Analog Control (Front-End) Design of RFID Tag in 0.35 µm CMOS Technology

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***Abstract*—The RFID (Radio Frequency Identification) can be defined as Automatic identification technology which uses radio-frequency electromagnetic fields to identify objects carrying tags when they come close to a machine reader. In this paper authors designed the analog part using frequency 13.56 MHz in the RFID tag, includes a rectifier, demodulator and modulator. The first part a method of rectifier cascade combines multiple cells to obtain voltage doublers which used source of voltage on other components, the second part we call demodulator. Demodulator uses two stage of comparator that detects bias negative voltage, and the last part modulation used Amplitude Shift Keying (ASK) modulation. In this paper using 0.35µm CMOS technology to design RFID tag. The research goals purpose to design the analog part of the RFID tags are biased to function well as it should.**

Keywords-component; RFID; tag; 0.35µm CMOS technology; 13.56 MHz

I. Introduction

For many of us, using a key to ride a car, a card to access a building or room, and validating a bus or underground ticket have become part of our daily routine. Without always realizing it, we use automatic data capture technology that relies on radio-frequency electromagnetic fields. This technology is known as Radio-Frequency Identification or RFID. RFID has transformed technology such as barcode, this system is it can only be identified by the way closer to a barcode reader, and in addition to the barcode can only be the one-time program so that the data cannot be updated, in the item barcode. This limitation arises because the RFID technology that successfully covers up the weakness of barcode technology.

RFID technology is flexible, and easy to use. RFID can be read only or can be read and written. RFID tag is a device made of electronic circuits and antennas. Electronic circuit of the RFID tags have memory has the ability to store data.

RFID tags have two parts control, that is analog control (front-end) and digital control (control logic), which both of the part are integrated in the RFID tag system.

II. Circuits Design

A. Rectifier Design

The direct rectification operation that was described in the previous section produces low DC voltage that is not sufficient for biasing the circuits of the RFID tag chip. Although there are many other versions of this circuit, this configuration has the advantage of being easy to be cascaded. Here is the part circuit of Rectifier of RFID tag can see in figure 1.

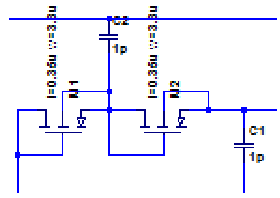

FIGURE I. DOUBLERS CELL [1],[2]

And after combined in a cascade, then the result of the merger will establish the following rectifier circuit, as shown in figure 2.

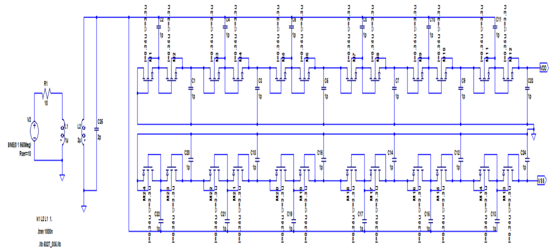

FIGURE II. RECTIFIER CIRCUIT[2]

B. Demodulator Design

Demodulator consists of a series detector circuit; comparator and an inverter are combined to become a component of the demodulator. In the research, a component of the demodulator was made is then put together so that it becomes whole circuit of the demodulator [2][4][5][6].

C. Envelope Detector

As in the rectifier, the diode is replaced with a equivalent PMOS transistor. The negative DC voltage is generated using a two cascaded voltage doublers cells similar to that used in the rectifier. To be compatible with standard digital CMOS process, the resistors are replaced with a diode connected transistors with low trans. Conductance. The implementation of the envelope detector circuit is shown in figure 3.

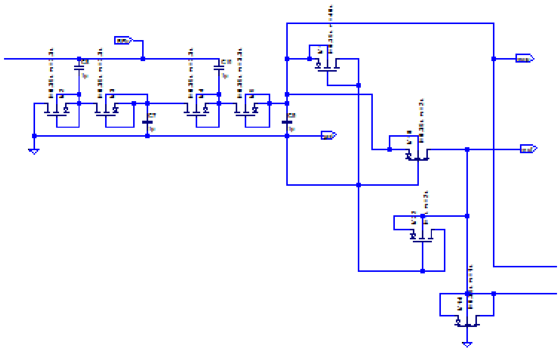

FIGURE III. COMPLETE ENVELOPE DETECTOR CIRCUIT

D. Comparator

In this part using two stage comparator with current source, the current source using one PMOS and two NMOS, with specification V_{DD} using 1.65V and V_{SS} using -1.65V, K_p = 36µA/V2 K_n = 90µA/V2 and V_{thp} = -0.62V V_{thn} = 0.48V.

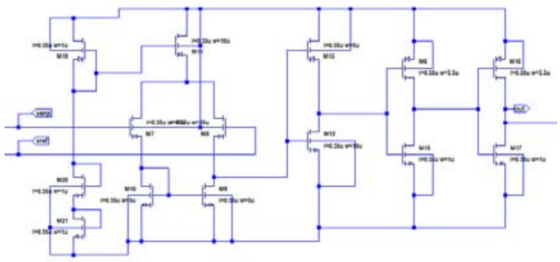

FIGURE IV. COMPARATOR DESIGN

From the equation, based on data from the simulation can be derived to calculate the AV, there is:

$$AV1 = \frac{gm9}{gm8} = 1.18$$

$$AV2 = \left(\frac{gm12 + gm13}{2}\right) R2 = 1.75$$

With equation to be used:

$$gm = \sqrt{2ID(K'n, p)Sn'p}$$

$$AV1 = \frac{gm10}{gm7} = \frac{gm9}{gm8}$$

$$AV2 = \left(\frac{gm12 + gm13}{2}\right) R2$$

$$R2 = (gm13rds13) \| (gm12rds12)$$

$$rds = \frac{1}{\lambda}$$

Where λn = 0.0002 V and λp = 0.0001V

E. Demodulator

To harmonize the data sent by the RFID reader towards to RFID tag using Pulse Width Modulation (PWM) so the distance is acceptable to have two different pulse widths T_{-high} and T_{-low} are in accordance with the pulse width. For PWM demodulator circuit can be seen in the figure 5.

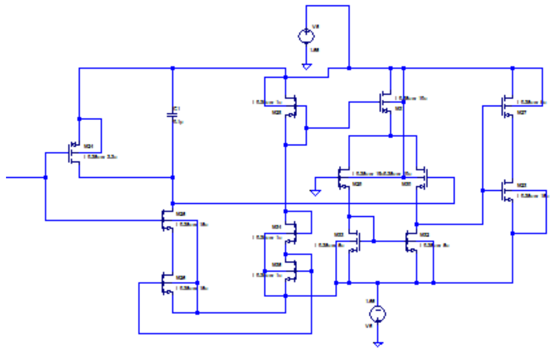

FIGURE V. PWM DEMODULATOR CIRCUIT

F. Modulator

In this section, we designed the ASK modulator for modulating. The circuit can be seen at figure 6.

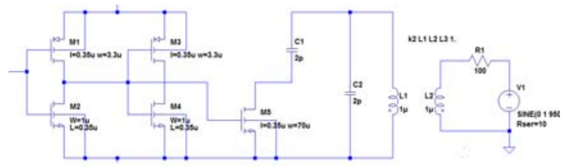

FIGURE VI. PWM DEMODULATOR CIRCUIT[3][4]

III. Simulation Results And Analysis

We shown the results of simulations that have been performed on each sub-block for the results include rectifiers, in which there demodulator envelope detector, PWM demodulator and modulator on RFID Tag 13,56 MHz in 0.35 µm CMOS technology.

A. Rectifier Test

The result of a complete circuit of the rectifier can be seen in figure 7.

FIGURE VII. SIMULATION OF RECTIFIER CIRCUIT

In the figure 7, the output voltage of the rectifier which receives induction of the RFID reader and in the fox later confirmed to be a source of stress for RFID tags, which produces output in the form of a DC voltage, the voltage of the source to the working of the components on RFID tags.

B. Demodulator Test

- Analysis of envelope detector

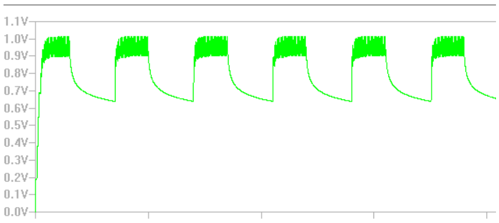

FIGURE VIII. FINAL RESULT ENVELOPE DETECTOR CIRCUIT RFID TAG

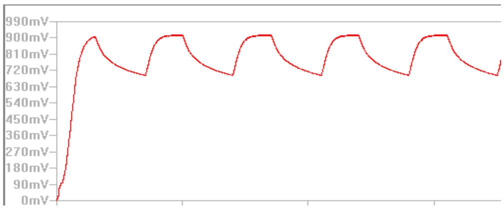

FIGURE IX. FINAL RESULT V-REF ENVELOPE DETECTOR CIRCUIT RFID TAG

It is the output of the envelope detector circuit, shown in Figure 8 for V_{env} output and for Figure 9 is the output waveform to V_{ref}. The wave V_{env} issued is in accordance with the desired and is appropriate as well as V_{ref}.

- Comparator Result Analysis

The following shows that the digital output signal from the comparator has a time difference of 1.6 ns to V_{env} signals and signal V_{ref}, and seen that the signal V_{ref} and the comparator compares the signal V_{env} then form a boosted signal so it looks output signal from the comparator as shown in figure 10.

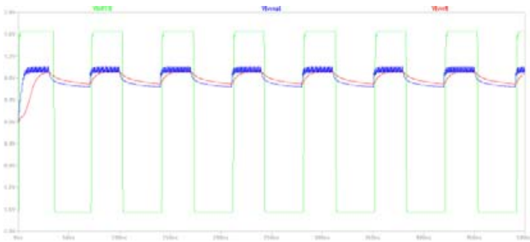

FIGURE X. DIFFERENTIAL PERIOD OUTPUT OF THE COMPARATOR

TABLE I. RESULT OF DIFFERENCE TIME OF $V_{\_REF}$, $V_{\_ENV}$ AND DIGITAL OUTPUT

	V_{env}	V_{ref}	Digital Output
Period	280.17ns	280.17ns	281.77ns

The following shows that the digital output signal from the comparator has a time difference of 1.7 ns of the ASK modulated signal as shown in table 1.

In the output shown already seen that the output signal into digital form, and can be read, but it needs to be added to the PWM demodulator encode to process the data from the reader to the RFID tag.

C. PWM Demodulator Result Analysis

PWM demodulator is used to reconcile the data sent by the RFID reader towards to the RFID tag, so the pulse width between T_{high} and T_{low} are different according to the pulse width of the logic "1" and logic "0". It also uses a comparator circuit similar to that used in the envelope detector, let's we see in the figure 11 of PWM Demodulator circuit.

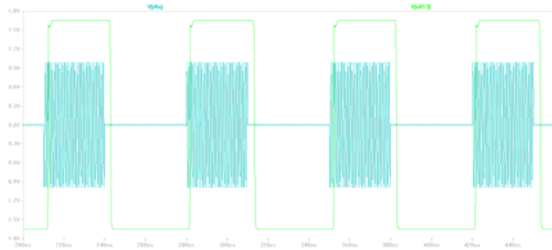

FIGURE XI. DIFFERENTIAL PERIOD OUTPUT

At the demodulator circuit we see the results of ASK modulation generated by the circuit and the results are in accordance with the desired signal which has been modulated in the modulation well we can see in the image sequence and the result we see in thefigure 12.

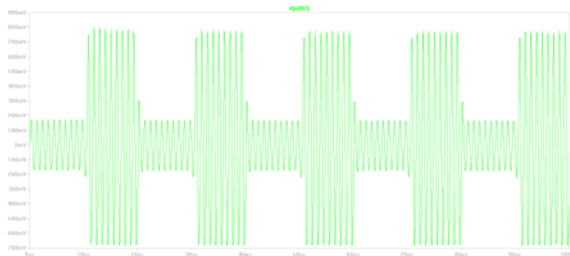

FIGURE XII. RESULT OF MODULATOR CIRCUIT

IV. CONCLUSIONS

The design of analog control (Front-End) RFID tag 13.56 MHz in 0.35 µm CMOS technology have done well. From the simulations results obtained can be summarized as follows:

- Rectifiers are used can product 5,8V with doublers voltage.
- Using comparator two stage because can detect for low power signal.
- On demodulator Av1 comparator is 1.18 and Av2 comparator is 1.75
- modulation using ASK modulation is used in order to detect the low power

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