A 13.56MHz RFID system based on organic transponders

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15.2 A 13.56MHz RFID System based on Organic Transponders


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Electronics based on organic transistors is suited to the manufacture of RFID tags for retail applications [1] because of its low-cost, mechanical flexibility and the possibility it offers to integrate circuits with antennas on packaged items. Organic electronics [2] and antennas can be manufactured using low-cost high-volume technologies like printing. Still a convincing demonstration of the technical feasibility of organic RFID transponders is missing.

The RFID tags presented here are manufactured using a photolithographic bottom gate technology [3] on a 25μm thick plastic substrate. The p-type semiconductor is pentacene, deposited from a precursor source solution. Transistors consistently provide field-effect mobilities in the saturation region of 0.01cm²/Vs and on/off current ratios of 10⁶.

A crucial element in any DC-powered tag (Fig. 15.2.1) is the rectifier, the only device that must work at the RF carrier frequency. In our technology the organic semiconductor is the top layer in the stack. Integration of a vertical diode [4] would require additional masks and process steps; therefore we chose to implement the integrated rectifier using diode-connected transistors.

The channel length of the transistors is typically 4μm. As the mobility is 0.01cm²/Vs, one would expect a time of flight between source and drain of 160ns at a Vds of 100V. Based on this simplistic time of flight estimation, the antenna must have large inductance and a low capacitive and inductive antenna coupling (Fig. 15.2.1). At low frequencies beyond 20MHz, far above the limits expected from the simplistic time of flight estimation. The reason for this excellent behavior is attributed to the fact that mobility in organic semiconductors is a power function of the applied gate-source voltage [6] and the rectifiers are operated at large Vgs.

In order to establish the limits of our system, the functionality of the rectifier at higher carrier frequencies was characterized. The DC output voltage -Vdd as a function of the input peak-to-peak AC voltage Vpp is shown in Fig. 15.2.5. The rectifier works at frequencies beyond 20MHz, far above the limits expected from the simplistic time of flight estimation. The reason for this excellent behavior is attributed to the fact that mobility in organic semiconductors is a power function of the applied gate-source voltage [6] and the rectifiers are operated at large Vgs.

A system capable of generating the 13.56MHz carrier and to readout the tags via the capacitive antenna was built. This system could successfully energize and readout code A and code B tags at 13.56MHz. The measured output codes are shown in Fig. 15.2.6; the bit rate is 1kb/s for code A and 700b/s for code B. At this carrier frequency an inductive RF link could be advantageously used to increase the range of the RFID system.

Repeated exposure, in air, of the tags to the AC voltage needed to generate sufficient DC supply did not result in measurable performance degradation.

In summary, a complete RFID system has been presented working at 13.56MHz, the current standard for item level RF identification, which is able to distinguish between two tags manufactured with organic transistors. Also reported are functional organic 64b transponders. All measurements presented have been obtained in air. These results demonstrate the technical feasibility of commercially relevant RF identification systems based on organic tags.

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References:
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Figure 15.2.3: The 64b code generator architecture (reset state).

Figure 15.2.4: Signals measured on the 64b code generator at $V_{dd}=-30V$. The programmed code is shown in hexadecimal together with the generated code signal.

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