Development of Frontend Interface for Digital Calibration Certificate for AC High Current Source Parameters

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***Abstract* – CSIR-National Physical Laboratory, India an apex level body which provides calibration services to various secondary, tertiary calibration and testing labs and industries across the country. In general, calibration reports are commonly created in paper or word format to produce PDFs, which are time-consuming, tedious, and susceptible to human errors. Due to this several issues, BIPM- France is taking suitable goals to overcome this issue through the development of DCC. As globally leading NMIs like PTB, Germany, etc were working towards DCC developments, CSIR-NPL (NMI of India) takes part in DCC working group which are in-line with the leading NMIs. The main aim of this work is to create and implement a web application based on react.js to create digital calibration certificates. By deploying this solution, there will be substantial gains in data traceability, security, reliability, and accessibility. The project encompasses the creation of a Digital Calibration Certificate (DCC) platform that substitutes the conventional manual procedures with an automated, scalable system with the ability to produce structured and verifiable digital certificates. To further verify the authenticity and ease of validation, a model based on QR codes has been implemented that produces a unique, scannable code corresponding to a cloud-hosted copy of the certificate, permitting secure and instantaneous access. Also, advanced cryptographic algorithms like cryptographic hashing and PDF encryption are applied to secure the digital certificates and to ensure that the certificates remain tamper-proof and intact over their lifecycle. This end-to-end digital solution not only updates the laboratory's calibration report process but also establishes a new standard for secure, transparent, and effective calibration services.**

I. INTRODUCTION

CSIR-NPL, the NMI of India has a central role in ensuring the accuracy and consistency of measurements by hosting six of the seven SI base units: meter (m), kilogram (kg), kelvin (K), second (s), ampere (A), and candela (cd). It maintains traceability of measurements to the SI units through its comprehensive calibration services and thereby provides critical assistance to various industries, calibration and testing laboratories, and research institutions all over India and other SAARC nations. In spite of their critical significance to the business process, the standard practice of preparing calibration reports remains antiquated today—using paper-based records and manually generated PDF files. Not only are the conventional methods wasteful of precious time and efforts, but also prone to fallibility due to human errors. Such methods therefore risk compromising on the accuracy as well as credibility of calibration records. Moreover, these methods cannot meet the modern requirements of secured handling of data, traceability, and interfacing data between systems.

To overcome these limitations, this work proposes the design and development of a web-based application using React.js—a robust and modern JavaScript framework. The proposed platform aims to automate the creation of calibration certificates, thereby improving the real-time digital record management. By embracing digital transformation, this initiative aligns with the broader industry trend of automation and enhanced data-driven processes. For security and authenticity purposes, the system employs cryptographic hashing and QPDF to shield PDF certificates against unauthorized access and tampering. Also, a QR code generation system has also been developed with *Streamlit* and Python. After the calibration certificate is created, it is stored in a secure cloud storage platform (such as Google Drive), and a downloadable share link is generated. The link is then converted into a QR code, which is placed directly on the certificate. Users can scan the QR code to access or validate the certificate, allowing for immediate, secure, and traceable access from anywhere. This work creates a new platform in the field of calibration services, providing a scalable, secure, reliable and robust solution that enhances trust in digital calibration information and assists with the metrological traceability towards SI Units.

II. LITERATURE SURVEY

Researchers in [1] have developed a bilingual NIM-DCC [1, 2] metamodel based on the PTB-DCC metamodel [3]. They also have developed software for generating and validating NIM-DCC. The system had been deployed on a microservices architecture, supporting service scalability and coordinating development and operation. The system has different layers, multiple fields, clear interfaces and standardized transparency. The proposed methodology has been tested and applied in more than 10 laboratories of NIM and local metrology institutes

In [4], the problem of secure and authentic signing of official e-government documents using XML have been discussed. It suggests "authentic PDF" can be used as a solution. The authentic PDF technique has been used to satisfy key requirements like, classic visual looks, signature representation with authenticity, recreation of the electronic version from a printout etc. The authors in [5] explore the potential of using Convolutional Neural Networks (CNNs) for symmetric encryption. The authors implemented a CNN-based symmetric encryption scheme and compared its performance against the Advanced Encryption Standard (AES) using various file sizes and content. The comparison focused on execution time, memory usage, and processor load during encryption and decryption. While the paper acknowledges that the robustness of the CNN encryption against cryptanalytic attacks was not evaluated, the experimental results suggest that CNNs could be a viable option for symmetric cryptographic applications under the specific conditions tested.

This research in [6] addresses the increasing necessity of verifying authenticity, non-repudiation, and integrity of electronic documents, especially PDF documents. PHP has been used to create a web-based application that incorporates the RSA digital signature scheme with the SHA-3 hash value to securely sign and authenticate PDF documents. RSA, one of the most common public-key cryptographic methods, delivers digital signing functionality, and SHA-3 guarantees the integrity of the document by creating a distinctive digital fingerprint. The system has tried on PDF files of 6 KB and 23 MB sizes, and tested across principal web browsers—Google Chrome, Microsoft Edge, and Mozilla Firefox. The signing and verification times are average in all browsers but efficient and comparable, taking approximately 1.3309 seconds on Chrome, 1.2565 seconds on Edge, and 1.2667 seconds on Firefox.

The researchers in [7] present a novel image encryption model that combines a Convolutional Neural Network (CNN) with an intertwining logistic map to generate robust secret keys. This approach leverages the chaotic nature of the logistic map, influenced by initial conditions, control parameters, and CNN-derived keys, to produce diverse sequences for pixel scrambling and manipulation through permutation, DNA encoding, diffusion, and bit reversion. The model further enhances security by employing different subkeys, private keys, and public keys generated by the CNN, leading to a larger keyspace and improved confusion and diffusion. Extensive analysis against various attacks (cropping, noise, differential, statistical) and evaluations of key space, sensitivity, histogram, information entropy, and correlation coefficient demonstrate that the proposed method outperforms existing image encryption techniques. The results highlight significant improvements in information entropy, randomness, resistance to attacks, and overall efficiency, establishing the model as a more stable, secure, and reliable solution for image encryption. [7]

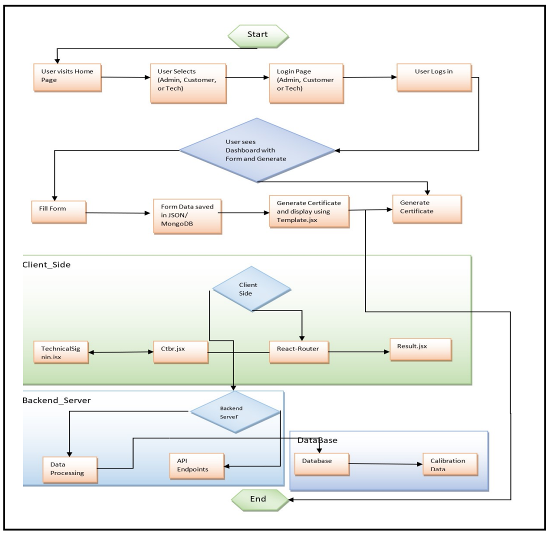
III. METHODOLOGY

The methodology outlines the structured approach used to design, develop, and implement the digital calibration certificate generation system. It follows a modular and web-based architecture, ensuring scalability, ease of access, and data security. The system is designed using React.js for the frontend and integrates secure mechanisms to validate and protect certificate data.

A. Overall Architecture: DCC

The Digital Calibration Certificate (DCC) system streamlines the process of generating and managing calibration certificates through a user-friendly web interface. The system begins with a clear and straightforward homepage featuring three primary navigation buttons: "Administration," "Technical," and "Customer." When users select the "Technical" button, they are directed to a secure sign-in page where they must enter their credentials to gain access to the technical functions. The overall architecture is shown in Fig. 1.

Fig. 1: Overall architecture of DCC



Upon successful login, users are redirected to the TechnicalCalibrationForm.jsx page. This form is crucial for submitting detailed technical information required for calibration. In addition to filling out the form, users must upload a file containing relevant data. Once the form and file are submitted, the system processes the information and navigates the user to the Result.jsx page.

The Result.jsx page presents all the entered data and the contents of the uploaded file in a comprehensive and organized manner. Users can review this information and download the results as a file, ensuring they have a complete and accessible record of the calibration details. This structured workflow not only enhances efficiency but also ensures accuracy and convenience in the calibration certification process.

The architecture of the Digital Calibration Certificate generation platform is designed to automate the certificate creation process by leveraging both manual form entry and bulk CSV uploads. The system is built with modular components, covering form initialization, data input, CSV parsing, form validation, PDF generation, and secure file handling. The flowchart of the work is given in Fig. 2.

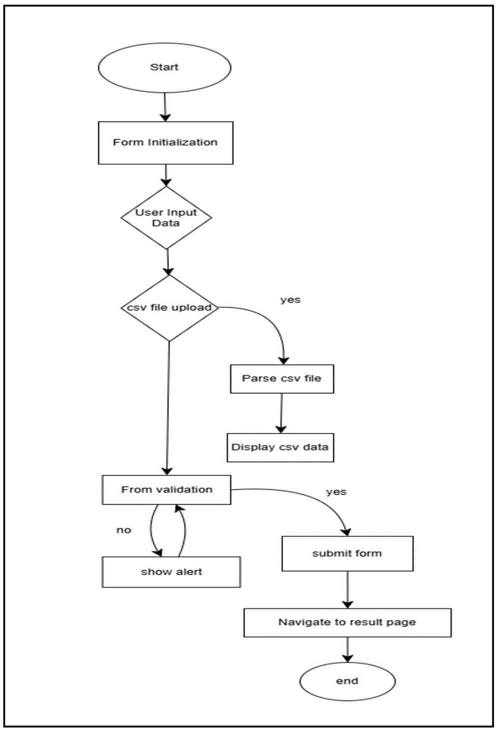


Fig. 2. Generation of DCC from user input to result

B. Architecture of Cryptography

Fig. 3 illustrates the overall workflow of the secure PDF generation and download process. It begins when the user initiates the download. The frontend captures the webpage, generates the PDF, embeds a unique hash for security, and sends it to the backend. The backend then signs and encrypts the PDF before returning it. Once received, a secure download link is generated for the user, completing the download process smoothly and securely.

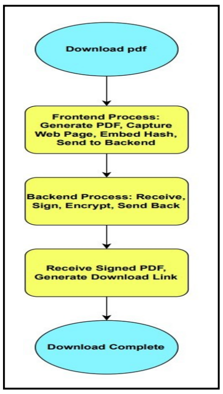

Download pdf
Frontend Process: Generate PDF, Capture Web Page, Embed Hash, Send to Backend
Backend Process: Receive, Sign, Encrypt, Send Back
Receive Signed PDF, Generate Download Link
Download Complete

Fig. 3. Flowchart for secure PDF generation.

C. Architecture for QR code generation

Figure 4 depicts the flowchart of QR code-based system used for secure digital access to calibration certificates. PDF generation and upload to a cloud storage solution like Google Drive is the starting point. A shareable link is generated and encoded as a QR code. This QR code is placed on the certificate so that users can scan and download or verify the certificate securely from any device. The flow provides both accessibility and document authenticity.

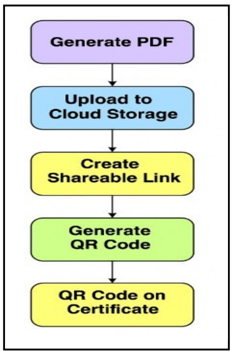


Fig. 4. Flow chart for QR code generation.

IV. DATA COLLECTION AND TECHNIQUES USED

For the generation of DCC, calibrations are performed on a Current Injection Test Set with inputs as 415Volts, A.C., 1 Phase, 50 Hz, and outputs are 0-3 Volts/5000Amperes, 0-6 Volts/2500 amperes, 0-12 Volts/1250Amperes and 0 - 415 Volts/60Amperes [8]. The test set was manufactured by Automatic Electric Ltd., Mumbai. For the measurements, standard environmental conditions, viz., temperature: (25 ± 2)^{0}C and relative humidity: (50 ± 10) %, are maintained. The calibrations are carried out by a comparison method using a standard Current Transformer (with associated uncertainty as ±0.0025%) along with a standard Digital Multimeter (with associated uncertainty as ±0.002% - ±0.07%). The results obtained as shown in Table 1.

Table 1: Calibration results of current injection test set

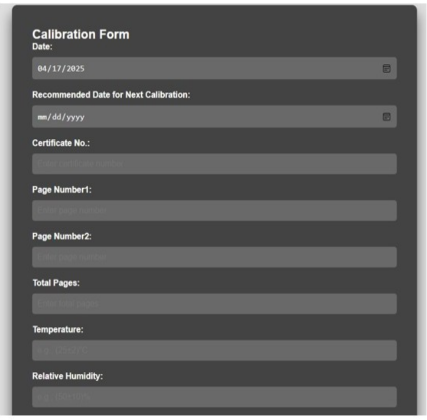
Indicated Value (A)	Measured Value (A)	Coverage Factor (k)	Expanded Uncertainty (%)
100	103.2	2	0.70
500	508.4	2	0.16
1000	1013.3	2.21	0.07
1500	1517.4	2.25	0.09
2000	2021.5	2	0.07
2500	2522.9	2	0.06
2500	2521.7	2	0.08
3000	3023.6	2.52	0.28
3500	3525.4	2.21	0.13
4000	4031.0	2.37	0.16
4500	4528.5	2.52	0.23

This data is used for the generation of DCC models. Data is initially received in .csv format then internally converted into JSON objects, for seamless processing across the frontend and backend systems. Before certificate generation, the system performs preprocessing steps such as parsing and validating the CSV structure, detecting missing or malformed values, standardizing formats (like dates and units), and preparing clean, consistent data for output [9]. To maintain data integrity, the system includes real-time validation rules during input, automatic error detection for uploaded files, and checks for duplicates or inconsistencies. Additionally, cryptographic hashes are embedded into the generated PDFs to ensure authenticity and prevent tampering.

For programming, JavaScript has been used as a primary language for both frontend and backend development due to its wide ecosystem and flexibility. React.js is used to build a responsive, component- based frontend that handles user input and displays the generated certificate technically similar to paper format. The vite.js is used to develop as a frontend build tool which enables fast development and real- time updates during coding. Node.js Facilitates backend logic, including request handling, data processing, and certificate generation. Also, express.js and MongoDB are used to store calibration data, user records, and metadata related to certificate generation. For the PDF security, QPDF and Hashings are used to generate a unique digital fingerprint for each certificate, verifying the integrity and detecting any changes made after generation [10-12]. The development environment includes Visual Studio Code, Node.js, npm, and Git on Windows/Linux systems.

V. RESULTS AND DISCUSSION

For the generation of digital certificates, different form pages are generated. The snapshots of the forms are given in Figs. 5 and 6. Finally the QR code based digital certificate for the data of Table 1 is given in Fig. 7.



Calibration Form

Date:

04/17/2025

Recommended Date for Next Calibration:

mm/dd/yyyy

Certificate No.:

Enter certificate number

Page Number1:

Enter page number

Page Number2:

Enter page number

Total Pages:

Enter total pages

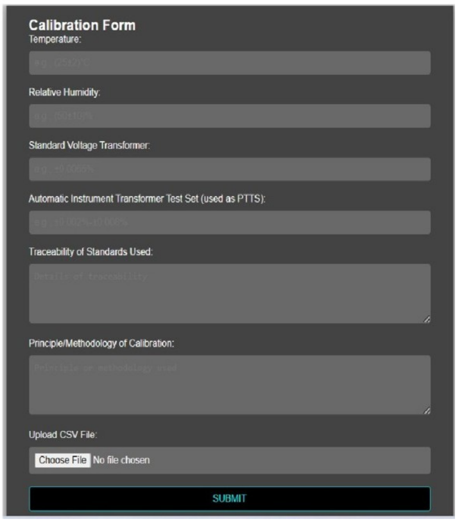
Temperature:

e.g., (25±2)°C

Relative Humidity:

e.g., (50±10)%

Fig. 5(a): Snapshot of the administration form



Calibration Form

Temperature:

e.g., (25±2)°C

Relative Humidity:

e.g., (50±10)%

Standard Voltage Transformer:

e.g., ±0.0065%

Automatic Instrument Transformer Test Set (used as PTTS):

e.g., ±0.002%-±0.008%

Traceability of Standards Used:

Details of traceability

Principle/Methodology of Calibration:

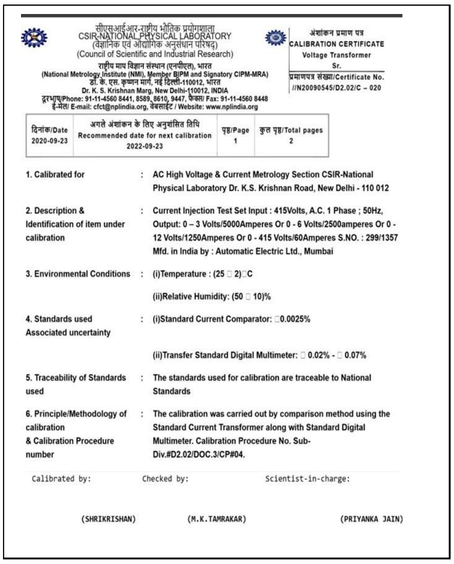
Principle or methodology used

Upload CSV File:

Choose File No file chosen

SUBMIT

Fig. 5(b). Snapshot of technical form



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अंशांकन प्रमाण पत्र
CALIBRATION CERTIFICATE
Voltage Transformer
Sr.
प्रमाणपत्र संख्या/Certificate No.
//N20090545/D2.02/C – 020

दिनांक/Date	अगले अंशांकन के लिए अनुशंसित तिथि Recommended date for next calibration	पृष्ठ/Page	कुल पृष्ठ/Total pages
2020-09-23	2022-09-23	1	2

1. Calibrated for : AC High Voltage & Current Metrology Section CSIR-National Physical Laboratory Dr. K.S. Krishnan Road, New Delhi - 110 012

2. Description & Identification of item under calibration : Current Injection Test Set Input : 415Volts, A.C. 1 Phase ; 50Hz, Output: 0 – 3 Volts/5000Amperes Or 0 - 6 Volts/2500amperes Or 0 - 12 Volts/1250Amperes Or 0 - 415 Volts/60Amperes S.NO. : 299/1357 Mfd. in India by : Automatic Electric Ltd., Mumbai

3. Environmental Conditions : (i)Temperature : (25 □ 2)□C

(ii)Relative Humidity: (50 □ 10)%

4. Standards used Associated uncertainty : (i)Standard Current Comparator: □0.0025%

(ii)Transfer Standard Digital Multimeter: □ 0.02% - □ 0.07%

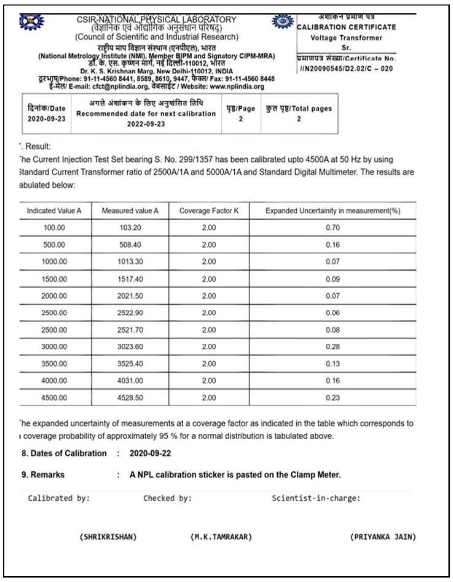
5. Traceability of Standards used : The standards used for calibration are traceable to National Standards

6. Principle/Methodology of calibration & Calibration Procedure number : The calibration was carried out by comparison method using the Standard Current Transformer along with Standard Digital Multimeter. Calibration Procedure No. Sub-Div.#D2.02/DOC.3/CP#04.

Calibrated by: Checked by: Scientist-in-charge:

(SHRIKRISHAN) (M.K.TAMRAKAR) (PRIYANKA JAIN)

Fig. 6(a). First page of DCC



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अंशांकन प्रमाण पत्र
CALIBRATION CERTIFICATE
Voltage Transformer
Sr.
प्रमाणपत्र संख्या/Certificate No.
//N20090545/D2.02/C – 020

दिनांक/Date	अगले अंशांकन के लिए अनुशंसित तिथि Recommended date for next calibration	पृष्ठ/Page	कुल पृष्ठ/Total pages
2020-09-23	2022-09-23	2	2

'. Result:

'he Current Injection Test Set bearing S. No. 299/1357 has been calibrated upto 4500A at 50 Hz by using Standard Current Transformer ratio of 2500A/1A and 5000A/1A and Standard Digital Multimeter. The results are abulated below:

Indicated Value A	Measured value A	Coverage Factor K	Expanded Uncertainity in measurement(%)
100.00	103.20	2.00	0.70
500.00	508.40	2.00	0.16
1000.00	1013.30	2.00	0.07
1500.00	1517.40	2.00	0.09
2000.00	2021.50	2.00	0.07
2500.00	2522.90	2.00	0.06
2500.00	2521.70	2.00	0.08
3000.00	3023.60	2.00	0.28
3500.00	3525.40	2.00	0.13
4000.00	4031.00	2.00	0.16
4500.00	4528.50	2.00	0.23

'he expanded uncertainty of measurements at a coverage factor as indicated in the table which corresponds to ı coverage probability of approximately 95 % for a normal distribution is tabulated above.

8. Dates of Calibration : 2020-09-22

9. Remarks : A NPL calibration sticker is pasted on the Clamp Meter.

Calibrated by: Checked by: Scientist-in-charge:

(SHRIKRISHAN) (M.K.TAMRAKAR) (PRIYANKA JAIN)

Fig. 6(b). Second page of the DCC

Fig. 6(c): QR code for the DCC

VI. CONCLUSION

The Digital Calibration Certificate (DCC) platform is a milestone in the process of modernizing calibration reporting at CSIR-NPL. The transition away from manual, paper-based documentation to a secure, automated web-based platform is a major improvement in obtaining more reliable digitized data, as well as improving efficiency and accessibility. Implementing cryptographic hashing and PDF protection on behalf of the DCC, users significantly enhance the integrity and security of the documents. Furthermore, leverages QR code technology that provides end-users with an efficient and expedient mechanism for authenticating and verifying certificates.

VII. ACKNOWLEDGMENT

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REFERENCES

[1] Hackel, S. Gustav, Härtig, Frank, Hornig, Julia, and W. Thomas, "The digital calibration certificate", PTB-Mitteilungen Vol. 127 2017, vol. Issue 4, p. 7, 2017, https://doi.org/10.7795/310.20170403

[2] "Digital Calibration Certificate – DCC", Apr. 14, 2021. https://www.ptb.de/cms/en/researchdevelopment/into-the-future-with-metrology/the-challengesof-digital-transformation/kernziel1einheitlichkeitim/digitalcalibration-certificate-dcc.html

[3] Xingchuang Xiong, Zilong Liu, Kan Kan, Yiwei Zhu, Wei Zhang, Xiang Fang, "Design and implementation of a digital calibration certificate web service system based on microservice architecture", Measurement: Sensors, vol. 38, 2025, https://doi.org/10.1016/j.measen.2024.101487

[4] T. Neubauer, E. Weippl and S. Biffl, "Digital signatures with familiar appearance for e-government documents: authentic PDF," First International Conference on Availability, Reliability and Security (ARES'06), Vienna, Austria, 2006, pp. 8 pp.-731, https://doi.org/10.1109/ARES.2006.54

[5] R. Forgáč and M. Očkay, "Contribution to Symmetric Cryptography by Convolutional Neural Networks," 2019 Communication and Information Technologies (KIT), Vysoke Tatry, Slovakia, 2019, pp. 1-6, https://doi.org/10.23919/KIT.2019.8883490

[6] A. Sharif, D. S. Ginting and A. D. Dias, "Securing the Integrity of PDF Files using RSA Digital Signature and SHA-3 Hash Function," 2021 International Conference on Data Science, Artificial Intelligence, and Business Analytics (DATABIA), Medan, Indonesia, 2021, pp. 154-159, https://doi.org/10.1109/DATABIA53375.2021.9650121

[7] K. Raghuvanshi, S. Kumar, S. Kumar, S. Kumar, “Image encryption algorithm based on DNA encoding and CNN, Expert Systems with Applications”, vol. 252, Part B, 2024, https://doi.org/10.1016/j.eswa.2024.124287

[8] H. Brom, L. Jol, G. Rietveld, E. So, “High-Current AC Current Transformer Calibration Using an Automated Sampling System”, Conference on Precision Electromagnetic Measurements, July 2012, https://doi.org/10.1109/CPEM.2012.6250697

[9] R. Campos, J. Carlos, Rico-Chagollán, Marianab, Chacón-Olivares, María del Carmenc and Guzmán-Hernández, Manuel Alejandro, “Frontend and Backend: The new approach to the development of a Web platform for automating the control and administration of degree processes at ITESI”, Journal of Computational Technologies, vol. 8, no. 21, pp. 1-9, 2024, https://doi.org/10.35429/JOCT.2024.8.21.2.9.

[10] A. Castiglione, A. Santis, C. Soriente, “Security and privacy issues in the Portable Document Format”, *Journal of Systems and Software,* vol. 83, no. 10, 2010, pp. 1813-1822, doi: https://doi.org/10.1016/j.jss.2010.04.062

[11] B. Khan, R. Olanrewaju, M. Morshidi, R. Mir, Laiha, B. Kiah, “Evolution and analysis of secured hash algorithm (SHA) family”, Malaysian Journal of Computer Science, Vol. 35 (3), 2022, pp. 179-200.

[12] S. Patra, M. Rani, “Evaluation and categorization of hashing algorithms based on their applications”, vol. 55, no. 3, pp. 540-552, 2025.