INTRODUCTION

The MCRF355 passive RFID device is designed for low cost, multiple reading, and various high volume tagging applications using a frequency band of 13.56 MHz. The device has a total of 154 memory bits that can be reprogrammed by a contact programmer. The device operates with a 70 kHz data rate, and asynchronously with respect to the reader’s carrier. The device turns on when the coil voltage reaches 4 VPP and outputs data with a Manchester format (see Figure 2-3 in the data sheet). With the given data rate (70 kHz), it takes about 2.2 ms to transmit all 154 bits of the data. After transmitting all data, the device goes into a sleep mode for 100 ms +/- 50%.

The MCRF355 needs only an external parallel LC resonant circuit that consists of an antenna coil and a capacitor for operation. The external LC components must be connected between antenna A, B, and ground pads. The circuit formed between Antenna Pad A and the ground pad must be tuned to the operating frequency of the reader antenna.

MODE OF OPERATION

The device transmits data by tuning and detuning the resonant frequency of the external circuit. This process is accomplished by using an internal modulation gate (CMOS), that has a very low turn-on resistance (2 ~ 4 ohms) between Drain and Source. This gate turns on during a logic “High” period of the modulation signal and off otherwise. When the gate turns on, its low turn-on resistance shorts the external circuit between Antenna Pad B and the ground pad. Therefore, the resonant frequency of the circuit changes. This is called detuned or cloaking. Since the detuned tag is out of the frequency band of the reader, the reader can’t see it.

The modulation gate turns off as the modulation signal goes to a logic “Low.” This turn-off condition again tunes the resonant circuit to the frequency of the reader antenna. Therefore the reader sees the tag again. This is called tuned or uncloaking.

The tag coil induces maximum voltage during “uncloaking (tuned)” and minimum voltage during cloaking (detuned). Therefore, the cloaking and uncloaking events develop an amplitude modulation signal in the tag coil.

This amplitude modulated signal in the tag coil perturbs the voltage envelope in the reader coil. The reader coil has maximum voltage during cloaking (detuned) and minimum voltage during uncloaking (tuned). By detecting the voltage envelope, the data signal from the tag can be readily reconstructed.

Once the device transmits all 154 bits of data, it goes into “sleep mode” for about 100 ms. The tag wakes up from sleep time (100 ms) and transmits the data package for 2.2 ms and goes into sleep mode again. The device repeats the transmitting and sleep cycles as long as it is energized.

FIGURE 1: VOLTAGE ENVELOPE IN READER COIL
FIGURE 2: (A) UNCLOAKING (TUNED) AND (B) CLOAKING (DETUNED) MODES AND THEIR RESONANT FREQUENCIES

(a) SW = OFF

(b) SW = ON

(c) SW = OFF

(d) SW = ON

\[ f_0 = 13.56 \text{ MHz} \]

\[ f_0' = (13.56 + \Delta f) \text{ MHz} \]

\[ f_0 = 13.56 \text{ MHz} \]

\[ f_0' = (13.56 - \Delta f) \text{ MHz} \]
ANTICOLLISION FEATURES

During sleep mode, the device remains in a cloaked state where the circuit is detuned. Therefore, the reader can’t see the tag during sleep time. While one tag is in sleep mode, the reader can receive data from other tags. This enables the reader to receive clean data from many tags without any data collision. This ability to read multiple tags in the same RF field is called anticollision. Theoretically, more than 50 tags can be read in the same RF field. However, it is affected by distance from the tag to the reader, angular orientation, movement of the tags, and spacial distribution of the tags.

FIGURE 3: EXAMPLE OF READING MULTIPLE TAGS
EXTERNAL CIRCUIT CONFIGURATION

Since the device transmits data by tuning and detuning the antenna circuit, caution must be given in the external circuit configuration. For a better modulation index, the differences between the tuned and detuned frequencies must be wide enough (about 3 ~ 6 MHz).

Figure 4 shows various configurations of the external circuit. The choice of the configuration must be chosen depending on the form-factor of the tag. For example, (a) is a better choice for printed circuit tags while, (b) is a better candidate for coil-wound tags. Both (a) and (b) relate to the MCRF355.

In configuration (a), the tuned resonance frequency is determined by a total capacitance and inductance from Antenna Pad A to Vss. During cloaking, the internal switch (modulation gate) shorts Antenna Pad B and Vss. Therefore, the detuned inductance L2 is shorted out. As a result, the detuned frequency is determined by the total capacitance and inductance L1. When shorting the inductance between Antenna Pad B and Vss, the detuned (cloak) frequency is higher than the tuned (uncloak) frequency.

In configuration (b), the tuned frequency (uncloak) is determined by the inductance L and the total capacitance between Antenna Pad A and Vss. The circuit detunes (cloak) when C2 is shorted. This detuned frequency (cloak) is lower than the tuned (uncloak) frequency.

The MCRF360 includes a 100 pF internal capacitor. This device needs only an external inductor for operation. The explanation on tuning and detuning is the same as for configuration (a).

Figure 4: VARIOUS EXTERNAL CIRCUIT CONFIGURATIONS

\[
\begin{align*}
    f_{\text{tuned}} &= \frac{1}{2\pi}\sqrt{\frac{L}{C}} \\
    f_{\text{detuned}} &= \frac{1}{2\pi}\sqrt{\frac{L}{C}} \\
    L_T &= L_1 + L_2 + 2L_m \\
    L_m &= \text{mutual inductance} \\
    K &= \text{coupling coefficient of two inductors} \\
    0 \leq K \leq 1
\end{align*}
\]

(a) Two inductors and one capacitor

(b) Two capacitors and one inductor

(c) Two inductors with one internal capacitor
PROGRAMMING OF DEVICE

All of the memory bits in the MCRF355/360 are reprogrammable by a contact programmer or by factory programming prior to shipment, known as Serialized Quick Turn Programming\textsuperscript{SM} (SQTP\textsuperscript{SM}). For more information about contact programming, see page 69 of the \textit{microID\textsuperscript{TM} 13.56 MHz System Design Guide} (DS21299). For information about SQTP programming, please see TB032 (DS91032), page 19 of the design guide.
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