KCEDZS Sensor Board
RFID Loop Antenna Gain Calculation

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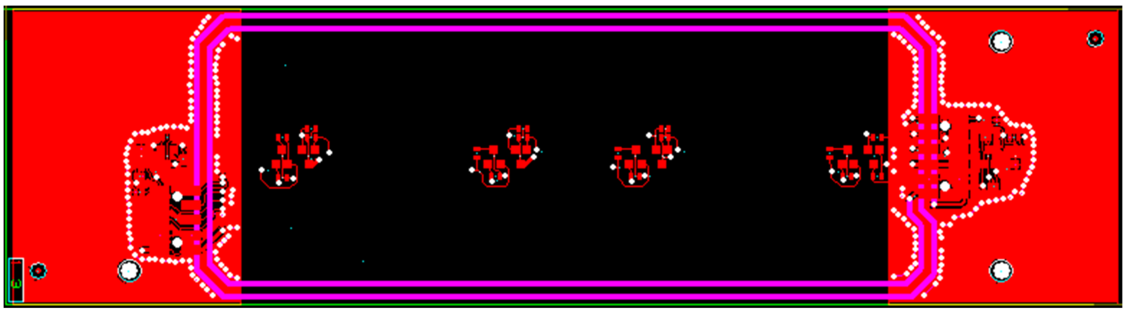
1 GENERAL

Purpose of this document is to theoretically calculate KCEDZS Sensor Board RFID antenna gain.

Calculation on this document are based on formulas given on conference paper “Simple Formulas for Near-Field Transmission, Gain, and Fields”, 2013, by Hans G. Schantz and Amin Nikravan.

ON KCEDZS Sensor Board there is a loop antenna formed on the PCB as seen on picture below (loop antenna seen on magenta color.



Antenna has two nested loops and antenna dimensions are roughly 47.5 x 125.0mm (127.7mm diagonal dimension).

2 ANTENNA GAIN CALCULATION

2.1 Gain calculation formulas

Antenna gain can be calculated using the following formula:

$$G = Q_L (kR)^3$$

where Q_L is loaded quality factor, k equals to k = 2π/λ, and R is radius of the boundary sphere enclosing the antenna. Loaded quality factor can be expressed in form of

$$Q_L = \frac{1}{bw} = \frac{f_C}{f_U - f_L}$$

, where f_C is center transmission frequency, f_u is upper -3db frequency and f_l is lower -3db frequency. Therefore, antenna gain

$$G_L = \frac{f_C}{f_U - f_L} \left(\frac{2\pi f_C}{c_0} \times \frac{D}{2}\right)^3$$

2.2 KCEDZS RFID antenna constants

f_c = 13.56MHz

$f_U - f_L$ = BW = 0.7MHz (simulated -3db point around center frequency)

c_0 = 299792458 m/s

D =0.1277m

2.3 Antenna gain

$$G_L = \frac{13.56MHz}{0.7MHz}\left(\frac{2\pi \times 13.56MHz}{299792458\,m/s} \times \frac{0.1277m}{2}\right)^3 = 116 \times 10^{-6}$$

$$G_L = 10\log(116 \times 10^{-6}) = -39.3dbi$$

Numerical modeling tends to indicate the relation might be closer to $G = \frac{1}{2} QL\,(kR)^3$, and therefore gain could be -3db lower at,

G_L = -42dBi

3 REFERENCES

"Simple Formulas for Near-Field Transmission, Gain, and Fields", 2013, by Hans G. Schantz and Amin Nikravan.

4 APPROVALS AND VERSION HISTORY

Compiled by:
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Issue	Date	Description of Change	Ref CR	Approved By
-	2021-03-31	First version	-	
-.2	2022-10-20	Silk print removed from PCB capture, document number rectified		