Turn-on circuits based on standard CMOS technology for active RFID labels

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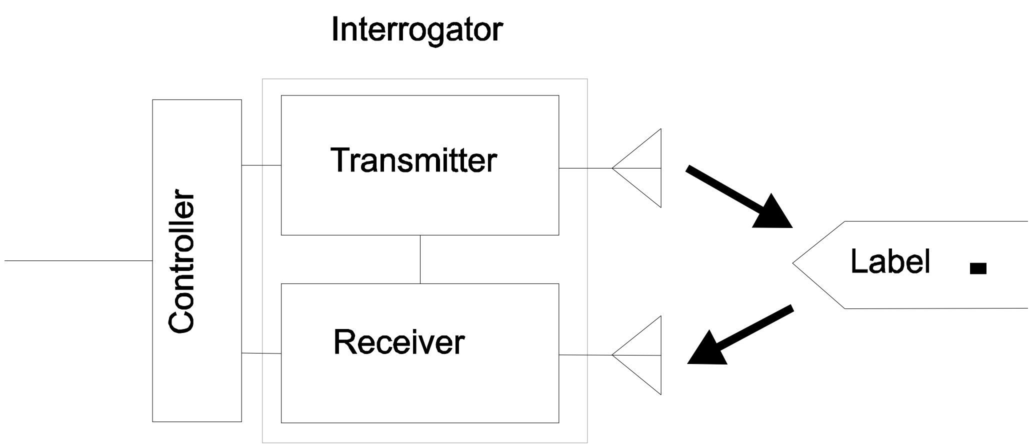
What is RFID?

A simple illustration of the concept of a Radio Frequency Identification (RFID) system is provided in figure below.



Here a transmitter of interrogation signals which is contained within an interrogator communicates via electromagnetic waves with an electronically coded label to elicit from the label a reply signal containing useful data characteristic of the object to which the label is attached. The reply signal is detected by a receiver in the interrogator and made available to a control system.

Why Turn-on Circuit?

The evolution of RFID Systems has lead to the development of a class hierarchy in which the battery powered labels are a set of higher class labels referred to as active labels.

The battery powering active transponders must last for an acceptable time, so the electronics of the label must have very low current consumption in order to prolong the life of the battery

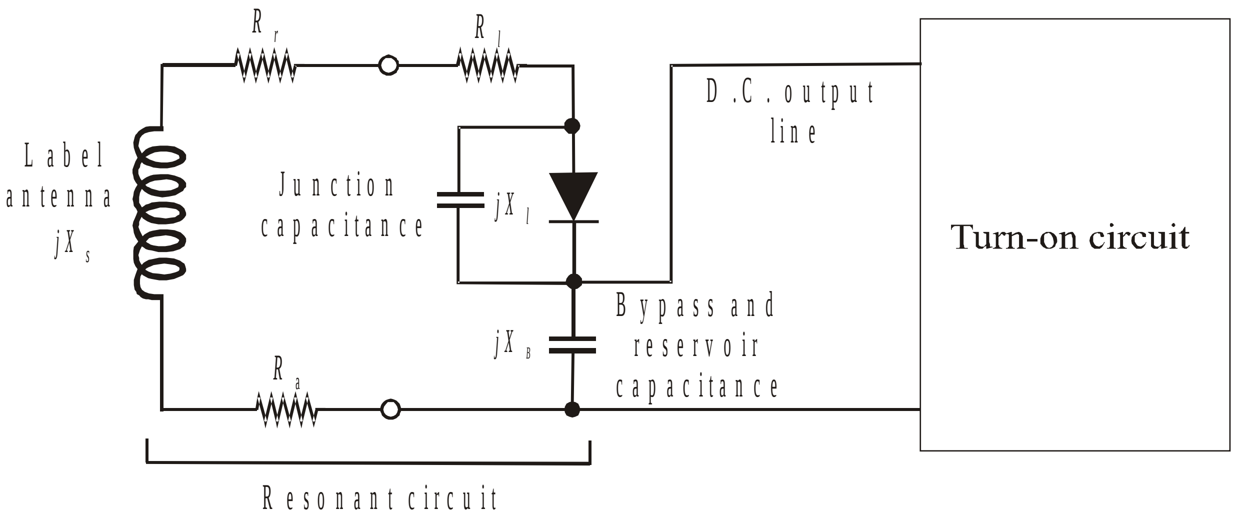
The practical options for turn-on circuits are two fold:

1. Rectifier circuits that can produce from an illuminating RF field a rectified voltage of the order of 1V that can turn a CMOS transistor from fully off to fully on; or

2. Rectifier circuits that can produce from an illuminating RF field a rectified voltage of the order of 5mV which when compared to an internal reference voltage can be used to trigger a transistor from fully off to fully on state

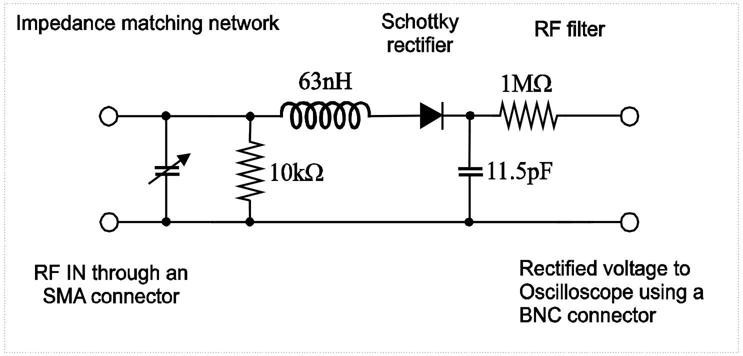
Evaluating The Concept

A label antenna, that in this application is preferably inductive, and the rectifying circuit that is intended to produce a rectifying voltage used for circuit turn-on, can be modeled as indicated in figure below.



Self Resonance of Diode

Experiments detailed in this paper utilized a Schottky Barrier Diode implemented on Standard CMOS process.



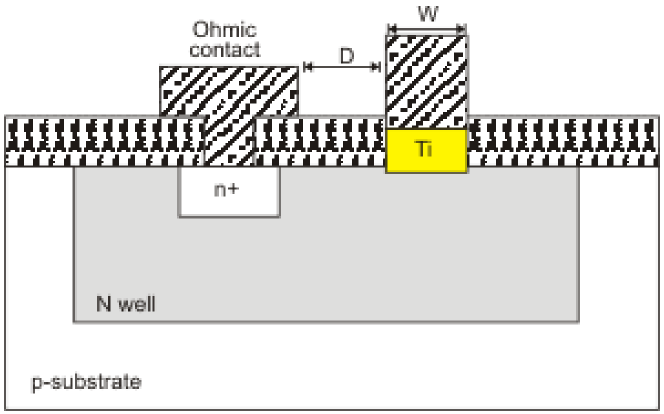
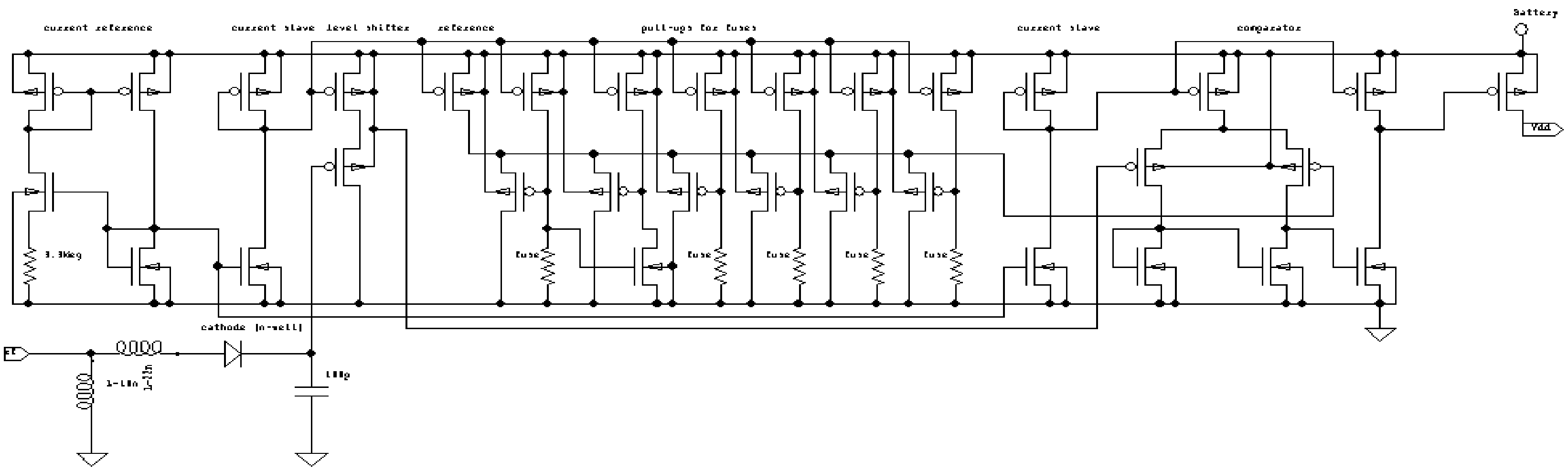


Figure on the left shows cross-sectional view of the Schottky barrier diode. Here the Schottky diode contact width is W, and the separation between the Schottky contact and the Ohmic contact is D.

Low Power Turn-on Circuit

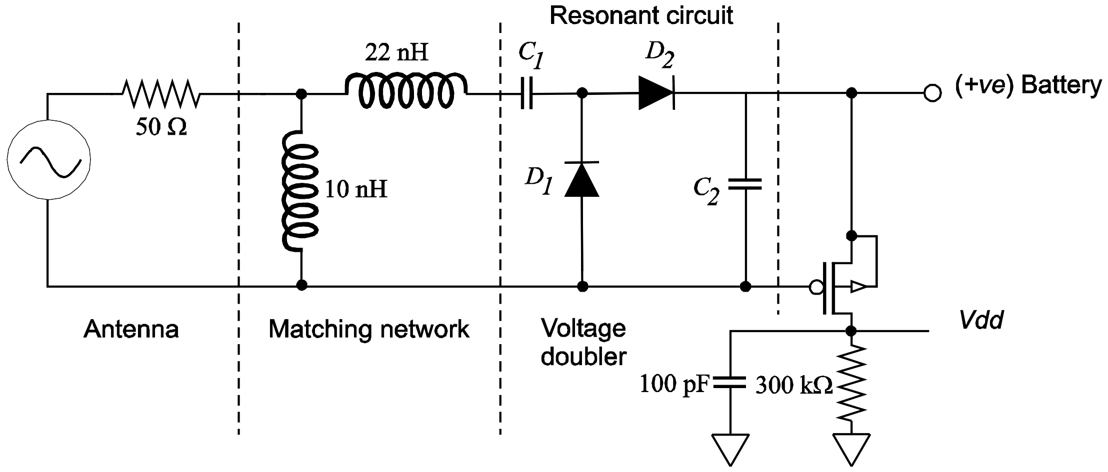
Figure below shows a fully integrated turn-on circuit which requires a small DC voltage to be developed by a Schottky diode rectifier.



The voltage provided by the diode is compared with an internal reference voltage, and activates a switch when the rectified voltage exceeds the internal reference value. The sensitivity of this circuit is adjusted by changing the internal reference voltage.

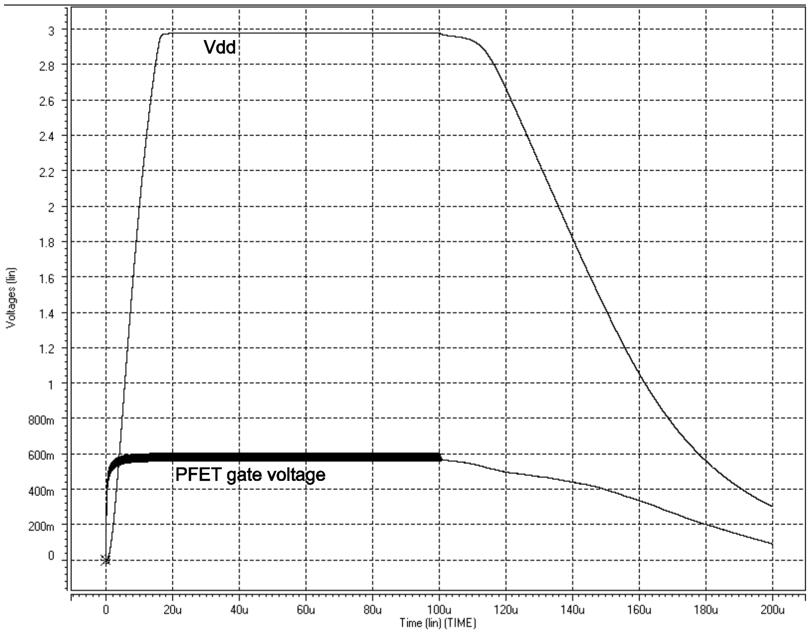
Zero Powered Turn-on Circuit

The proposed novel turn-on circuit below is adequate and cost effective for a backscattering active label.



In this proposal a p-channel FET was used as a switch to control the power supply to a labels control circuits and can be triggered by the incident RF radiation on the antenna. Thus the power generated and amplified by the diode resonance can be utilized to turn a p-channel FET from an off state to an on state.

Simulation Results



Simulated results for the turn on circuit implementation using HSPICE diode model for the fabricated CMOS Schottky diode

Conclusion

The development of active labels and sensors will eventually involve the incorporation of turn-on circuits. We have presented some concepts and a number of ways in which they can be exploited; however not all the alternatives my be practicable. The concept provided for a zero power turn on circuit in Section 4 involves the design of a turn-on circuit that functions by sweeping the excitation across a UHF bandwidth. This concept is a practicable alternative and it is illustrated through performance measurements taken in a scenario modeling a far field, and through range predictions under favorable conditions based on that scenario.