Application Note 604010

Title: **EM4095 AFE communication with EM4205/EM4305 basic principles**

Product Family: **125 kHz RIFD ICs**

Part Number: EM4095, EM4205, EM4305, EMDB409

Keywords: Read / Write Basic principles, Low Frequency, 125 kHz, Uplink-Downlink Communications

Steps to transmit an RF command to EM4305 or EM4205 RFID tag

1. Send 'first stop field' (mod pin of EM4095 'high' for 32 to 100 RF cycles).
    a. The 1st field stop duration is application dependent.
    b. 32 RF cycles is enough for ISO card size tags.
    c. The high Q tags (e.g.; glass tube animal chips) require up to 100 RF periods – the goal is to let the tag coil voltage drop below enough so that it recognizes this as a field stop. Additionally, it might help to start the 1st field stop modulation at the same time the tag is modulating itself (tag is in so called Default Read mode).
2. Mode pin 'low' for 17 RF cycles.
3. Send logic bit '0'
4. Send 3 command bits with parity bit (following LSB first rule)
5. Send address with parity bits (following LSB first rule)
6. Send Data with parity bits (D0 to D7, P0, D8 to D15, P1, ….., PC0 to PC7, '0') if present
7. Set the mod pin of EM4095 to 'low' to keep the tag further energized by the RF field

For transmitting logic bit '0', '1';

1. For logic '0';
    a. Set mod pin of EM4095 to 'high' for 15 RF cycles
    b. Then set mod pin of EM4095 to 'low' for 17 RF cycles
2. For logic '1' – set mod pin of EM4095 to 'low' for 32 RF cycles.

Please use style "Body Text" (font Arial 9pt) for the main text.
Furthermore, it is recommended to write the application note in a two-column format and always SINGLE LINE SPACING.

Steps to Write Word into EM4305 or EM4205 RFID tag

1. Transmit the Write Word command to the tag according to the previous paragraph
    a. The command is (first to transmit)"0101"(last to transmit) incl. parity
    b. Address is as appropriate
    c. Data is as appropriate – see also EM4205/EM4305 datasheet Data structure paragraph (Table 12)
2. When the tag recognizes the received command, it starts to execute it.
    a. If the word is locked, the tag returns ERR pattern after tPC time.
    b. If the word is not locked, the tag writes the data, and then returns the OK pattern. The timeout for this write time is tPC+tWEE time.

Please notice that tPC and tWEE are in [ms]. You can either use your uC crystal oscillator to wait for this duration, or you can use EM4095 RDY/CLK clock signal to count the equivalent duration. As EM4095 uses PLL it implies the exact resonant frequency is determined by overall antenna LC values. Assuming your tuning frequency is 125kHz, you can count RDY/CLK for the time corresponding to tPC+tWEE assuming the RDY/CLK is 150kHz as the upper worst case bound estimation.

After the last command bit is transmitted, the reader needs to observe EM4095 DEMOD_OUT output for tPC+tWEE and decode all incoming response bits.

For now I assume you (the customer) are developing the reader code, thus it is not necessary to catch the Write Word command response right from the beginning, instead you can use Read Word command to verify the written contents indirectly. Hence, I'm omitting the Write Word command response reception here. However, the response principle is the same as it is described in the Read Word paragraph.

Steps to Read Word from EM4305 or EM4205 RFID tag

1. Transmit the Write Word command to the tag according to the previous paragraph

   a. The command is (first to transmit)“1001”(last to transmit) incl. parity

   b. Address is as appropriate

   c. Data field is not present

2. When the tag recognizes the command, it starts to execute it.
   a. Within the tPP time, the reader shall ignore the EM4095 DEMOD_OUT, to be ready to decode the tag response.
   b. The reader shall decode EM4095 DEMOD_OUT for continuous 8 + 45 bit periods at given encoding. The actual bit period is configured in the tag Config Word – typically 32 or 64 RF periods. Again, use upper bound estimation to set a timeout for the response reception. The actual encoding is also configured in the tag Config Word, typically it is Manchester or Bi-phase.

      See below the example of the reception algorithm

   c. Once the response stream is received, the reader shall analyse it to
      - detect the ERR or OK pattern
      - in case of OK pattern to extract the read data word and check the parity (note the read data structure is same as in the command – see Table 12 of the datasheet).

In the following text it is assumed that the tag is configured to RF/64 Manchester encoding.

Steps to receive an RF response from EM4305 or EM4205 RFID tag

Please see the Manchester encoding example in the EM4205/EM4305 datasheet (Return Link Encoder chapter).

1. The Manchester signal needs to be measured;
   a. set the uC timer to measure the tPP + expected response duration timeout (this is for cases when the tag does not respond or does not recognize the command, etc.)
   b. set the Manchester value bit variable to 0
   c. set the Manchester position variable to 0
   d. set the uC counter to count the number of EM4095 RDY/CLK periods between the consecutive sequence of EM4095 DEMOD_OUT edges (from rising to falling, then from falling to rising edge, etc.)

      Until the timeout, process the Manchester decoder code below for each measured duration value;

If the measured duration > 64+8 then

- Store the bit encoding error into the response stream. As the response measurement is started prior the first response edge, this condition is 100% sure to occur, hence serving as the response begin synchronization mark.
- Set the Manchester position to 1

If the measured duration > 48 then [note that 48 is the threshold between 32 and 64]

- Set the Manchester value bit to 1 if the recent DEMOD_OUT edge was falling, else to 0.
- Store the Manchester value bit into the response stream.
- Set the Manchester position to 0

else

If the Manchester position > 0 then

- Store the Manchester value bit into the response stream.
- Set the Manchester position to 0

else

- Set the Manchester position to 1

2. Stop all the timers/counters, and let's analyse the response stream.
   a. What shall we find in the response stream buffer?

- In case of OK pattern, the response stream shall look like “ <encoding error flag>,0,0,0,0,1,0,1,0]

Note that if the command is the Read Word, there is 45 read data bits following immediately after the OK pattern.

- In case of ERR pattern, , the response stream shall look like “ <encoding error flag>,0,0,0,0,0,0,0,1]

Note that the tag configured in the Default Read mode continues transmitting the predefined word contents immediately after the last OK pattern / ERR pattern / of the last read data word bit. Please ignore these bits.

b. Thus, the goal of the data extraction is to look for the OK or ERR patterns, and optional extract the read word data bits structure (as in Table 12).

- Since the 1st response modulation pulse might be distorted or otherwise corrupted, it is better to search for the shortened OK/ERR pattern; i.e. [0, 0, 1, 0, 1, 0] and [0, 0, 0, 0, 0, 1]. (The initial two bits are dropped.) within the first 10 bits of the received stream (this 10 bit limit is also important because without it we might mistook the consequent read data value for one of these patterns).
- <encoding error flags> presence serves as the response corrupted timing rejection indicating the poor quality of the tag to reader communication (e.g.; tag too far or perpendicular to the antenna, other external noise, etc.).

References

EM4205/E4305 Datasheet, rev.E (02/08)

EMDB409 Reader standard firmware source files implementing the above described principles are available to customers