireless communication systems and electronic devices. In residential buildings, RF fields typically range from several hundred MHz to a few GHz and propagate through indoor spaces, interacting with building materials.

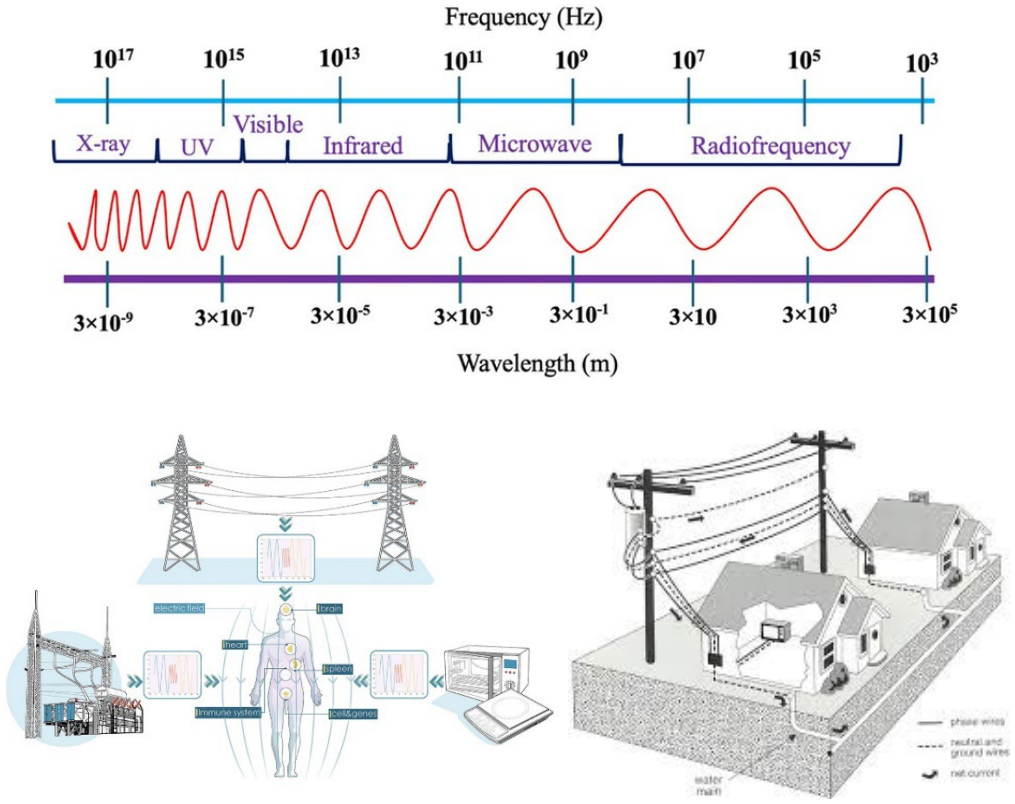

Fig.2. Classification of electromagnetic fields encountered in residential buildings according to frequency

4. METHODS FOR EMF EXPOSURE ASSESSMENT

4.1. Direct Measurements

Direct measurement represents the most reliable method for assessing actual EMF exposure levels. Specialized equipment such as electromagnetic field analyzers, electric and magnetic field probes, and broadband or frequency-selective instruments are used [6].

Measurements are usually performed in frequently occupied areas such as living rooms, bedrooms and home offices, at representative heights corresponding to occupant presence.

Measurements were performed in representative indoor locations, such as living rooms and bedrooms, at typical occupant height (Fig. 3).

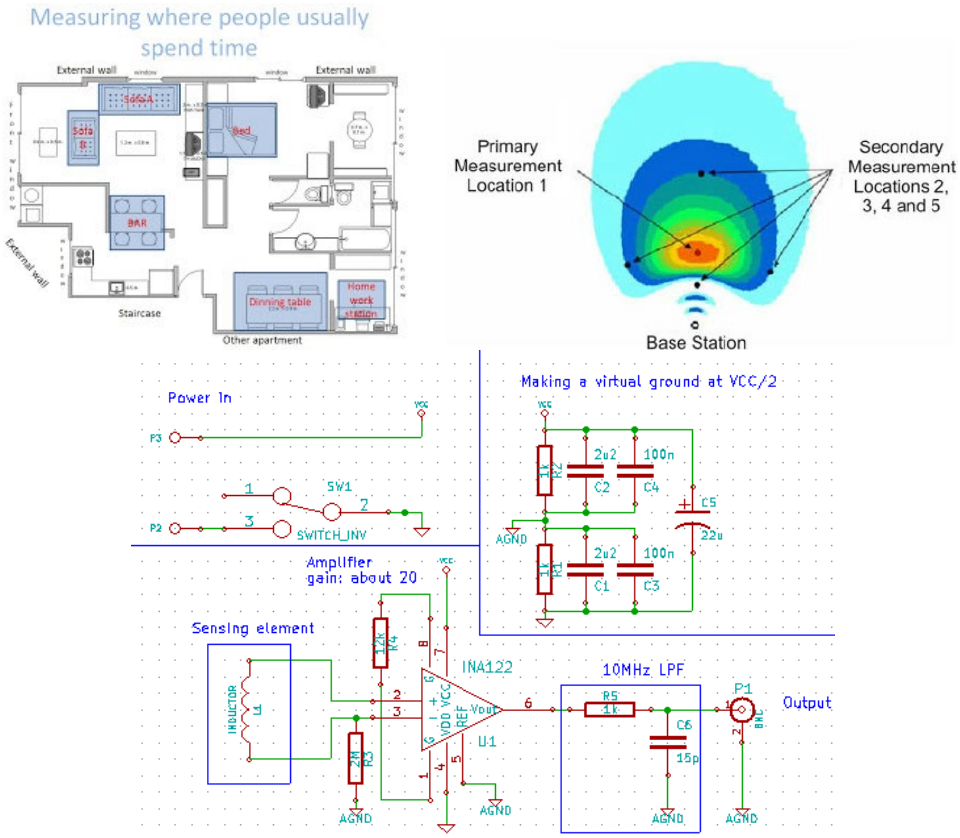

Fig.3. Typical measurement points for electromagnetic field assessment in residential rooms

4.2. Numerical Modelling and Simulation

In modern building design, electromagnetic field distribution can be assessed through numerical modelling and simulation. Specialized software allows the analysis of EMF propagation depending on building geometry, source location and material properties [7]. This approach is particularly useful during the design stage.

5. REGULATORY FRAMEWORK AND EXPOSURE LIMITS

Exposure to electromagnetic fields is regulated internationally by the guidelines issued by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). These guidelines establish reference levels for general public exposure and occupational exposure [8]. At European and national levels, these recommendations are implemented through specific directives and standards related to electromagnetic compatibility and public health protection [9].

6. MEASURES FOR REDUCING EMF EXPOSURE

Several technical and design measures can be applied to reduce EMF exposure in residential buildings, including proper positioning of electrical and electronic equipment, use of shielded cables, adequate grounding of electrical installations, limitation of prolonged exposure to wireless devices and application of construction materials with electromagnetic attenuation properties [10].

7. CASE STUDY: EMF ASSESSMENT IN A RESIDENTIAL BUILDING

7.1. Building Description

The case study was conducted in a multi-storey residential building equipped with standard electrical installations, Wi-Fi networks and typical household appliances. Measurements were performed in living rooms and bedrooms, at a height of approximately 1.2 m above floor level.

7.2. Measurement Results and Analysis

Measured electric field values for ELF sources ranged between 5 and 40 V/m in the vicinity of electrical panels, while RF field levels measured near Wi-Fi routers remained below 3 V/m. All recorded values were below the ICNIRP reference levels for public exposure. The spatial distribution of electromagnetic field intensity highlights higher values in the proximity of electrical panels and wireless routers (Fig. 4).

7.3. Discussion

The spatial distribution of electromagnetic fields highlights localized increases in proximity to electrical panels and wireless routers.

However, normal operating conditions ensure compliance with applicable exposure limits, emphasizing the importance of proper equipment placement and design optimization.

8. CONCLUSIONS

Electromagnetic fields are an unavoidable component of modern residential buildings. Through proper assessment, compliance with regulations and implementation of technical mitigation measures, EMF exposure can be maintained at safe levels.

Integrating electromagnetic field evaluation into the design and operation of residential buildings contributes to healthier indoor environments and supports sustainable construction principles.

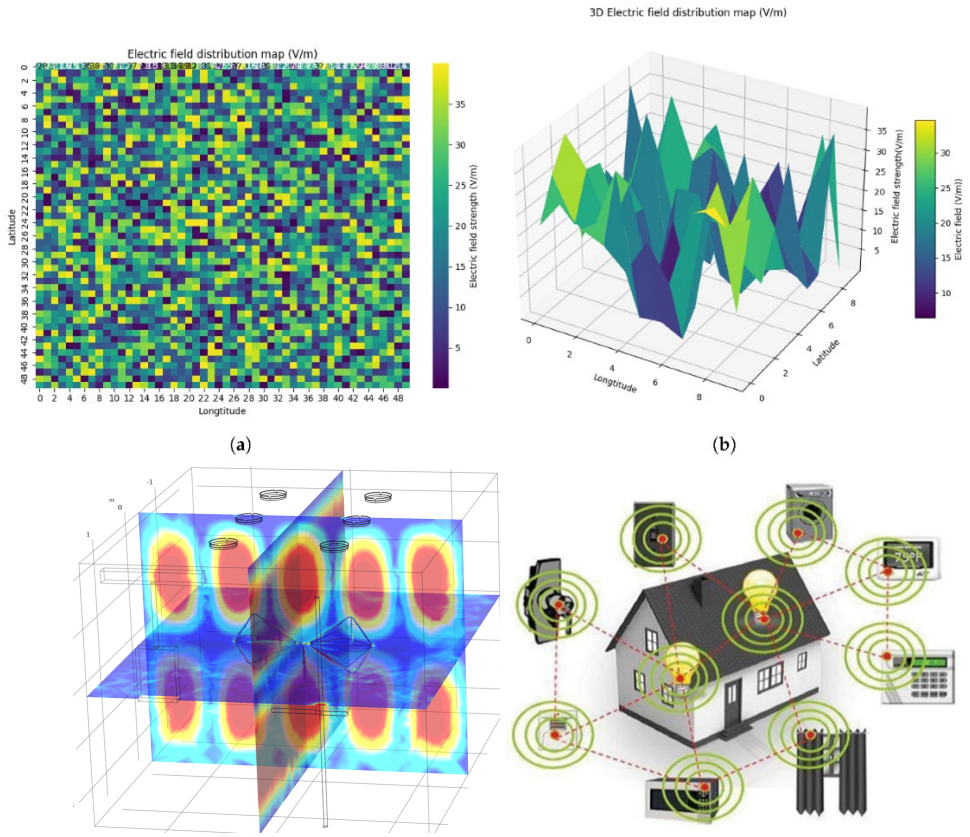

Fig.4. Electromagnetic field intensity distribution in a living room – case study

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