ATTACHMENT J.

- THEORY of OPERATION -

Theory of Operation

The MFRC531 is member of a family of highly integrated reader Ics for contactless communication based on 13.56MHz. The MFrc531 Supports all layers of ISO 14443. Figure 1 shows a simplified blockdiagram.

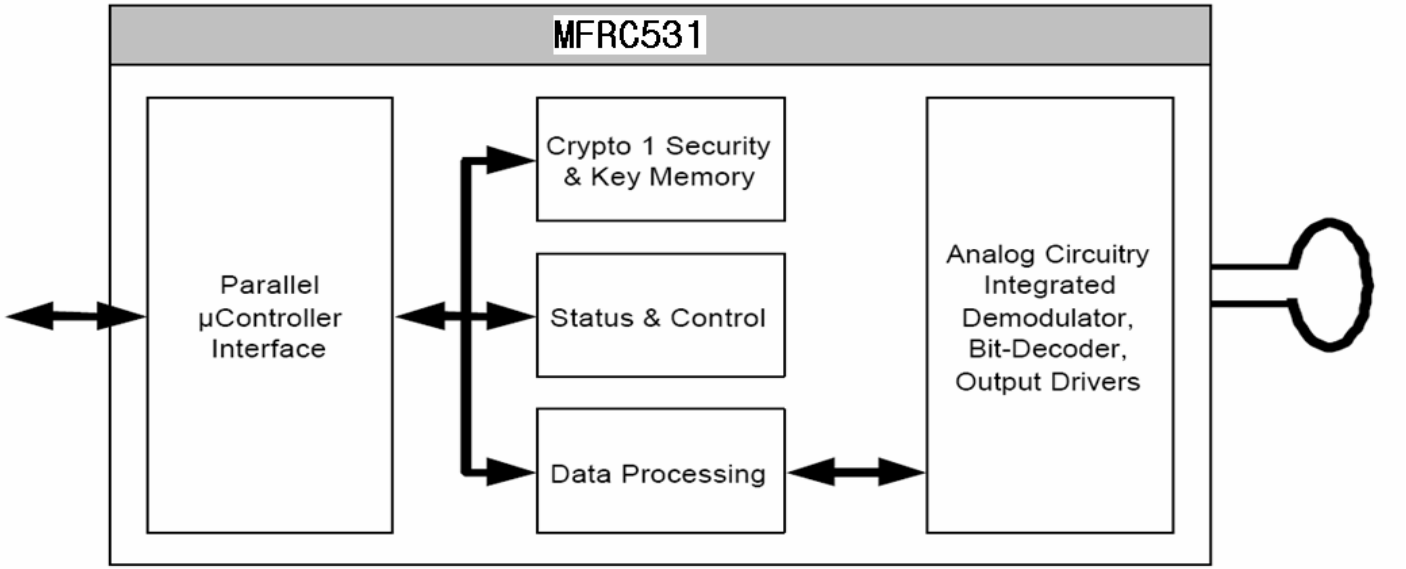


Figure1 : Simplified MFRC531 Block Diagram

-The parallel u-Controller interface detects automatically the connected 8bit parallel interface

-The data procesing part performs the parallel to serial conversion of the data.It supports the framing generation check.the CRC/Parity generation and check as well as the bit coding and processing. All layers of ISO14443-A are supported,as the MFRC531 operates in transparent mode.

-The status amd control part allows the configuration of the device to environmental influences to achieve the best performance for each application.

-The Cryto1 stream cipher unit is implemented to support communication to MIFARE CLASSIC products

-A secure non-volatile key memory is included to store Crypto 1 key-sets.

-The analog part includes two internal bridge driver outputs to achieve an operating distance up to 100m depending on the antenna coil and environmental influences.Futhermore,the internal receiving part allows the receiving and decoding of data without external filtering.

7.1 RF Interface

The MIFARE technology describes an ISO 14443-Type A compliant RF interface for a communication between a reader and a contactless card.

Overview MIFARE RF Interface

- Energy transmission : Transformer principle; MIFARE card is passive

-Operating frequency : 13.56MHz

- Communication structure : Half duplex,reader talks first

-Data rate : 105.6KHz

-Data transmission : Both directions

RWD → Card : 100%ASK,Miller coded

Card → RWD : subcarrier load modulation,subcarrier frequency 847.5KHz,OOK,Manchester Code

7.2 Energy Transmission

The energy transmission between the reader antenna and passive PICC is based on the transformer principle.At PCD side an antenna coil is required as well as a card coil implemented in the MIFARE card Figure 2 shows the basic principle and the equivalent electronic circuitry.

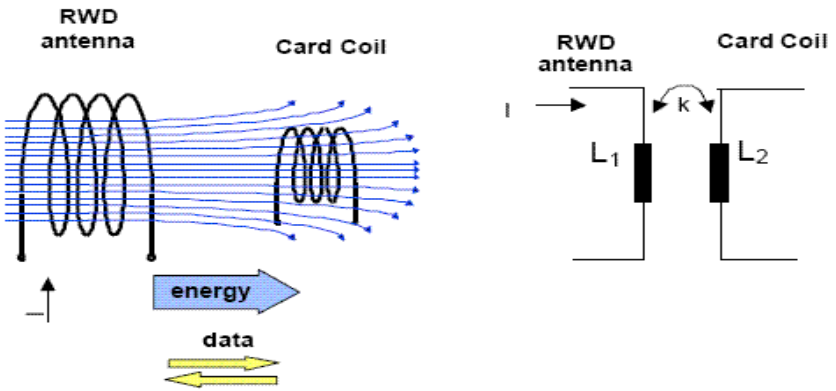


Figure 2 :Transformer Model

The current in the RWD antenna coil generates a magnetic flux.Parts of this flux flow through the card coil and induce voltage in the card itself.This voltage will vary within the distance between reader antenn and transferred power.The right part shows the equivalent electical circuitry,the transformer model.

7.3 Data transmission RWD → Card

To transfer data between the PCD and the PICC a half-duplex communication structure is used.The PCD always starts the communication.The data tranmission from the PCD to the PICC uses a 100% ASK modulation to the ISO14443 Type A.Figure 3 shows a typical Signal shape.

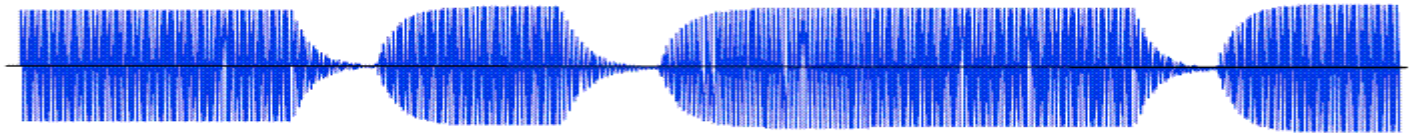


Figure3: Data Transmission PCD →PICC,typical signal shape

Due to the Quality factor Q of the antenna the transmitted Signal is deformed to the shape shown in Figure 4. This shape can be used to measure the tuning of the antenna.

As the PICC is passive,the energy for the PICC has to be provided during the communication between PCD and PICC.Therefore, ISO 14444A uses an optimised coding to provide a constant level of energy independently from the data transmitted to the PICC.This id the modufied Miller code,which is shown is shown in Figure5 in detail

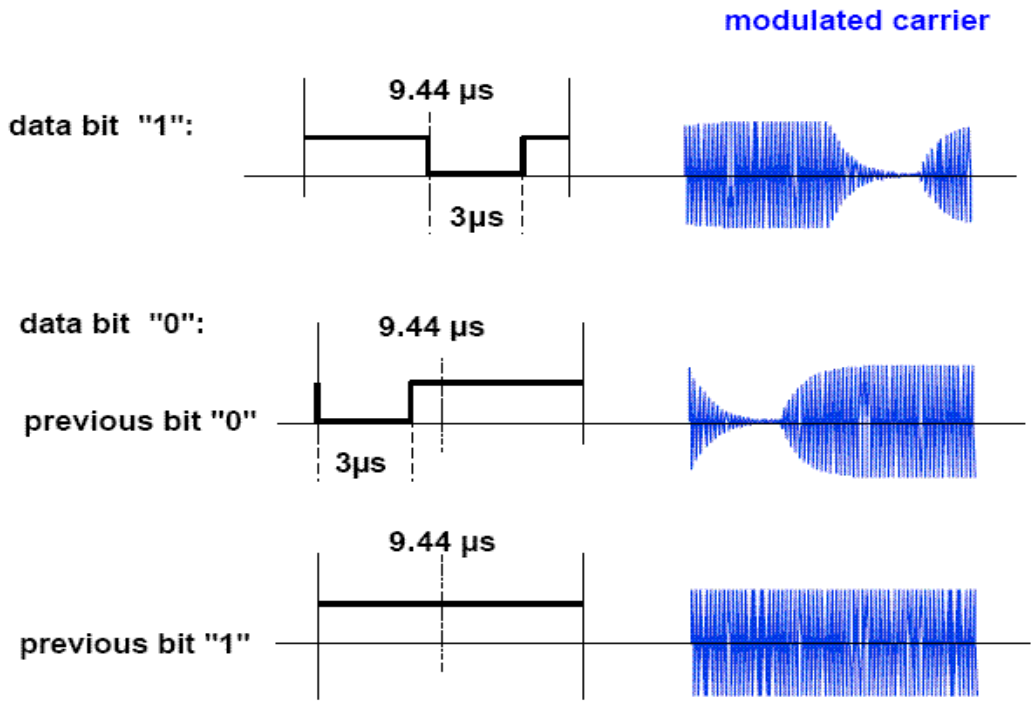


Figure 4 : Data Transmission PCD → PICC,Miller Coding

The data rate of MIFARE is 105.9KHz,so the length of a frame is 9.44us.A pulse in the Miller coding has a length of 3us.
A logical '1' expressed with a pulse in the centre of the bit frame.
Two possibilities are given to code a logical '0' Tis coding depends on the previou bit;
If the previous bit was a'0',the following '0' is expressed with apulse of 3us at in the first half of the next bit frame.
If the previous bit was a'1',the following'0'the following'0' is expressed without a pulse in the next bit frame.

7.4 Data Transmission PICC → PCD

Subcarrier load modulation principle

The data transmission from the PICC back to the PCD uses the principle of load modulation shown in Figure 5. The PICC is designed as a resonance circuitry and consumes energy generated by the PCD.This energy consumption has a feedback effect as a coltage drop on PCD side.This effect is used to transfer data from the PICC back to the PCD by changing the load in the card IC.

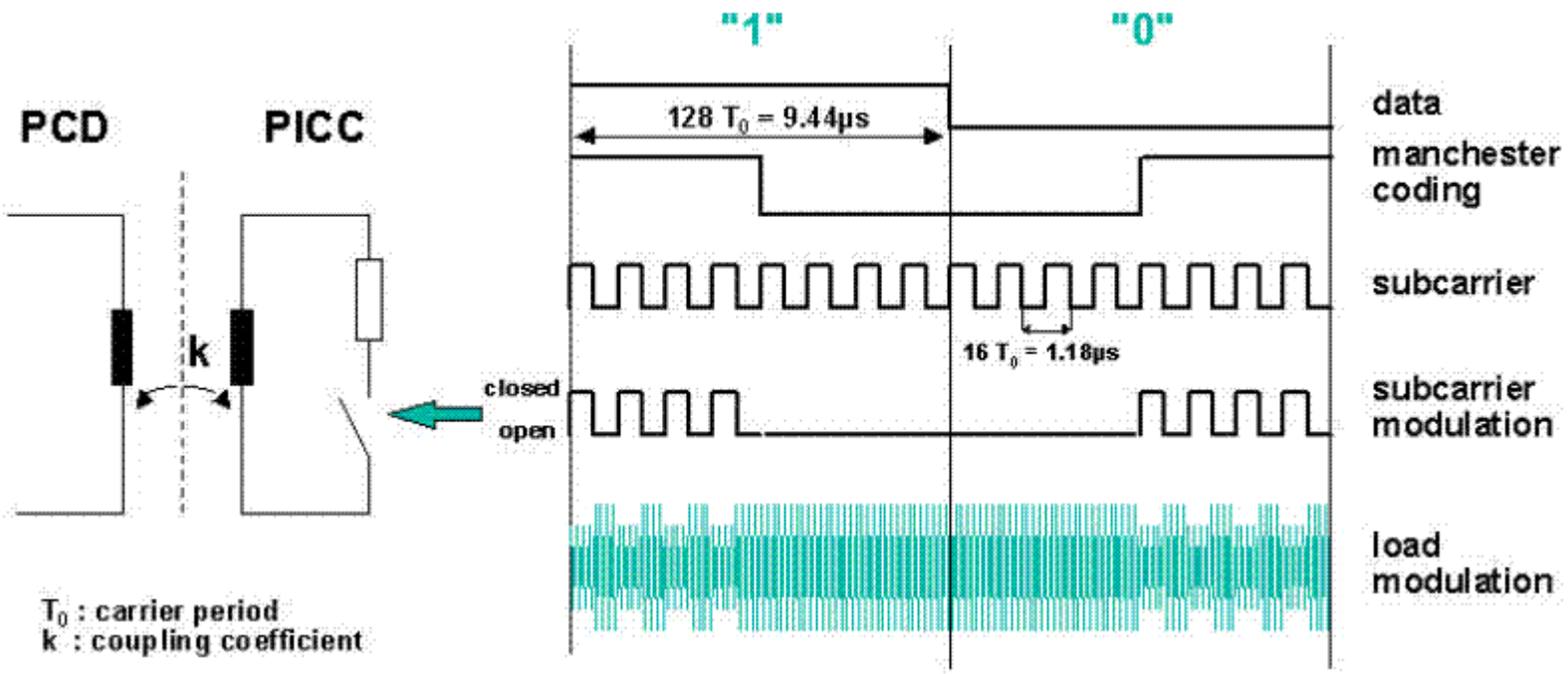


Figure 5: Subcarrier Load Modulation Principle

The PCD antenna is tuned to a resonance frequency Fr=13.56MHz. The time T0 expresses he pulse length of the operationg frequency T0=1/Fr 74ns. In fact,this resonance curcuit generates voltages at the PCD antenna several times higher than the supply voltage.Due to small coupling factor between the PCD and PICC antenna PICC's reponse is up to 60dB below thw voltage generated by the reader.To detect such a signal,it requires a well designed receiving circuit.

The PICC data transfer back to the PCD uses a data rate of 105.9kbit/s with Manchester coding.At Manchester Coding each bit is represented by either a raising or a falling edge in the centre of a bit frame.For the MIFARE principle this is shown on the right side of Figure5 :

A logical '1' is expressed with a falling egde in the centre of the bit frame.

A logical '0' is expressed with a rising edge in the centre of the bit frame.

This Manchester coded data modulates a sub carrier F sub = Fr/16 =847.5KHz.

Finally, this modulated sub carrier switches the load of the PICC,which result in the load modulation as shown in the last line of Figure5, and which is received and decoded again by the PCD.

Figure 6 shows the relation between the time and the frequency domain of the load modulation.Due to the data of

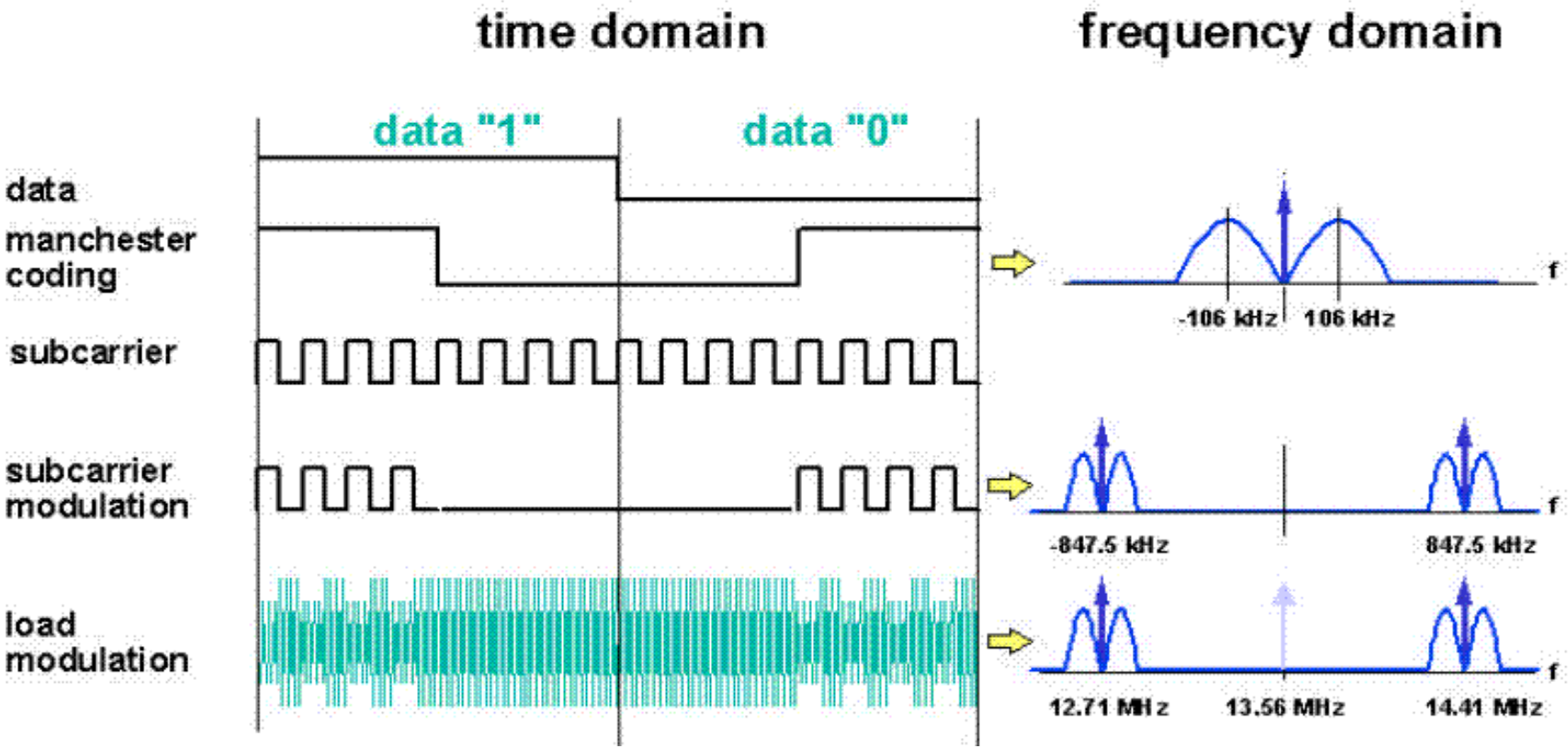
$$v \approx 106kBd \approx \frac{1}{9.44\mu s}$$

The Manchester cde generates sidebands at both of the sub carrier frequency:

$$f_{mSUB} = 847.5kHz\big|_{Subcarrier} \pm 106kHz\big|_{Data}$$

The modulation sub then generates sidebands at both sides of the carrier frequency:

$$f_{mR} = 13.56MHz\big|_{Carrier} \pm 847.5kHz\big|_{Subcarrier} \pm 106kHz\big|_{Data}$$



Figuren6 : Principle of Data Coding PICC→ PCD,Time and Frequency Domain

Antenna Specification

ANTENNA	**PCB Pattern Antenna**
ANTENNA STYLE	**50 ohm Match , Loop Antenna**
ANTENNA SIZE	**Width : 83.19 mm , Length : 85.72 mm**