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A Novel Rectifier Architecture for UHF RFID Transponder

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1. Introduction

RFID is an emerging technology used for object identification by means of radio waves. It is widely used in logistics, security and bioengineering. In RFID systems, the query unit (reader) transmits modulated RF signal or continual wave (CW) to a remote transponder (tag) consisting of an antenna and an integrated circuit(IC). According to the power supply, the transponder can be completely passive, semi-passive, or active [1]. Passive RFID tag has been widely adopted because of its compact, inexpensive and no power requirement characteristic. In fact, compared with active or semi-passive tag, the passive tag has an inherent drawback with regard to long-distance communication capability due to a lack of sufficient power supply arising from battery-less. For this reason, the work to extend communication range is most challenging and significant.

Because the communication range of passive RFID system strongly depends on the threshold power of tag [2], there is a significant meaning to improve power efficiency and reduce total power consumption for extension of communication distance. In RFID transponder chips, a rectifier circuit converting RF power to DC power is indispensable. Although various rectifier structures exist, only two kinds of rectifier are practical for UHF RFID transponder because UHF RFID has more constrains [3]. One is the gate cross-connected bridge structure, which does not utilize diode/diode-connected MOS Tr. so it can provide high power conversion efficiency (PCE). But this circuit has less capability to gain high output voltage; this characteristic limits its application especially for high voltage requirement. The other is Dickson charge pump structure; we can use numerous stages to get higher voltage level as we want. But the threshold voltage drop due to diode-connected MOS Tr. may result in low PCE, on the other hand, Schottky diodes with a low forward voltage drop are available but their implementation is expensive due to they require extra mask layers and processing steps.

2. Main works

To overcome the drawbacks of conventional rectifier mentioned previously, we proposed a novel rectifier structure by the concepts as follows.

- For solving the threshold voltage drop problem, diode and diode-connected MOSFET should be avoided.
- Reverse current from the storage capacitor to the antenna should be suppressed as possible.
- The optimization of the size of the MOS Tr. should be done with regard to channel resistance and parasitic capacitor.
- The charge pump characteristic is desired for the sake of obtaining high output voltage.

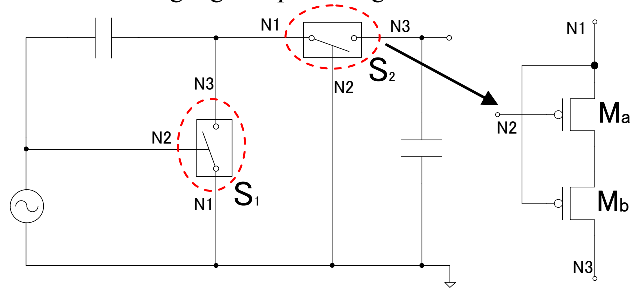

Fig.1 Proposed rectifier structure.

The proposed circuit is shown in Fig.1; Sub-circuit S_1/S_2 consists of two PMOS Tr. as shown on the right. MOS Tr. Ma and Mb are not diode-connected so forward voltage drop can be largely saved as gate cross-connected structure. For improving the potential reverse current drawback of gate cross-connected, MOS Tr. Mb is added, Due to the current is very small, there is less significance for reducing the voltage drop arises from channel resistance, so we give priority to diminish the parasitic capacitor, this will make sense to save losses arising from charge and discharge. Moreover, Charge pump can be easily realized by stacking the circuit shown in Fig.1 as Fig.2.

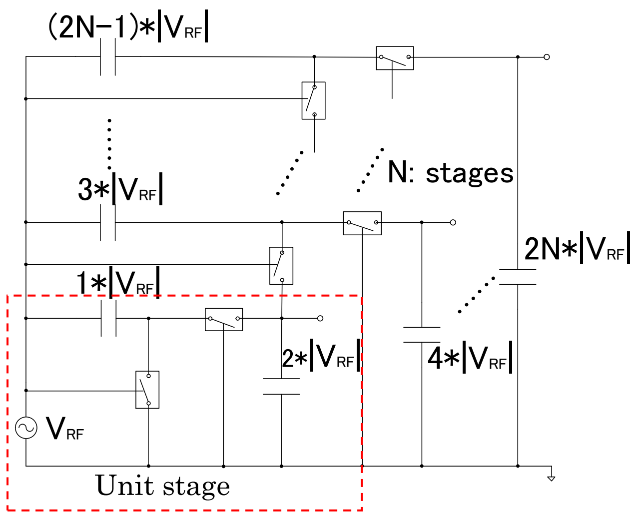

Fig.2 Charge pump structure by proposed circuit.

The rectifier with voltage booster we proposed is suitable for any standard CMOS process due to it is only made up of MOS Tr. and high PCE can be obtained simultaneously due to it does not suffer from high threshold voltage losses.

3. Measurement results

These circuits were fabricated in the 0.18µm five-metal CMOS process. The die photograph is shown in Fig.3. The active device area is 0.03 mm^2. The die is packaged into a 80 pin package.

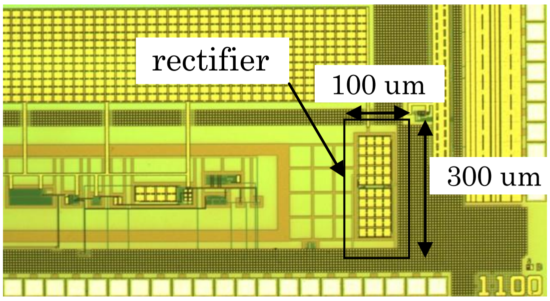

Fig.3 Photomicrograph of the fabricated chip.

Due to decrease the reflections during UHF band, an impedance controlled PCB shown in Fig.4 has been designed. And the packaged device is directly mounted onto the board.

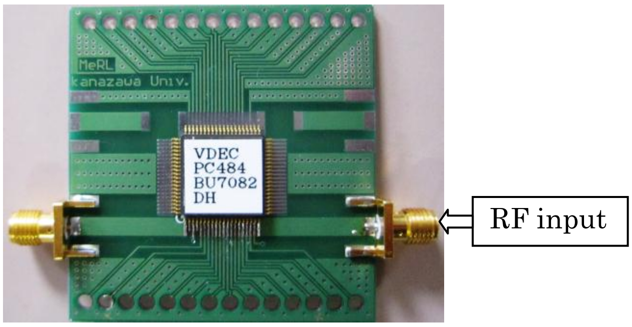

Fig.4 Photo of PCB for measurement

In order to measure the efficiency of the rectifier, a 953-MHz RF signal is applied to the rectifier IC. And matching networks are used to connect test chip to RF signal generator via a coaxial cable. A swing of RF input power is fed into the input of rectifier, at the same time; the output voltage and output current are measured at output terminal of rectifier, respectively.

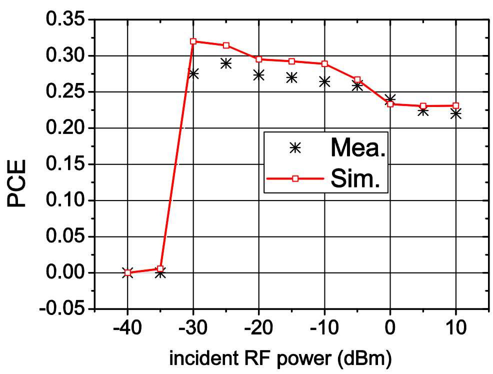

Fig.5 Simulation and measurement results

Fig.5 shows the comparison with regard to the results obtained by simulation and measurement. The results show good agreement between simulation and measurement result. The output voltage of 1V is obtained with -30dBm RF input power and 0.32uW load, therefore the threshold RF power of this device could be confirmed as low as 1uW. Moreover, a high PCE is reached as 32%. However, A decrease of PCE accompany increase of stage number should be anticipated.

4. Conclusion

We present a novel rectifier circuit with high PCE. A high output voltage can be obtained as desired without suffering from threshold voltage drop losses and it is suitable for standard CMOS process. These circuits have been fabricated in 0.18um mixed signal CMOS process. Experiment results show 32% conversion efficiency. This indicated a potential operating range up to 30m.

Acknowledgements

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