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Research Article

COMPARATIVE ANALYSIS OF PLASTIC CURRENCY-DEBIT AND CREDIT CARDS USING VSC®-8000/HS

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ABSTRACT

Comprehensive analysis of plastic currency used in India is done focusing on essential security features such as Micro printing, Ultra Violet (UV), Infrared (IR), and Fluorescence etc. The present evaluation involves credit and debit cards from major Indian banks like State Bank of India, Bank of Maharashtra, Punjab National Bank, and Federal Bank etc., utilizing advanced technology (VSC®-8000/HS) via diverse lighting and magnification settings. The examination revealed that these cards adhere to standard security protocols like Ultra-Violet, Hologram, Optical Variable Device (OVD), Card Verification Value (CVV), Transmitted Light (TL), Spot Light (SL), Spot Fluorescence light (SFL), among many. These features meet current standards, effectively safeguarding against counterfeiting and fraud. While the existing security measures are robust, potential enhancements such as incorporating IR features, fluorescence-based elements, security threads, 3D-silver foil patches, and advanced printing techniques could further augment the security of plastic currency in India.

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INTRODUCTION

Technological advancements in various fields have significantly transformed our daily lives, altering the way we interact with various objects. The practice of exchanging goods to acquire other items, commonly known as the barter system, predates the invention of money. Money simplified the process of buying and selling once introduced, but with ongoing developments and technological progress, the most advanced form of exchange today involves the use of plastic currency (Prime *et al.*, 2010).

The term "Plastic Currency" primarily refers to rigid plastic cards issued by banks or authorized entities, granting specific privileges to customers or users. These cards enable a range of functions, including making payments and gaining secure access to various services (Prime *et al.*, 2010, Gupta *et al.*, 2015). Plastic currency finds application in different contexts, describing a wide array of payment systems and technologies. Plastic currency serves as an alternative to physical cash or conventional money. Plastic currency is a general term encompassing various card types, such as bank cards, credit cards, and smart cards (Gupta *et al.*, 2015, Bozhkova *et al.*,

2017). The concept of plastic currency was introduced in the 1930s and has since become an indispensable form of currency. Citibank holds the distinction of being the first bank to introduce credit cards in India in 1991.

Types of Plastic Currency

1. Credit Cards

Credit cards are typically plastic cards issued to cardholders, featuring a predefined credit limit that enables the purchase of goods and services on credit or obtaining cash advances. Banks, in collaboration with companies like Visa, Mastercard, and Diners Club, issue credit cards following a thorough account holder verification process. Credit cards offer overdraft facilities, allowing customers to make purchases exceeding the balance in their accounts. Interest charges apply to the unpaid balance beyond the due date (Bozhkova *et al.*, 2017, Budhram, 2007). Cardholders have the option to settle the entire amount to avoid interest charges. Banks may also offer Equated Monthly Instalment (EMI) schemes for substantial purchases. Clearing and settlement amounts can be conveniently paid via credit cards, with banks playing a crucial role in this process (Bozhkova *et al.*, 2017, Budhram, 2007).

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Figure 1 Standard Indian Credit Card

2. Debit Cards

Debit cards are magnetically encoded plastic cards issued by banks, serving as a cash and check replacement. They eliminate the need for carrying physical currency when making purchases of goods and services. In many cases, debit cards are multipurpose, allowing cash withdrawals and account balance checks at different banks' ATMs, as well as facilitating online payments. Banks typically provide debit cards free of charge to savings or current account holders. Debit cards serve as an efficient online payment tool, deducting the purchase amount immediately from the customer's account and crediting it to the merchant's account, provided there are sufficient funds in the customer's account. This method offers speed and security, rendering traditional check-based payments obsolete (Budhram, 2007, Mercer, 2002)

Currently, debit card transactions are processed through two methods:

- A. Online debit (also known as PIN-based).
- B. Offline debit (also known as signature debit).

These methods cater to varying preferences and security requirements of cardholders.



Figure 2 Standard Indian Debit Card

3. Smart Card

A plastic card equipped with a computer chip that grants the holder the ability to make purchases, access restricted areas, retrieve medical, financial, or other data stored on the chip, or perform operations that rely on the chip's data. In India, Smart cards were introduced by the Bus Rapid Transit Services (BRTS) in Gujarat (Budhram, 2007, Mercer, 2002).

4. Charge Card

A charge card shares many similarities with credit cards. However, the key distinction lies in the requirement for the customer to settle the entire billing amount by a specified due date. Failing to do so may result in the customer being classified as a defaulter, often incurring substantial late payment fees (Mercer, 2002, Khangar&Dua, 2017).

5. ATM Cards

ATM cards are primarily used at Automatic Teller Machines (ATMs) for cash withdrawals, deposits, or fund transfers between accounts. To ensure security, customers must insert the card into an ATM and enter a Personal Identification Number (PIN) for authentication. The system verifies the account's balance before allowing any transactions (Barker *et al.*, 2008, Magdumet *al.*, 2021, Govindarajan *et al.*, 2012).

6. Amex Card

Amex, short for American Express, represents a well-known category of charge cards. These cards possess their own network of affiliated merchants and are not reliant on the MasterCard or Visa networks (Magdumet *al.*, 2021).

7. MasterCard and Visa

MasterCard and Visa are global non-profit organizations dedicated to fostering the expansion of the card industry worldwide. They have established extensive networks of partner merchant establishments in collaboration with numerous banks, enabling customers worldwide to utilize their credit cards for a wide range of purchases (Khangar&Dua, 2017).

8. RuPay Card

RuPay, India's pioneering global card payment network, boasts extensive acceptance at various establishments, including shops, ATMs, POS devices, and e-commerce platforms throughout the country. This highly secure network offers protection against phishing attempts, underlining its status as India's own solution for card-based payments, and it proudly distinguishes itself from international payment networks. RuPay aligns with the Reserve Bank of India's (RBI) vision to promote a 'less cash' economy (Mercer, 2002, Khangar&Dua, 2017, Barker *et al.*, 2008, Magdumet *al.*, 2021, Govindarajan *et al.*, 2012). This objective necessitated the transformation of Indian banks and financial institutions into tech-savvy entities capable of offering electronic payment solutions. The National Payments Corporation of India (NPCI) is responsible for overseeing RuPay as part of its broader role in managing retail payments in the country. The Payment and Settlement Systems Act of 2007 granted authority to the Reserve Bank of India (RBI) and the Indian Banks' Association (IBA) to establish a secure electronic payment and settlement system within India (Magdumet *al.*, 2021, Govindarajan *et al.*, 2012). RuPay cards are presently issued by over 1,100 banks, encompassing Public Sector Banks, Private Sector Banks, Regional Rural Banks, and Co-Operative Banks. Among the ten core promoter banks involved in RuPay are the State Bank of India, Punjab National Bank, Canara Bank, Bank of Baroda, Union Bank of India, Bank of India, ICICI Bank, HDFC Bank, Citibank N. A., and HSBC. As of now, 56 banks are stakeholders in NPCI (Khangar&Dua, 2017, Prime *et al.*, 2010, Barker *et al.*, 2008).

9. Store Card

Store cards are similar to credit cards in some ways, but they come with the drawback of high interest rates and limitations on where they can be used. In certain cases, these cards are only valid for purchases within the store brand that issued them.

Security Features on the Front of the Card

1. Hologram

Holograms consist of small metallic shapes containing laser-etched images on their surface. These images change in shape and color based on the viewing angle, making them challenging to counterfeit. The most prominent feature on a credit card's front is a three-dimensional hologram of a dove, typically located on the right side. When tilted, the hologram creates the illusion of movement in the dove's wingtips and changes color. Additionally, the last four digits of the embossed account number are integrated into the hologram. Genuine counterfeit holograms are exceedingly rare. In most counterfeit card instances, the hologram is not a genuine hologram but rather a look-alike that is "reflective" rather than "refractive." Authentic holograms are refractive, causing the items within them to appear to move, whereas reflective items are simply printed on reflective material. Forged holograms have included printed images produced using various materials and inks, with some employing plain foils or diffraction grating foils (Goyat & Singh, 2016, Amanze *et al.*, 2018, Thomas *et al.*, 2018).

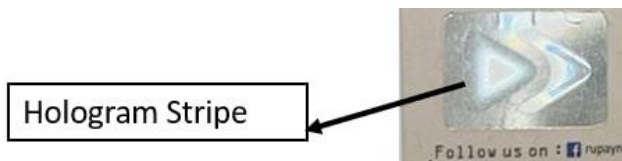


Figure 3 Depicting Hologram Stripe

2. Security Printing

Located in the upper right corner on the front side of all Visa cards is the Visa logo, surrounded by a security feature known as security printing or micro printing. This fine line printing, visible only under magnification, consists of a repeated alphanumeric sequence that provides specific identification and verification details, including product type and card printer information. Micro printing is extremely small, making it nearly impossible to copy or reproduce through technical means. Some attempts at forgery have involved carefully removing the fine line printing with a sharp razor blade and substituting it with new fine line printing or a similar imitation using special liquid glue. However, upon close inspection, solid lines can be detected, revealing the tampering (Magesh, 2017).

3. Ultraviolet Features

In the centre of the card's front, there is an ultraviolet security feature. Over a portion of the account number below the expiration date, you'll find the ultraviolet (UV) feature. When exposed to ultraviolet light, a fluorescent image of a dove becomes visible on the card's surface. This image is distinct from the one found in the hologram. Criminals rarely tamper with this security feature, and in many cases, they are unaware of its existence (Bozhkova *et al.*, 2017).

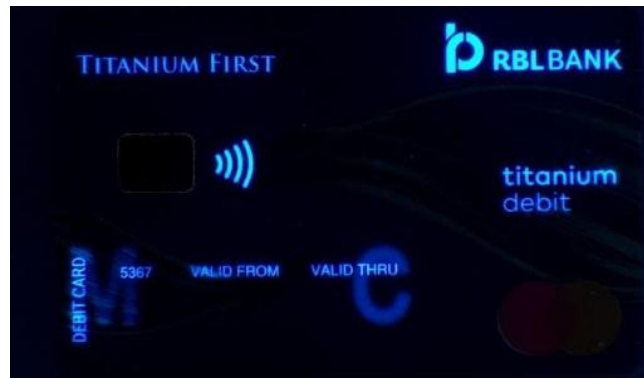


Figure 4 under UV light

4. Printed BIN

Another highly noticeable security feature is the printed BIN (Bank Identification Number) located below the first four digits of the account number. This four-digit printed number matches the initial four digits of the embossed account number. The printed BIN serves as the bank's identification number and can be found either above or below the start of the embossed account number. Criminals often employ a method called "shave and paste," involving careful removal of details using a sharp tool, such as a razor blade, and then attaching new details using special liquid adhesive (Liu *et al.*, 2010).

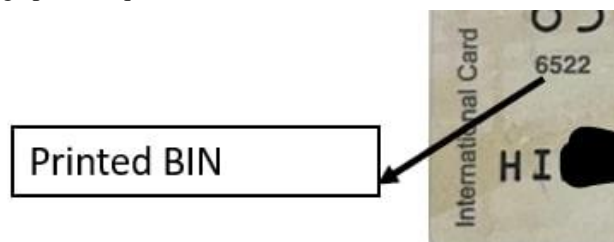


Figure 5 Depicting BIN

Security Features on the Back of the Cards

5. Magnetic Stripe

A magnetic stripe is a strip of magnetic tape affixed to the card's back, containing vital cardholder and account-related data. This stripe can hold approximately 130 characters or numbers and facilitates transaction processing when scanned at an electronic point of sale terminal. The information it carries includes the account number and expiration date, which must match the embossed details on the card's front. The use of non-standard stripes complicates the task of encoding information onto the magnetic stripe, making it challenging for counterfeiters. While it is technically feasible to remove and replace a magnetic stripe or re-record its data (including CVV), this process involves applying a stripe of magnetic ink on the card's back for data that can only be read by a magnetic reader (Thomas *et al.*, 2018).



Figure 6 Depicting Magnetic Stripe

6. Card Verification Value (CVV)

The Card Verification Value, often referred to as the CVV number, is a number calculated algorithmically and verified by the issuing bank during transactions conducted at electronic

point of sale terminals. This number is located on the back of the card. The CVV check enables the bank to confirm that the information matches that encoded on the genuine card's magnetic stripe. To combat the threat of encoded counterfeit cards, the industry initiated encoding unique information on the magnetic stripe of all valid cards. The CVV is derived from the account number, expiration date, and service code and is calculated accordingly (Gupta *et al.*, 2015), (Bozhkova *et al.*, 2017), (Budhram, 2007).

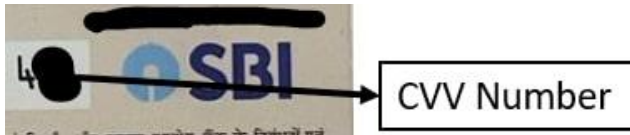


Figure 7 Depicting CVV number

7. Signature Panel

The signature panel on the card's back typically displays the word "Visa" in blue and gold at a 45-degree angle against a white background. If tampered with, the word "void" will become visible, indicating an attempt to remove a genuine signature. Upon receiving the card, the legitimate cardholder is required to sign the signature panel. All signature panels should feature a repetitive, colour design of either the "Visa" or "MasterCard" name. Any alterations to the signature panel, such as discoloration, painting, gluing, erasing, or covering with white tape, may signal fraudulent activity.



Figure 8 Depicting Signature Panel

Overall features present in the Debit and Credit Cards



Figure 9 Standard Indian Debit Card with Overall security features (Front side)



Figure 10 Standard Indian Debit Card with Overall security features (Back Side)

METHODOLOGY

In this study, Credit and Debit cards of different banks namely- State Bank of India (SBI), Bank of Maharashtra, Punjab National Bank (PNB), Federal Bank, DBS Bank, Axis Bank,

RBL Bank, and Union Bank were analysed using the Video Spectral Comparator 8000 (VSC®-8000/HS) by foster+freeman. The VSC®-8000/HS is an advanced non-destructive spectral analytical system that allows for the examination of various security documents, employing different light sources such as Poly light. Furthermore, the VSC can assist examiners in identifying additional characteristics like absorption, reflectance, fluorescence, and transmitted spectra. During the study, each Credit and Debit card sample was individually placed in the live-camera unit, and their images were captured using the Super Resolution Imaging (SRI) system, which utilizes a highly precise 12-megapixel camera within its optical system. Images of both the front and back sides of the cards were taken using white light. Subsequently, the samples were exposed to various illumination settings, including Side Light (SL), Oblique Light (OL), Transmitted Light (TL), UV-light (365 nm), Poly light, and Infrared light (780 nm), in the same manner for both sides of the cards. Following this, a detailed examination of various security features, such as Microprinting and Micro texting, was conducted one by one under similar viewing settings.

OBSERVATION

Debit Card

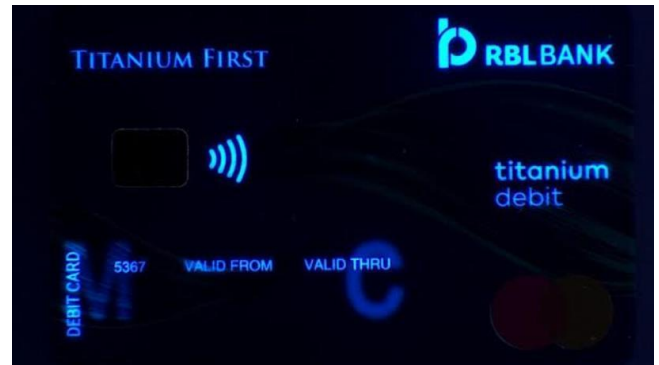


Figure 11 Under UV-312 nm

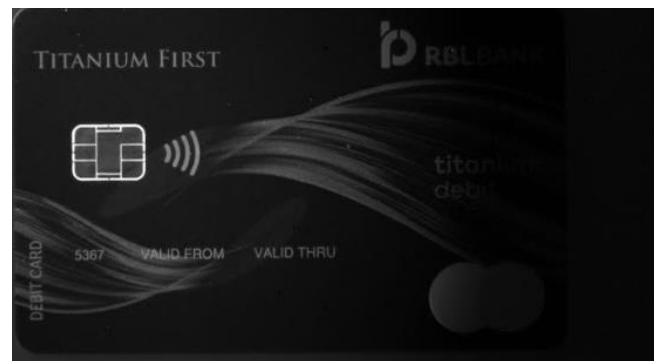


Figure 12 Under IR



Figure 13 Under UV-365 nm



Figure 14 Hologram under OVD-1



Figure 15 Hologram under OVD-2

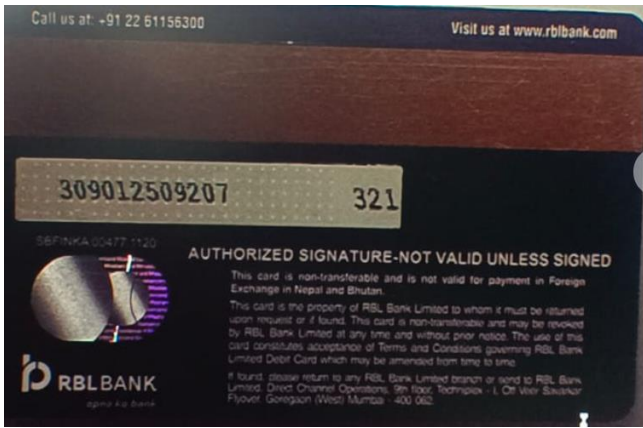


Figure 16 Hologram under OVD-3



Figure 17 Under UV-312 nm- Front



Figure 18 Under UV-254 nm- Front



Figure 19 Under UV-365 nm- Front



Figure 20 Under Spot Fluorescence- Front



Figure 21 Hologram under OVD-1- Back Front



Figure 22 Hologram under OVD-2- Back



Figure 23 Hologram under OVD-3- Back



Figure 24 Hologram under OVD-4- Back

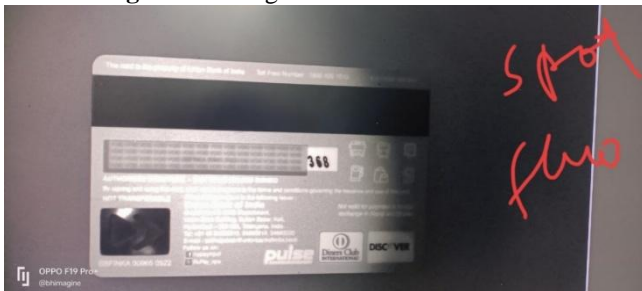


Figure 25 Under IR- Back

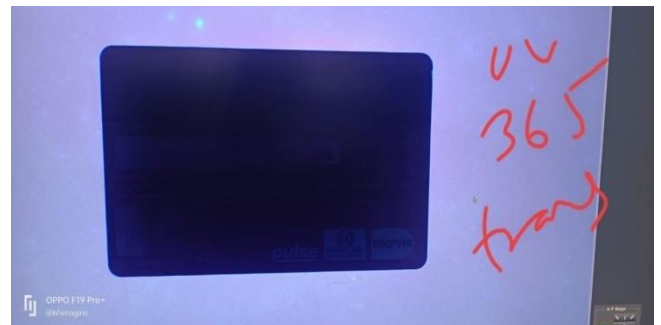


Figure 26 Under TL- Back



Figure 27 Under UV-Back- 312nm



Figure 28 Under UV- Back- 254nm

Table 1 Comparison of Debit and Credit cards of various Indian Banks

Security Features	State Bank of India (SBI)	Bank of Maharashtra	Punjab National Bank (PNB)	Federal Bank	DBS Bank	Axis Bank	RBL Bank	Union Bank
Ultra-violet	✓	✓	✓	✓	✓	✓	✓	✓
Infrared	✗	✗	✗	✗	✗	✗	✗	✗
Hologram	✓	✓	✓	✓	✓	✓	✓	✓
OVD-Hologram	✓	✓	✓	✓	✓	✓	✓	✓
CVV	✓	✓	✓	✓	✓	✓	✓	✓
Signature Panel	✓	✓	✓	✓	✓	✓	✓	✓
Magnetic Stripe	✓	✓	✓	✓	✓	✓	✓	✓
Printed BIN	✓	✓	✓	✓	✓	✓	✓	✓
Card Type	✓	✓	✓	✓	✓	✓	✓	✓
Bank Logo	✓	✓	✓	✓	✓	✓	✓	✓
Transmitted Light	✗	✗	✗	✗	✗	✗	✗	✗
Spot Light	✗	✗	✗	✗	✗	✗	✗	✗
Spot Fluorescence light	✗	✗	✗	✗	✗	✗	✗	✗
Magnetic Microchip	✓	✓	✓	✓	✓	✓	✓	✓
Name of the Card Holder	✓	✓	✓	✓	✓	✓	✓	✓
Valid From and Thru	✓	✓	✓	✓	✓	✓	✓	✓
Account Number	✓	✓	✓	✓	✓	✓	✓	✓



Figure 29 Under UV-365 nm Transmitted

DISCUSSION

As per the directives of the Payment Card Industry (PCI) Card and their Production Security requires every bank and the issuer of the cards must adhere to the guidelines of PCI Standards and RBI such as Master Direction – Credit and Debit Card – Issuance and Conduct Directions, 2022, Banking Regulation Act, 1949 and RBI Act, 1934 [17,18].

All of the samples that were analysed completely adhered to the security features and standards established by the PCI, a collaboration between Visa, MasterCard, American Express, and Discover.

- **UV features:**
Cards are produced utilizing the best inks and UV coatings, computer technology, and a range of spectacular fluorescent effects. They also incorporate cyber security measures. Under UV they projected glowing effect; areas like: Valid thru, Dates, card type, bank name and logo, some specific words like TITANIUM, M, C, etc. were observed with characteristic colour and fluorescent glow.
- **Backdrop design:**
Every bank has along with the time, use of technology and multiple software has produced their specific colour code, design, structure, pigments and coatings to be used on the background of the card. Different levels of cards have different and uniquely attractive finishing's, coatings and designs to provide a sense of personalization and customer specific effect.
- **Card information:**
By making it more difficult to copy, the embossed, thick, raised account numbers, issuance and expiration dates, and personal data running along the bottom of the card acts as a security feature.
- **Under IR:**
Nothing much was observed with IR effect, magnetic stripe and contact-Wi-Fi symbol was seemed to produce a little glitter-silvery glow under the light.
- **OVD Lights:**
Multiple variety of OVD lights were shone on the cards, the hologram patch observed producing multiple coloured variant effect. VSC hashorizontal: 31 LEDs and vertical: 9 LEDs. The visualization of Optically Variable Inks (OVI); both vertical and horizontal allows the scanning of Diffractive Optically-Variable Devices/Holograms.

The secondary security aspects identified are as follows

- **Micro printing:** No micro printing is observed on credit and debit cards.

- **Fibre that glows:** Under UV light, fluorescent yellow fibre can be seen in the lower right corner
- **Fluorescent ink:** On the bottom of the cards, a concealed letter "M" and "C" abbreviation for Master Card may be seen in blue fluorescence when exposed to UV light.

CONCLUSION

Based on an overall analysis of all security features examined using forensic and computerized technology, it was found that electronic transaction cards, which serve as the nation's primary form of identification and authentication in contact or contactless payments or transactions, are highly secure documents with a variety of security features, such as micro printing, a unique magnetic stripe, visible and invisible holograms. These features are difficult to replicate precisely, and their counterfeiting can be detected using this particular non-destructive technique.

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