STRUCTURAL HEALTH MONITORING BY EMBEDDING RFID SENSOR SYSTEM IN CONCRETE

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ABSTRACT:

Absolutely embedded sensor systems for long-term operation offer revolutionary opportunities for structural fitness tracking of concrete structures. Measuring of applicable parameters, e.g., temperature, humidity, or indication of corrosion may be done with low electricity sensors. This permits to put into effect passive RFID sensor systems without cable connection and battery, which might be electricity supplied exclusively by means of the electromagnetic subject from the external reader device. To evaluate characteristics and situations of this idea, a systematically investigation of the transmission traits with variant of relevant parameters, as communiqué frequency, installation depth, form of concrete, moisture content material, etc. is presently finished in an interdisciplinary research undertaking at BAM. Further effects are supplied in this paper.

Keywords--- *embedded sensor, energy harvesting, wireless sensors, RFID sensors, transmission characteristics, structural health monitoring.*

I. INTRODUCTION

Steel strengthened concrete bridges are a real instance in civil engineering for the application of structural health monitoring (SHM). SHM is necessary in situations that deliver a danger of structural failure because of software and boundary situations. In Germany, most of the people of bridge homes are notably older than 30 years; however the heavy goods vehicle traffic expanded five-fold for the duration of the identical length. On the grounds that legally relevant and currently carried out inspection strategies are primarily based on non-public, e.g., visual evaluation, its miles affordable to increase, validate, and establish alternative and/or complementary techniques based totally on cutting-edge era.

Absolutely embedded RFID sensors offer the chance to display applicable parameters of structural integrity, which might be within the case of bolstered concrete, e.g., temperature, humidity and corrosion [1], [2]. Such systems can be included in structural components of recent buildings in the course of production or by way of subsequent integration at crucial positions of present homes. For the latter the approach of integration needs to be solved carefully, to minimize the impact on the structure and to assure consultant measurements [3]. Passive RFID structures are operated wirelessly without any internal energy supply and provide high-quality necessities for lengthy-term operability and robustness. A decisive issue for such systems is the transmission reliability after structural integration. The set up depth and the concrete moisture content are proscribing elements [4].

The supplied have a look at systematically investigates the transmission characteristics of concrete embedded RFID sensors. Two similar forms of passive RFID sensor systems, every containing a temperature and a humidity sensor, were assembled in research and development sports, simply differing of their transmission frequencies of 13.fifty six MHz (HF) and 868 MHz (UHF). The investigation in their transmission characteristics is executed with RFID evaluation equipment that utilizes the corresponding frequency degrees 10 to 30 MHz (HF) and 860 to 960 MHz (UHF).

This paper offers the primary layout of RFID sensors structures for embedding in concrete and first results from experiments which might be executed to examine each RFID structures (HF and UHF) in described eventualities, in particular embedded in concrete with variation of the set up depth and concrete moisture content. When you consider that experiments are ongoing,

the actual consciousness lies on the HF RFID systems and version of the set up depth.

II. RFID SENSOR SYSTEMS

The device design is applied at a length of 25 x 25 mm2. The equal basic design became applied for HF and UHF systems (determine 1). RFID transponders ready with a microchip and sensor interface form the middle of the machine (determine 2). The sensor system features digital interfaces (E) to attach energetic and passive external sensors (eS).

Operation precept is that the RFID antenna absorbs electricity from the electromagnetic area, that's carried out via an external RFID reader tool. The analog frontend (AFE), that's linked to the antenna, transmits the power through the power management module (PM) to perform the outside sensors. The sign input (Sin) is processed via the microchip and communicated via the electromagnetic subject thru load modulation (HF) or backscattering (UHF).

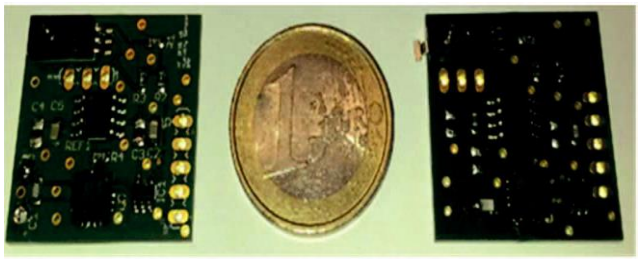

Figure (a) RFID sensor system (UHF left, HF right)

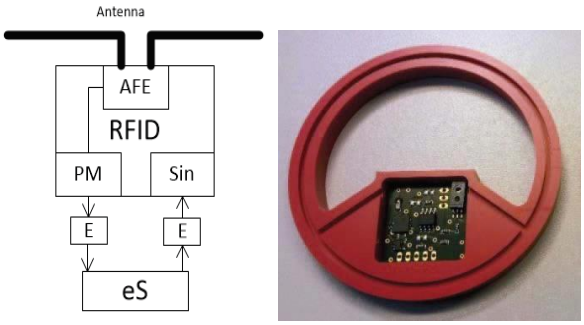

Figure (b) RFID sensor system scheme (left) and system design with circular HF antenna (right)

Long-term embedding in concrete additives calls for a completely sturdy design. Except implementation in passive form (without batteries), and for this reason sturdy encapsulation which resists durably in the aggressive concrete environment is vital. Investigations are executed, to pick out and optimize suitable materials.

III. INVESTIGATION OF THE TRANSMISSION CHARACTERISTICS

For systematic investigation of the transmission traits a research routine become installed and operated in analogous way for each dimension. At consistent frequency, an excitation signal is sent with increasing transmission electricity from 0 to 29 dBm. Once a backscattered signal from the RFID device can be acquired with the aid of the analysis tool, the characteristic parameters are recorded, e.g., the transmitted and backscattered electricity, and the sign phase. Parameter curves are decided by using sequentially repetition of this ordinary at stepwise varied frequencies (right here in 0.01 MHz steps). Additionally, a theoretical transmission variety can be calculated from the results. This lets in for comprehensive characterization of the structures transmission behaviour as a characteristic of frequency.

A number of test specimens had been assembled and prepared with RFID structures. Many kinds of concrete with different moisture characteristics were used. Specimens have been assembled for every concrete type, one geared up with RFID gadgets, one without, respectively. This gives a reference for, e.g., moisture content and lets in for simulation of larger installation intensity by means of placing the second one specimen on pinnacle of the prepared one.

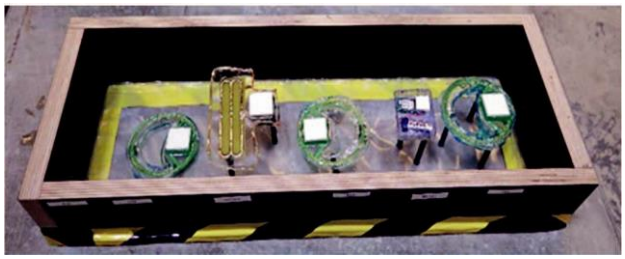

Figure (c) Test specimen with RFID systems before filling with concrete.

Set up depth (antenna in circle form), one UHF RFID sensor system (dipole antenna, 2nd from left), and a

Bluetooth low strength system (with battery, 2nd from right). The take a look at specimen have dimensions of fifty x 15 x 10 cm3. HF structures had been located with 3, 6 and 9 cm distance to the pinnacle floor.

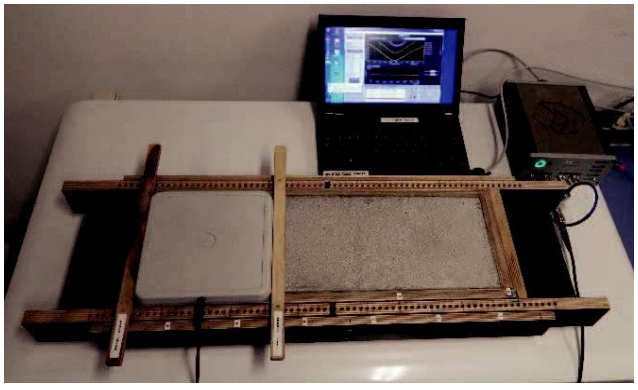

Figure (d) Measurement at test specimen with wooden

frame for fixed antenna positions of the RFID reader.

VI. RESULTS AND DISCUSSION

Parent five displays traditional consequences for the HF RFID structures. The transmitted electricity represents the minimal energy transmitted through the reader device, that's required to get hold of a reaction sign from the RFID transponder. Lowest values are accomplished at frequencies among 13.45 and thirteen.55 MHz. The set up intensity of thirteen cm is simulated by means of the usage of a 2d specimen on top, as defined in section 3. The corresponding reaction sign is near the energy restrict of 30 dBm and can be assumed as the maximal possible installation intensity for the implemented boundary conditions (device and antenna design, kind of concrete, moisture content material, and many others.

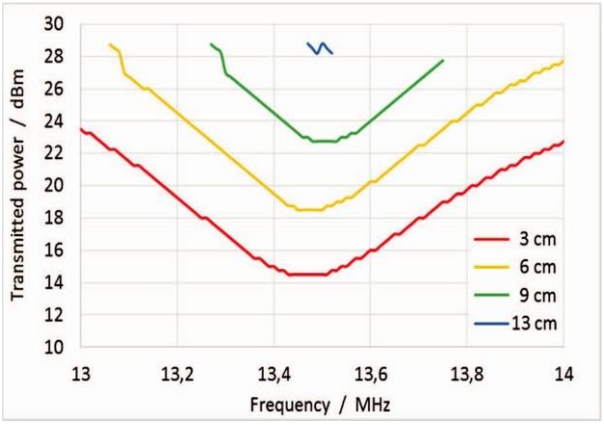

Figure (e) Exemplary results of HF measurements for RFID systems at different installation depth

All results of the HF measurements have superb reproducibility for straight away repeated measurements. An exemplary widespread deviation of 0.27 for sixteen measurements at

13.29 MHz was calculated. Measurements for RFID structures at the equal set up depth show excessive similarity, to this point (5 weeks after assembly), pretty independently from the concrete type and date of dimension.

An evaluation between consequences of HF and UHF measurements is displayed in parent 6. The minimal required transmitted power at most desirable frequency is plotted over the installation depth for measurements in any respect sorts of concrete and from all dates, to this point finished. HF consequences show a linear relation between required power and installation depth. on the grounds that UHF measurements are nevertheless underneath optimization concerning the orientation of the antenna and positioning of the reader, results need to be interpreted carefully. For RFID systems near the floor (three or 6 cm set up intensity), the HF communication seems to require less power, whereas UHF effects seem to suggest a weaker boom of required energy for increasing set up intensity. But, to ensure these findings, extra dependable measuring outcomes are wished.

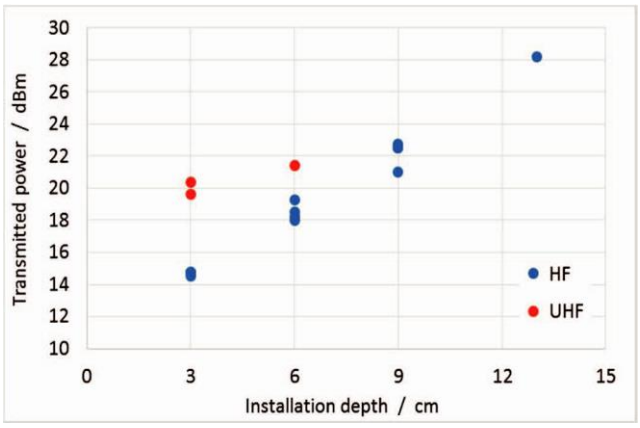

Figure (f) Comparison between the results of HF and UHF measurements.

V. CONCLUSIONS AND OUTLOOK

The paper presents a systematically approach to evaluate the potential of RFID-Sensor- Systems for embedding in concrete structures. To implement systems for long-term operation, which can be a couple of decades, a number of challenges have to be investigated. Beside resistant and long term reliable components and encapsulation, as well as a simple and robust design, the reliable communication to an external reader device under different ambient conditions must be ensured. The presented investigation method and first measuring results provide a promising approach. For a comprehensive study of relevant parameters, further measurements are necessary and currently running.

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