The Evolution in Manufacturing Techniques to Produce Reliable Dual Interface Smartcards

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**Goals**

- Map the evolution of manufacturing Dual Interface (DIF) Smartcards.
- Reference some significant patents over the past 25 years.
- Focus on inductive coupling techniques for DIF cards.
- Discuss integration of DIF into metal card bodies.

**Search Engines:**

- [www.google.com/patents/](http://www.google.com/patents/)
Introduction

- Dual Interface (DIF) or CombiCard Technology started in the late Eighties with an invention from Hans-Diedrich Kreft of Angewandte Digital Elektronik GmbH.


- Inductive coupling Technology for chip cards can be attributed to Johannes Harm Lukas and Hogen Esch of Nedap for their invention in 1991 (refer to NL 9 100 347).

A chip card capable of selectively transmitting data via contacts or transmission coils. The card includes a switching element device, preferably a multiplexer, coupled between a semiconductor device and contacts in a contact field and transmission coils. A voltage transmitted via the coils can be operative to automatically set the multiplexer for transmission via the coils.
There is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success than to take the lead in the introduction of a new order of things

Machiavelli
Four Manufacturing Processes to Produce Dual Interface Smartcards were developed and patented by the Pioneers over the past 25 years:

- Stand alone DIF Transponder Chip Modules
- Hard-wired connection between an in-card wire embedded antenna and a contact chip module
- Flexible conductive adhesive making an electrical connection between in-card chemical etched, printed or wire embedded antenna and a contact chip module
- Inductive coupling between an antenna chip module and an in-card booster antenna

Pioneers

- Mühlbauer and Oberthur Technologies led the way with flexible connective adhesive to electrically connect the chip module to the in-card antenna
- In the early days Siemens and PAV were the front runners on inductive coupling
• “...a combination chip module for transmission of electrical signals or data with or without contact to an external read-write station

• “...The circuits are connected, via connecting terminals (6), a) to one or more couplers of an interface circuit which is either separate or in integrated form and provided in the chip module (1), which interface circuit enables contactless bidirectional data communication between the chip module (1) and the external read-write station,
Abstract: Antenna for the Plug-in Dual Interface Smart Card

- An antenna for the non-contact interface of a plug-in dual-interface smart card,
- Pins 4 & 8 reserved, provides path for antenna access
- Pins on module connected to leads on antenna, then module glue to substrate

Interesting Point:
- Idea originally designed for modifying a phone for mobile payment applications
Flexible Conductive Adhesive in DIF Smartcards

**Abstract:** Hybrid Chip Card Capable of both Contact and Contact-Free Operation

**Key Points:**

- A **hybrid chip card** comprising: an electronic module having an IC chip, contact pads connected to said IC chip for a contact-using operation of said card, and first and second contact zones;

- A card body, the card body having a **cavity** formed therein for holding the electronic module, and the cavity opening out on a face of the card body for receiving the electronic module;

- An antenna, the antenna having first and second contacts situated in the **cavity**, and the antenna being connected to said first and second contact zones of said electronic module via the first and second contacts.
### Key Points:

- A method for producing a card-shaped data carrier comprising the steps of providing a chip module (2) having an integrated circuit (10), and

- A card body (1) in which an antenna (3) is embedded at least partly; and

- Exposing terminals (4) of the antenna (3) by **removing superjacent card material**, and **removing material forming the terminals (4)** to **produce a bevel** on the terminals

- Wherein exposed terminals (4) are connected with the chip module (2) by means of a **conductive adhesive (7)**
Flexible Conductive Adhesive in DIF Smartcards

Ref. US 6,467,692  Assignee: G&D  Status: Active  Expiration date: Feb. 2017
In a data carrier configuration having predetermined dimensions, the improvement comprising:

• A semiconductor chip having given dimensions;
• A first conductor loop connected to said semiconductor...
• At least one second conductor loop having at least one winding...
• ...third loop inductively coupling said first conductor loop and said at least one second conductor loop to one another; and

**Abstract: Contactless Chip Card**

In a data carrier configuration having predetermined dimensions, the improvement comprising:

• A semiconductor chip having given dimensions;
• A first conductor loop connected to said semiconductor...
A connecting arrangement for producing a chip card comprising:

- A module having a semiconductor chip and a card carrier with an opening for receiving the module, characterized in that formed with
- The module is a first coil which is electrically connected to terminals of the semiconductor chip, and that formed with
- The card carrier is a second coil, wherein after insertion of the module into the opening an inductive coupling results and that in addition
- There is an electrical connection to a third coil provided in the card carrier for wireless interconnecting with the surroundings
A smart card having both a function of a contact and a function of a non-contact, the smart card comprising an IC module and an antenna element

Said IC module comprises an IC chip incorporating a contact transmission function and a non-contact transmission function, and a module substrate having an external terminal serving as a contact transmission element and a first coupler coil.

Said antenna element comprises an antenna for performing at least one of power reception and signal transmission/reception with an external read/write apparatus, and a second coupler coil connected to said antenna, and

Said first coupler coil of said IC module and said second coupler coil of said antenna element for non-contact transmission are disposed to be closely coupled to each other, and said IC module and said antenna element are coupled in a non-contact manner by transformer coupling
A coupling device is formed by a continuous conductive path having a central section and two extremity sections, the central section forming at least a small spiral for inductive coupling with the transponder device, the extremities sections forming each one large spiral for inductive coupling with the reader device, wherein the small spiral shows a larger pitch than the ones of the large spirals, and wherein the two extremities of the continuous path are loose such that the coupling device forms an open circuit. The pitches of the large spirals are chosen such as that the inter-turn stray capacitances is important and that the large spirals have mainly a capacitive behavior. And the pitch of the small spiral is chosen such as that the inter-turn stray capacitances are negligible, and that the small spiral has mainly an inductive behavior.

**Key Claims:**

A coupling device for coupling a transponder device comprising a transponder antenna connected to a transponder chip with a reader device, the coupling device comprising:

- A continuous conductive path having a central section and two external sections, the central section forming at least a small spiral configured to inductively couple the coupling device with the transponder device,
- The external sections each forming one large spiral configured to inductively couple the coupling device with the reader device, wherein
- The small spiral of the central section shows a larger pitch than the pitches of the large spirals of the external sections, and wherein
- Two extremities of the continuous path are loose, such that the coupling device forms an open circuit
A portable electronic device comprising a supporting member receiving on one side conductive contact lands or tracks extending substantially as far as the edge of the side and connecting an electronic microcircuit, the conductive contact lands or tracks comprising a plurality of perforations. **The device is noteworthy in that the interior of the perforations is free, or intended to be kept free, of metal.**
Current Manufacturing Trends

- **Inductive Coupling:** This technology may replace the use of conductive adhesive for the antenna interconnections in the construction of DIF smartcards especially in North America.

- **Hard-wired Connected DIF Smartcards:** Finding the wire ends of an embedded antenna in a card body is still the preferred solution in certain countries.

With a Growing Contactless Payment Infrastructure – Reliability will be Paramount
Antenna Chip Module

An antenna chip module requires a booster antenna in order to communicate with a point of sale terminal at 4 cm, as stipulated by the EMV standard.

Antenna Chip Modules on 35 mm glass epoxy tape come in two sizes: ISO standard 6 or 8 contact pads.
**Implementation - Hard-Wired Connection**

**Former KBC Smart Card Solutions**

**Location:** Originally in Seoul, Korea

**DIF Product Technology:** Solder connection antenna to the module termination points

**Pros**

- Embedded wire antenna provides for passive communication with a reader
- Soldered connections provide reliable interconnections to the chip module

**Some Facts**

- Semi-automated process

Enlarged view showing soldered interconnection of antenna to module
**Implementation - Hard-Wired Connection**

**Smartrac**

**Location:** Bangkok Thailand

**DIF Technology:** Soldered Connection between module and in-card antenna

**Pioneer:** OTI unveiled its “Hera” Process at Cartes in 2007

**Pros**
Embedded wire antenna
Soldered connection provides reliable interconnect

**Some Facts**
6 soldered connections in total
Production throughput – 1200 cards per hour
Production line machine to make the physical interconnections
Implementation - Flexible Conductive Adhesive

Mühlbauer Flex-Bump

Location: Roding, Germany

DIF Technology: Conductive Polymer Connection between module and in-card antenna

Pros (from Mühlbauer website)
- Patented Process
- Proven Technology
- Cost-efficient turnkey solution
- Complete Technology & know-how Transfer

Some Facts
- Production throughput ~1200 cards per hour
- Second milling operation required to expose antenna termination points
- Requires added equipment and materials
Implementation - Inductive Coupling

SPS – Toppan Printing

**Location:** Rousset, France

**DIF Technology:** Inductive Coupling

**Pros** (from SPS website)
- High reliability – 25 times ISO 10373 (bend & torsion)
- High throughput & yield – up to 5,000 per hour
- No Additional Equipment
- 5 line embossing
- DIF card manufacturing made easy

**Some Facts**
- Etched Al inlay on PET requires capacitor tuning
- PET inlay requires adhesive layer for card assembly
- Etched IC antenna module available in 8-contact footprint
- Productions measures to collate
Implementation - Inductive Coupling

Infineon Technologies

Location: Neubiberg, Germany

DIF Technology: Inductive Coupling

Pros (from Infineon website)

High Yield at card production
Simplified card manufacturing process & logistics
Reduced total cost of ownership - no additional equipment required
20% thinner module – better card backside appearance
Improved reliability & corrosion resistance
Card antenna inlay specifically tuned to meet the Coil on Module requirements according to ISO 14443 and EMVCo 2.0.1

Some Facts

Antenna module is packaged using Flip Chip technology on PET
Module antenna is etched Cu in 8-contact footprint
Wire Embedded Booster Antenna Arrays

Sonotrode – Wire Embedding Head with Pressure and Power Profiling

US 8,474,726 - AmaTech Booster Antenna
Ultrasonic Wire Embedding Technology supports a variety of card compatible materials:
- PVC
- PET-G
- Polycarbonate
- Teslin
- Tritan

Illustrated is an insulated copper wire embedded into a synthetic material.
Infineon Antenna Inlay

As an alternative to chemical etched antennas, Infineon proposes wire embedded antenna which are comparable with most card body materials.

*US 2013/0146671 Patent Pending - Infineon Booster Antenna*
An RF proximity financial transaction card, comprising:

- An integrated circuit carried by said inlay storing card-specific data;
- An antenna carried by said inlay that is operatively connected to said integrated circuit;
- A metallic foil layer having a peripheral edge that is substantially coextensive with said continuous peripheral edge of said plastic inlay,
- Printed graphics or text on or above said metallic foil layer
- Said card being constructed to inductively couple with an RF proximity card reader that is spaced from said card in order to support limited-range wireless communication between the card and the card reader up to a maximum coupling distance, beyond which said card will not couple.
DI Metal Hybrid Cards

- Solid metal front with polymeric back
- Full Dual Interface Capability
- Inductive Coupling Technology
- EMVCo & China Union Pay Compatible
- Similar Decorative features to traditional Metal Hybrid Card
- 17.5 Gram weight
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