The golden harmony of Fibonacci
Striking a fine balance in banknote design

by Anton Bleikolm

With the introduction of a multitude of technological innovations in the banknote industry over the past decade, many banknote designs of our time tend to emphasise functionality and printability, whilst giving artistic considerations secondary importance. While a banknote is an industrial product fulfilling the fundamental function as a means of payment, it is also perceived as the symbol of a nation and is closely linked to the daily life of its people. Anton Bleikolm explains how a banknote specimen based on the Fibonacci sequence aims to explore the design possibilities in an attempt to reach for coherence and harmony in banknote design through a balanced structural and thematic approach.

A banknote specimen built on Fibonacci principles
It is important that a banknote design evokes emotions and is loved by the people while at the same time fulfilling a complex set of functionalities required for all target users including central banks, commercial banks, cash handling professionals and automated systems. It is amid these parameters that the Fibonacci Project has been undertaken by the Swiss company SICPA - an exploration of the creative design possibilities during the integration of modern banknote technologies for an efficient cash cycle.

In creating a new banknote specimen incorporating the latest ink-based security technologies (see figures 1 and 2), the company has tried to strike a fine balance among the various parameters of banknote design:
• a universal theme which resonates with different cultures;
• an effective and structural integration of banknote technologies;
• an artistic and thematic integration of banknote technologies;
• printability on an industrial scale;
• functionality, security, aesthetics and durability throughout the banknote lifecycle.

Fundamental banknote parameters
The successful exploration of banknote design implies a realistic understanding of four fundamental banknote parameters: functionality, security, aesthetics and durability. The goal was to explore the design possibilities in an attempt to reach for coherence and harmony in banknote design through a balanced structural and thematic approach.

The theme was selected with the Zürich-based designer Alexander Fellmann and elaborated around Fibonacci and the theory of the Fibonacci sequence (see box 1 and figure 3). The idea of developing a banknote specimen based on this theme was to aim for a harmonious integration of security technologies, and to reach for an aesthetic and functional balance.

Capturing the essence of the Fibonacci concept, recreating the universal harmony within a banknote framework, and technically and aesthetically translating it to printable reality proved a challenge. It also was not easy to integrate current and new banknote security technologies in a creative and artistic way while ensuring the functionality of the security features and the printability and durability of the designed specimen. By letting the designer work closely with SICPA’s Design & Integration and Technical specialists and the origination team at Orell Füssli Security Printing Ltd, it was anticipated from the conceptual stage on, how the design would impact on the functionality of the security features and the printability of the specimen, as well as to explore creative solutions within the given technological and industrial context. This understanding and close working relationship among designer, security provider and security printer proved to be the vital link to a successful production of an effective and emotionally enticing banknote specimen.

Artistic integration of security features
Various themes relating to Fibonacci observations and theories are thematically and artistically integrated in the security solutions in the Fibonacci specimen.
The Fibonacci sequence
Among the many works and contribution of Leonardo Fibonacci, the Tuscan mathematician is known in modern days for his ‘Fibonacci numbers’ - a sequence defined by a recurrence relation $F_n = F_{n-1} + F_{n-2}$ (the first two terms are 1 and each subsequent term is the sum of the preceding two terms. Thus, the third term is calculated by adding the first and second numbers while the fourth term is the sum of the second and third numbers). The Fibonacci series is infinite and shows constant growth: 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377…

Fibonacci discovered that the relationship between two consecutive terms represents a ratio with a constant value: 1.618 or Phi, which has been known since ancient times by the Egyptians and the Greeks. This golden ratio is believed to be the underlying principle of divine proportion. According to Fibonacci, the golden spiral and the golden rectangle that derive from the series are a reflection of universal harmony. This aesthetic proportion can be observed in many creations of nature, such as a starfish, daisy, head of sunflower, pine cone and nautilus shell.

Creative minds in different fields and in different eras have been inspired by the Fibonacci series and the golden ratio when creating structure and balance in their works. Today we can observe these inspirations in the domain of art, architecture, music, poetry, and product designs.

Visual authentication: SPARK®
Since public security features must enable the general public to reliably distinguish between a genuine banknote and a fake within a fraction of a second, they should be highly visible and visually attractive. Overt features are there for first line inspection and should be easy to use, yet complex and technologically advanced enough to deter counterfeiting. The SPARK® feature (see figure 4) has been integrated on the front side of the note as a main public feature for immediate recognition. It is an easily detectable overt feature, as the dramatic colour-shift and dynamic light effects can be easily observed when the specimen is tilted.

Three options have been studied in the integration of the SPARK® feature:
1. a cluster of Fibonacci numbers (1, 2, 3, 5, 8);
2. a golden spiral;
3. a series of pentagrams.

Each of the three design options is highlighted with generic or creative effects to bring out the thematic message while enhancing the visibility of the overt feature.

Tactile and visual authentication: Intaglio
An intaglio print is characterised by fine lines and colour intensity due to the high ink deposit transferred from a finely incised intaglio plate. This printing technique brings life and elegance to vivid portraits and principal design elements.

Intaglio printing and the resulting thick ink layers give banknotes the unique tactility universally recognised...
as the 'banknote feel', allowing anyone to intuitively recognise a genuine.

On the front side of the specimen, the portrait of the mathematician Fibonacci, his name and years, the outlines of a violin (figure 5), the microtext and the latent image are intaglio-printed. On the reverse of the specimen, the intaglio elements include a colour-shifting pine cone printed with a gold to green colour-shifting OVI®, pentagrams in various violet and blue tones printed with a single multitone intaglio ink, and most importantly, the enhanced infrared and magnetic features printed with clean-coloured intaglio inks.

Advantages of having intaglio on both sides are threefold:
1. It improves the durability of banknotes due to the double calendering effect achieved through the high-pressure printing technique.
2. Intaglio is a carrier of additional security features which enhances counterfeit resilience to an unprecedented level.
3. Double-sided intaglio also allows banknotes and feature functionalities to stay clean and effective over an extended lifecycle.

**Machine authentication: enhanced IR and magnetic technologies**

On the reverse of the Fibonacci specimen, the two innovative and complementary machine readable features are integrated in unconventional clean colours. The turquoise conch and surrounding area are IR-absorbing while the magnetic nautilus (figure 6), the letters 'Fibonacci' and the horizontal bars are in raspberry red. It is virtually impossible to reproduce the visible colours, specific IR absorption and magnetic response using conventional IR and magnetic inks. Both through the IR-absorbing area and the magnetic technologies, designers are provided with a wide spectrum of colour choices while reinforcing the counterfeit resilience of the banknote.

**Conclusion**

During the Fibonacci specimen development, a number of design flexibilities have been explored. These creative options have been integrated and printed to demonstrate industrial printability and feature functionality. Based on the four banknote design criteria - functionality, security, aesthetics and durability - the following observations can be made:

- The overt security features SPARK® and OVI® can
be integrated to increase the thematic coherence of the banknote design while enhancing the security functionality.

- Intaglio is both a high-security feature in itself while acting as an effective and durable carrier of machine readable solutions. Double-sided intaglio can ease the constraints of limited space since machine readable features can be integrated on the reverse side of the note.

- The innovative machine readable IR and magnetic features contribute to both design freedom and security concerns. The choice of clean shades brings ultimate security as conventional IR-absorbing and magnetic materials are dark in colour.

- Through an optimal use of banknote space, a multitude of security features can be efficiently integrated to create a coherent theme and harmonious unity.

- The banknote design can fulfill symbolic, emotional and functional parameters when security elements and design elements are artfully integrated.

- The banknote designer’s understanding of security and printing parameters at the conception stage has a fundamental and crucial impact on the functionality and printability of the banknote.

- The success of the banknote development process lies in the close communication between designer, security provider and security printer.

- A successful banknote is the result of good teamwork among designer, security providers, software developers, origination and design technicians, engravers and printers.

The designer of the Fibonacci specimen concluded that a beautiful banknote design which does not provide security functions and cannot be printed at industrial scale is not a successful design. The definition of good banknote design is an overall aesthetic balance, the artful integration of security elements, and printability - the artistic essence needs to be translated into technological language and be industrially viable.

**Figure 4**
SPARK®, a technologically advanced optical feature for frontline banknote protection. SPARK® can be integrated in various designs and styles. In the Fibonacci specimen, this overt feature is integrated in three graphic variants: a cluster of numbers from the Fibonacci sequence, a series of pentagrams, or a spiral motif.

**Figure 5 (left)**
A zoomed image of intaglio fine lines overprinted on SPARK®

**Figure 6 (right)**
The nautilus is a magnetic feature based on enhanced magnetic technology.