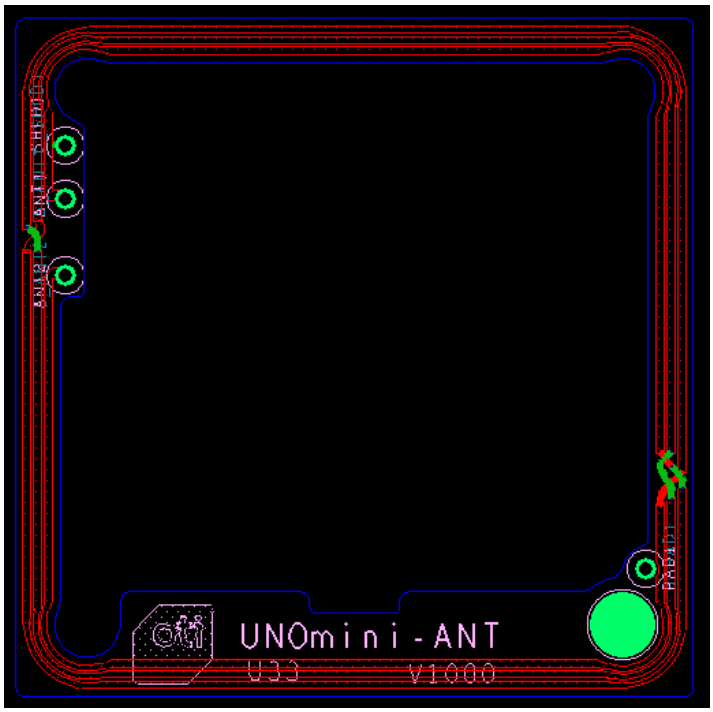
UNO-mini
Antenna Specifications

General:

- The UNO-mini is a Contactless Smart Card reader.
- It comprises two PCBs, a main board (which contains all the HW) and an antenna board. The antenna board is facing the front, just behind the front surface of the reader, and the main board is behind it, at the back of the reader housing.
- The bidirectional contactless communication with contactless cards operates at 13.56MHz carrier frequency via loop antennas (both at the reader and the card sides) and is based on inductive coupling and not on far field coupling. This strongly affects the antenna transmission characteristics as explained further below.
- Antenna gain: 0dBi

Antenna construction:

- The loop antenna is built of PCB traces, three turns at the perimeter of the 45x45mm antenna PCB as shown below.



Antenna characteristics:

- The transceiver chip, which is mounted on the main board and is fed by 3.3VDC supply, drives the antenna via low pass filter and matching circuitry.
- The drive signals from the transceiver chip are two opposite polarity square wave signals.
- The signal which develops at the antenna after the passive filtering is of sinusoid wave shape, at amplitude of few tens of volts peak to peak.
- The common **far field** terms like "output power", "antenna gain" and "radiation pattern" are not applicable to such inductive coupling antenna. See next for more details

Inductive coupling versus far field radiation:

- In the context of such readers, inductive coupling relates to close coupling between two loop antennas where the dimensions of the two antennas and the distance between it are very much smaller than the wave length of the carrier frequency.
    - The term "inductive" refers to the fact that the coupling is based on magnetic field and not on electrical field.
    - The transmitter generates relatively strong magnetic field which **reactively** "vibrates" at the close proximity of the antenna accompanied with very week electrical field.
- Such setup enable power and data transfer between the two antennas at close proximity with very little of the RF power actually propagating to the far field.
    - Close proximity means operating distance between the reader and the card in the range of few cm, typically up to about 7cm, mostly depending on the specific card.
- As mentioned above, very little of the antenna magnetic field (and even more so for the electrical field) is actually transmitted away from the antenna to the far field. This is due to the use of a very small loop antenna, which makes it a very inefficient radiator, or in other words - antenna which has a very low Radiation Resistance, so the transmitter power is actually spent as heat in the antenna ohmic resistance.
- Reiterating the above, the magnetic field around the antenna is of reactive type where energy is exchanged back and forth between current in the antenna and magnetic field in the small volume around it during each carrier cycle.
  Radiation resistance of small loop can be calculated as: $Rr = 31200(A/\lambda^2)^2$ where A is the loop antenna area and λ of 13.56MHz in free space (~22m). This formula yields an extremely small radiation resistance (less than one micro ohm!). This resistance may be considered as if connected in series with the antenna ohmic resistance (and the driver output resistance). This explains why only a minute fraction of the magnetic field energy actually propagates away from the antenna.

Field pattern - near field versus far field:

- The reactive magnetic field close to the antenna has a donut shape around it with an "accumulating" maximum "vertical" field level above the center of the antenna.
- At far field measurement the "vertical" vector above the antenna center is a "null", a direction with minimum transmitted energy.
- In contrary to the above, the directions at the antenna plane yield maximum transmission at far field while involving minimum levels at near field in close proximity to the antenna.

Field level - compliance with the relevant Contactless standards:

- The most relevant standards relating to the required and allowed levels of the magnetic field at close proximity to the reader antenna are ISO144443 and EMVCo Level 1.
- These standards define special measurement techniques taking into consideration the loading effect of the card on the reader antenna.
- It involved measuring the magnetic field level with specially designed tools which include loading means.
- ISO14443 allows maximum field level of 7.5A/m.
    - Our reader complies with this requirement.
- EMVCo L1 measurement tool limits are given in Volts w/o defined conversion to A/m units.
    - The UNO Mini also complies with these limits.

Summary:

- As explained above in detail, the standard typical parameters of "far field" of RF transmitters and antennas (e.g., output power, antenna gain and radiation pattern) are not applicable to loop antennas of contactless readers.
- The antenna is integrated inside the reader and its construction is fixed so the possibility of replacing it with an off the shelf alternative antenna is not applicable.

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