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Tel: +86-755-8981 8866 Fax: +86-755-8427 6832
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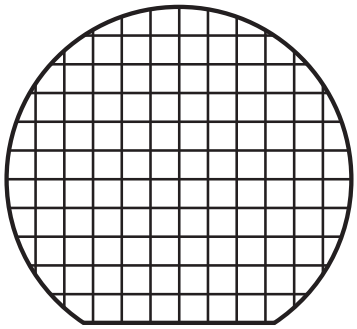
LRIS2K

2048-bit EEPROM tag IC at 13.56 MHz, with 64-bit UID and Password, ISO15693 and ISO18000-3 Mode 1 compliant

Features

- ISO 15693 standard fully compliant
- ISO 18000-3 Mode 1 standard fully compliant
- 13.56 MHz ±7 kHz carrier frequency
- To tag: 10% or 100% ASK modulation using 1/4 (26 Kbit/s) or 1/256 (1.6 Kbit/s) pulse position coding
- From tag: Load modulation using Manchester coding with 423 kHz and 484 kHz subcarriers in Low (6.6 Kbit/s) or High (26 Kbit/s) data rate mode. Supports the 53 Kbit/s data rate with Fast commands
- Internal tuning capacitor 21 pF
- 1 000 000 Erase/Write cycles (minimum)
- 40 year data retention (minimum)
- 2048-bits EEPROM with Block Lock feature
- 64-bit unique identifier (UID)
- Electrical article surveillance (EAS) capable (software controlled)
- Kill function
- Multipassword protection
- Read & Write (block of 32 bits)
- 5 ms programming time



Sawn Bumped Wafer

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1 Description

The LRIS2K is a contactless memory powered by the received carrier electromagnetic wave. It is a 2048-bit electrically erasable programmable memory (EEPROM). The memory is organized as 64 blocks of 32 bits. The LRIS2K is accessed via the 13.56 MHz carrier electromagnetic wave on which incoming data are demodulated from the received signal amplitude modulation (ASK: amplitude shift keying). The received ASK wave is 10% or 100% modulated with a data rate of 1.6 Kbit/s using the 1/256 pulse coding mode or a Data rate of 26 Kbit/s using the 1/4 pulse coding mode.

Outgoing data are generated by the LRIS2K load variation using Manchester coding with one or two subcarrier frequencies at 423 KHz and 484 kHz. Data are transferred from the LRIS2K at 6.6 Kbit/s in low data rate mode and 26 Kbit/s high data rate mode. The LRIS2K supports the 53 Kbit/s in high data rate mode in one subcarrier frequency at 423 kHz.

The LRIS2K follows the ISO 15693 recommendation for radio frequency power and signal interface.

Figure 1. Pad connections

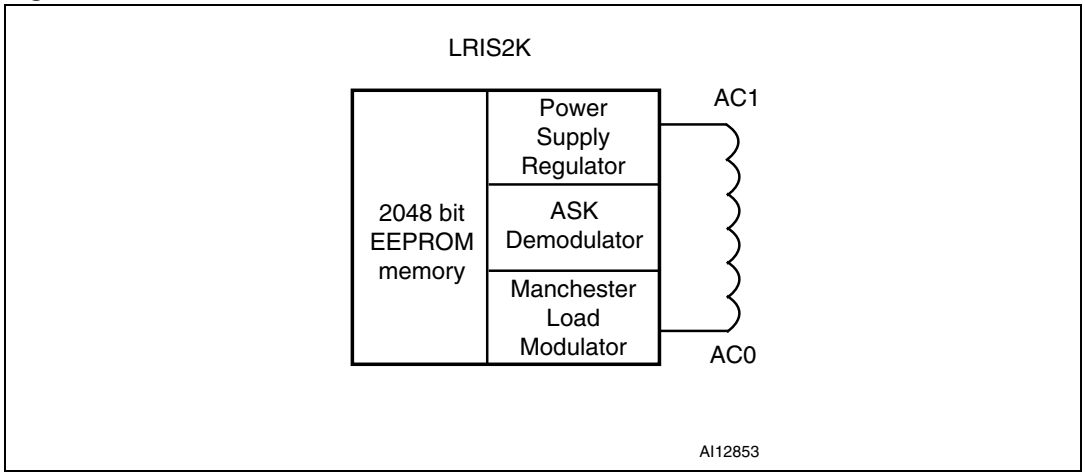


Table 1. Signal names

Signal name	Function
AC1	Antenna coil
AC0	Antenna coil

1.1 Memory mapping

The LRIS2K is divided into 64 blocks of 32 bits as shown in *Table 2*. Each block can be individually read- and/or write-protected using a specific lock or password command.

The user area consists of blocks that are always accessible. Read and Write operations are possible if the addressed block is not protected. During a Write, the 32 bits of the block are replaced by the new 32-bit value.

The LRIS2K also has a 64-bit block that is used to store the 64-bit unique identifier (UID). The UID is compliant with the ISO 15963 description, and its value is used during the anticollision sequence (Inventory). This block is not accessible by the user and its value is written by ST on the production line.

The LRIS2K also includes an AFI register in which the application family identifier is stored, and a DSFID register in which the data storage family identifier used in the anticollision algorithm is stored. The LRIS2K has four additional 32-bit blocks in which the Kill code and the password codes are stored.

Table 2. Memory map

Add	0 7	8 15	16 23	24 31	Protect status
0	User area				5 bits
1	User area				5 bits
2	User area				5 bits
3	User area				5 bits
4	User area				5 bits
5	User area				5 bits
6	User area				5 bits
7	User area				5 bits
8	User area				5 bits
...	...				...
60	User area				5 bits
61	User area				5 bits
62	User area				5 bits
63	User area				5 bits
	UID 0	UID 1	UID 2	UID 3	
	UID 4	UID 5	UID 6	UID 7	
	AFI	DSFID			
0(1)	Kill code				5 bits
1(1)	Password code 1				5 bits
2(1)	Password code 2				5 bits
3(1)	Password code 3				5 bits

1. RFU bit (b8) of Request_flag set to 1.

1.2 Commands

The LRIS2K supports the following commands:

- ***Inventory***, used to perform the anticollision sequence.
- ***Stay Quiet***, used to put the LRIS2K in quiet mode, where it does not respond to any inventory command.
- ***Select***, used to select the LRIS2K. After this command, the LRIS2K processes all Read/Write commands with Select_flag set.
- ***Reset To Ready***, used to put the LRIS2K in the ready state.
- ***Read Block***, used to output the 32 bits of the selected block and its locking status.
- ***Write Block***, used to write the 32-bit value in the selected block, provided that it is not locked.
- ***Lock Block***, used to lock the selected block. After this command, the block cannot be modified.
- ***Write AFI***, used to write the 8-bit value in the AFI register.
- ***Lock AFI***, used to lock the AFI register.
- ***Write DSFID***, used to write the 8-bit value in the DSFID register.
- ***Lock DSFID***, used to lock the DSFID register.
- ***Get System Info***, used to provide the system information value
- ***Get Multiple Block Security Status***, used to send the security status of the selected block.
- ***Initiate***, used to trigger the tag response to the Inventory Initiated sequence.
- ***Inventory Initiated***, used to perform the anticollision sequence triggered by the Initiate command.
- ***Kill***, used to definitively deactivate the tag.
- ***Write Password***, used to write the 32 bits of the selected password.
- ***Lock Password***, used to write the Protect Status bits of the selected block.
- ***Present Password***, enables the user to present a password to unprotect the user blocks linked to this password.
- ***Fast Initiate***, used to trigger the tag response to the Inventory Initiated sequence.
- ***Fast Inventory Initiated***, used to perform the anticollision sequence triggered by the Initiate command.
- ***Fast Read Single Block***, used to output the 32 bits of the selected block and its locking status.

1.3 Initial dialogue for vicinity cards

The dialog between the vicinity coupling device (VCD) and the vicinity integrated circuit Card or VICC (LRIS2K) takes place as follows:

- activation of the LRIS2K by the RF operating field of the VCD.
- transmission of a command by the VCD.
- transmission of a response by the LRIS2K.

These operations use the RF power transfer and communication signal interface described below (see *Power transfer*, *Frequency* and *Operating field*). This technique is called RTF (Reader Talk First).

1.3.1 Power transfer

Power is transferred to the LRIS2K by radio frequency at 13.56 MHz via coupling antennas in the LRIS2K and the VCD. The RF operating field of the VCD is transformed on the LRIS2K antenna to an AC Voltage which is rectified, filtered and internally regulated. The amplitude modulation (ASK) on this received signal is demodulated by the ASK demodulator.

1.3.2 Frequency

The ISO 15693 standard defines the carrier frequency (f_C) of the operating field as 13.56 MHz ±7 kHz.

1.3.3 Operating field

The LRIS2K operates continuously between H_{min} and H_{max}.

- The minimum operating field is H_{min} and has a value of 150 mA/m rms.
- The maximum operating field is H_{max} and has a value of 5 A/m rms.

A VCD shall generate a field of at least H_{min} and not exceeding H_{max} in the operating volume.

2 LRIS2K block security

The LRIS2K provides a special protection mechanism based on passwords. Each memory block of the LRIS2K can be individually protected by one out of three available passwords, and each block can also have Read/Write access conditions set.

Each memory block of the LRIS2K is assigned with a Protect Status area including a Block Lock bit, two Password Control bits and two Read/Write protection bits as shown in *Table 4*. *Table 4* describes the organization of the Protect status area which can be read using the Read Single Block command with the Option_flag set to '1', and the Get Multiple Block Security status command.

Table 3. Memory blocks with protect status area

Add	0 7	8 15	16 23	24 31	Protect status
0	User area				5 bits
1	User area				5 bits
...	User area				5 bits

Table 4. Protect status area organization

b_7	b_6	b_5	b_4	b_3	b_2	b_1	b_0
0	0	0	Password Control bits		Read / Write protection bits		Block Lock

When the Block Lock bit is set to '1', for instance by issuing a Block Lock command, the 2 Read/Write protection bits (b_1, b_2) are used to set the Read/Write access of the block as described in *Table 5*.

The next 2 bits of the Protect Status area (b_3, b_4) are the Password Control bits. The value of these two bits is used to link a password to the block as defined in *Table 5*.

Combinations not described in *Table 5* are reserved.

Table 5. Read / Write protection bit setting and block protection status

Block lock function		Password Control bits	Block access when password presented		Block access when password not presented		Block protection status
b_0	b_2, b_1	b_4, b_3					
0	00	00	Not applicable		READ	WRITE	the block is not protected
1	11	01	READ	NO WRITE	NO READ	NO WRITE	the block is protected by password 1
1	11	10	READ	NO WRITE	NO READ	NO WRITE	the block is protected by password 2
1	11	11	READ	NO WRITE	NO READ	NO WRITE	the block is protected by password 3
1	00	00	Not applicable		READ	NO WRITE	the block is not protected by a password

The LRIS2K password protection is organized around a dedicated set of commands plus a system area of four password blocks where the password values and the Kill code are stored. Each password block also has a Protect Status area, making it possible to set the Read / Write access right of each individual block. This system area is described in *Table 6*.

Table 6. Password system area

Add	0 7	8 15	16 23	24 31	Protect status
0	Kill code				5 bits
1	Password 1				5 bits
2	Password 2				5 bits
3	Password 3				5 bits

The dedicated password commands are:

- **Write Password:**

  The Write Password command is used to write a 32-bit block into the password system area. This command must be used to write or update password values and to set the kill code. Depending on the Read/Write access set in the Protect Status area, it is possible to modify a password value after issuing a valid Present Password command.

- **Lock Password:**

  The Lock Password command is used to set the Protect Status area of the selected block. Bits b_4 to b_1 of the Protect Status are affected by the Lock Password command. The Block Lock bit, b_0, is set to '1' automatically. After issuing a Lock Password command, the protection settings of the selected block are activated. The protection of a locked block cannot be changed. A Lock Password command sent to a locked block returns an error code.
  The Lock Password command is also used to set the Protect Status areas of the password blocks. RFU bit 8 of the Request_flag is used to select either the memory area (bit 8 = '0') or the password area (bit 8 = '1').

- **Present Password:**

  The Present Password command is used to present one of the three passwords to the LRIS2K in order to modify the access rights of all the memory blocks linked to that password (*Table 5*) including the password itself. If the presented password is correct, the access rights remain activated until the tag is powered off or until a new Present Password command is issued.

3 Example of LRIS2K security protection

Table 7 and *Table 8* show the block security protections before and after a valid Present Password command. The *Table 7* shows blocks access rights of an LRIS2K after power-up. After a valid Present Password command with password 1, the memory block access is changed as given in *Table 8*.

Table 7. LRIS2K block security protection after power-up

Add	0 7 8 15 16 23 24 31	Protect status					
		$b_7b_6b_5$	b_4	b_3	b_2	b_1	b_0
0	Protection: Standard, Read - No Write	xxx	0	0	0	0	1
4	Protection: Pswd 1, No Read - No Write	xxx	0	1	1	1	1

Table 8. LRIS2K block security protection after a valid presentation of password 1

Add	0 7 8 15 16 23 24 31	Protect status					
		$b_7b_6b_5$	b_4	b_3	b_2	b_1	b_0
0	Protection: Standard, Read - No Write	xxx	0	0	0	0	1
4	Protection: Pswd 1, **Read - No Write**	xxx	0	1	1	1	1

4 Communication signal from VCD to LRIS2K

Communications between the VCD and the LRIS2K takes place using the modulation principle of ASK (Amplitude Shift Keying). Two modulation indexes are used, 10% and 100%. The LRIS2K decodes both. The VCD determines which index is used.

The modulation index is defined as [a – b]/[a + b] where a is the peak signal amplitude and b, the minimum signal amplitude of the carrier frequency.

Depending on the choice made by the VCD, a “pause” will be created as described in *Figure 2* and *Figure 3*.

The LRIS2K is operational for any degree of modulation index from between 10% and 30%.

Figure 2. 100% modulation waveform

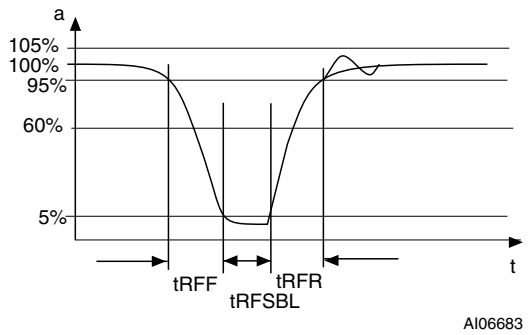
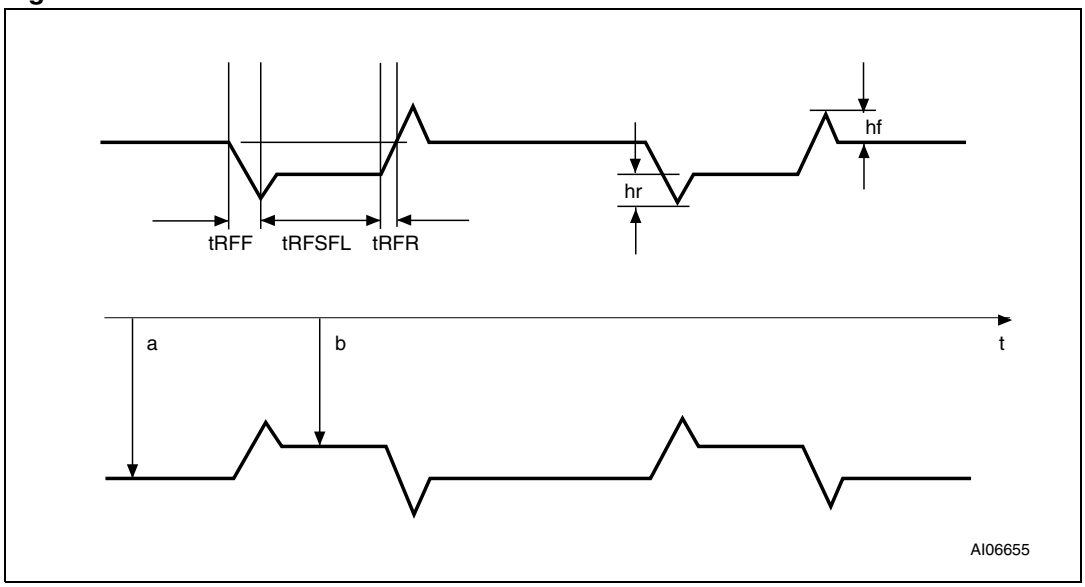


Table 9. 10% modulation parameters

Symbol	Parameter definition	Value
hr	0.1 x (a – b)	max
hf	0.1 x (a – b)	max

Figure 3. 10% modulation waveform



5 Data rate and data coding

The data coding implemented in the LRIS2K uses pulse position modulation. Both data coding modes that are described in the ISO15693 are supported by the LRIS2K. The selection is made by the VCD and indicated to the LRIS2K within the start of frame (SOF).

5.1 Data coding mode: 1 out of 256

The value of one single byte is represented by the position of one pause. The position of the pause on 1 of 256 successive time periods of 18.88 µs (256/f_C), determines the value of the byte. In this case the transmission of one byte takes 4.833 ms and the resulting data rate is 1.65 kbits/s (f_C/8192).

Figure 4 illustrates this pulse position modulation technique. In this figure, data E1h (225 decimal) is sent by the VCD to the LRIS2K.

The pause occurs during the second half of the position of the time period that determines the value, as shown in *Figure 5*.

A pause during the first period transmits the data value 00h. A pause during the last period transmit the data value FFh (255 decimal).

Figure 4. 1 out of 256 coding mode

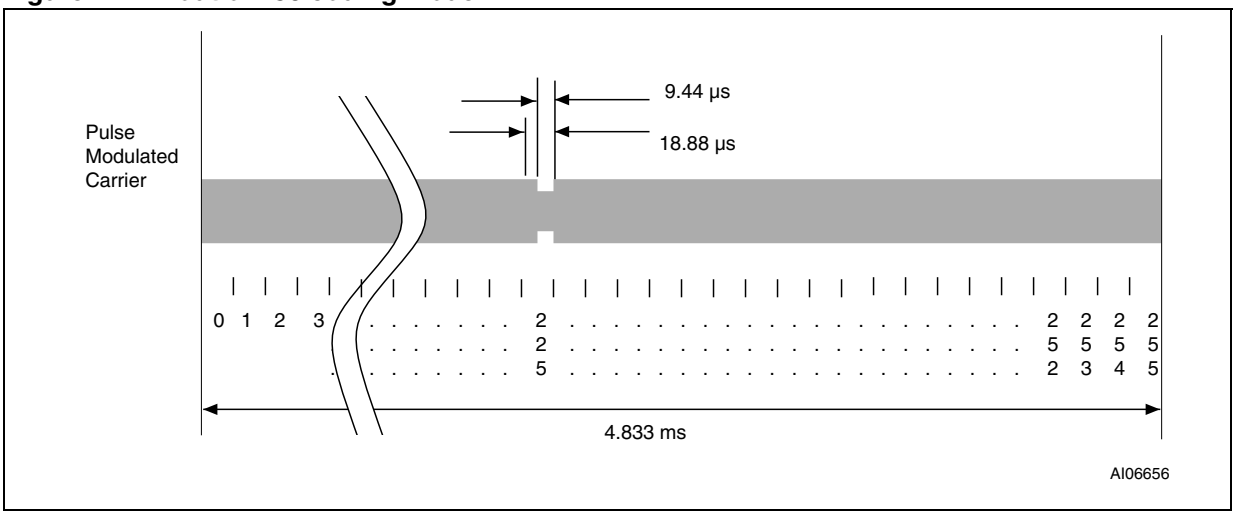
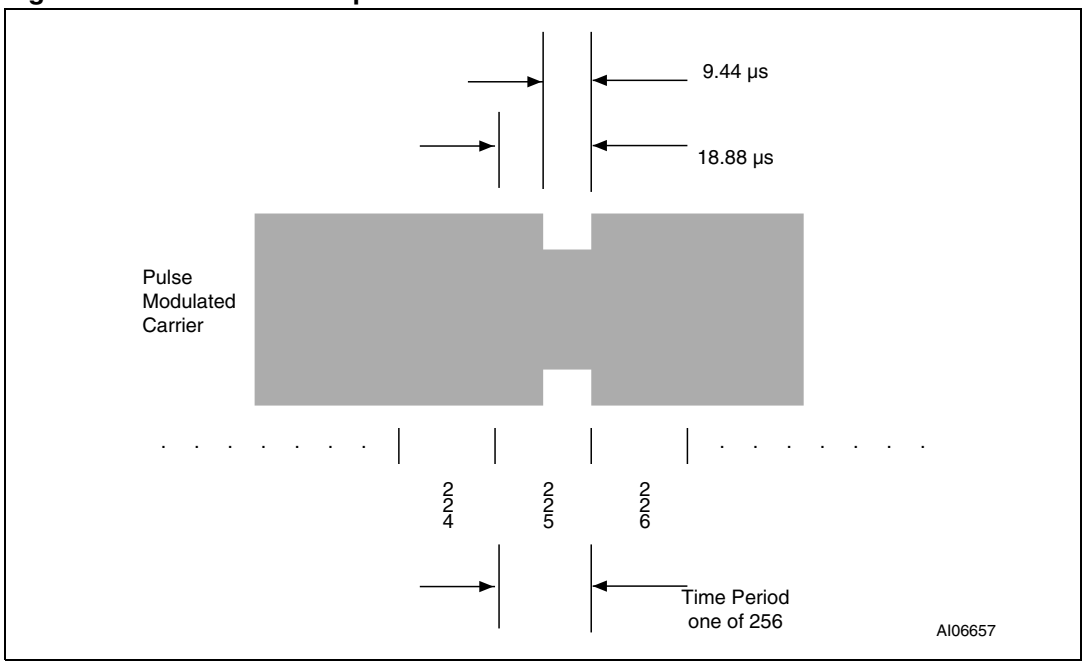


Figure 5. Detail of a time period



5.2 Data coding mode: 1 out of 4

The value of 2 bits is represented by the position of one pause. The position of the pause on 1 of 4 successive time periods of 18.88 µs (256/f_C), determines the value of the 2 bits. Four successive pairs of bits form a byte, where the least significant pair of bits is transmitted first.

In this case the transmission of one byte takes 302.08 µs and the resulting data rate is 26.48 Kbits/s (f_C/512). *Figure 6* illustrates the 1 out of 4 pulse position technique and coding. *Figure 7* shows the transmission of E1h (225d - 1110 0001b) by the VCD.

Figure 6. 1 out of 4 coding mode

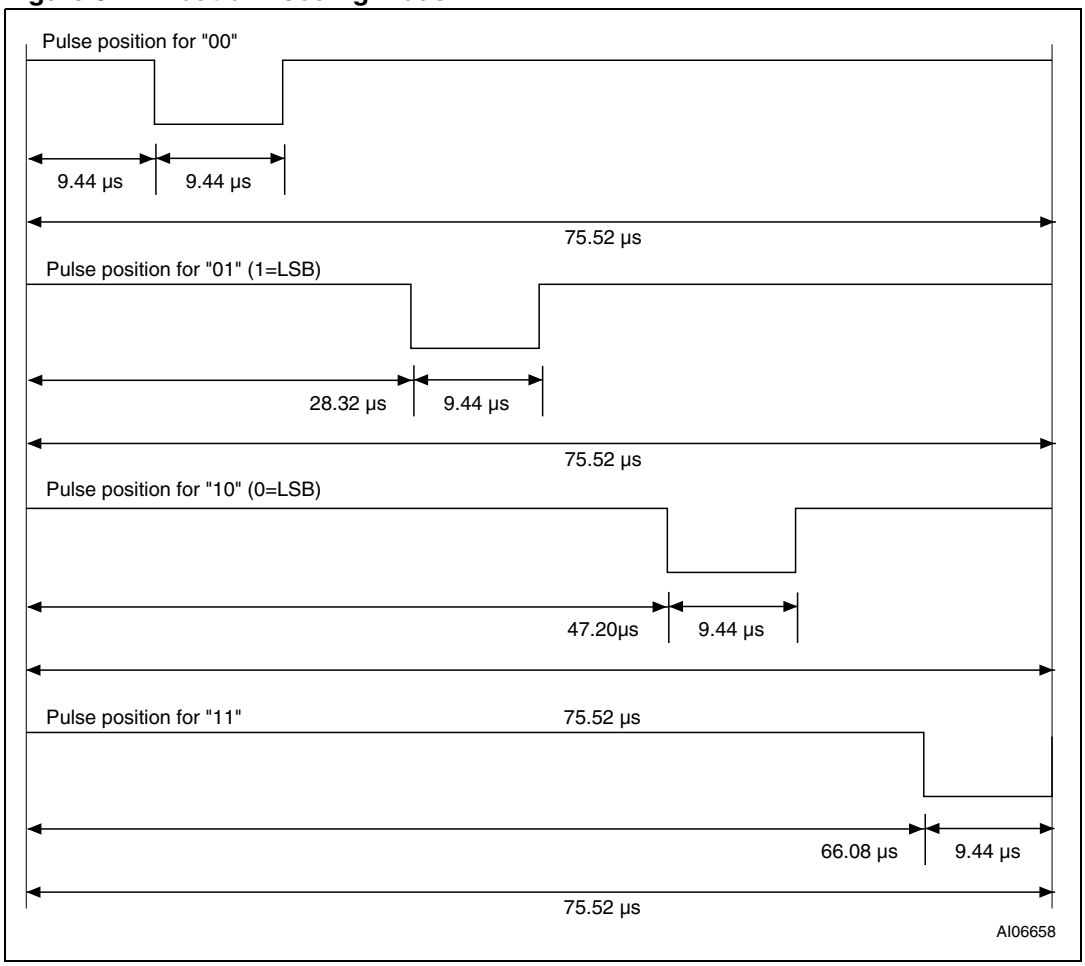
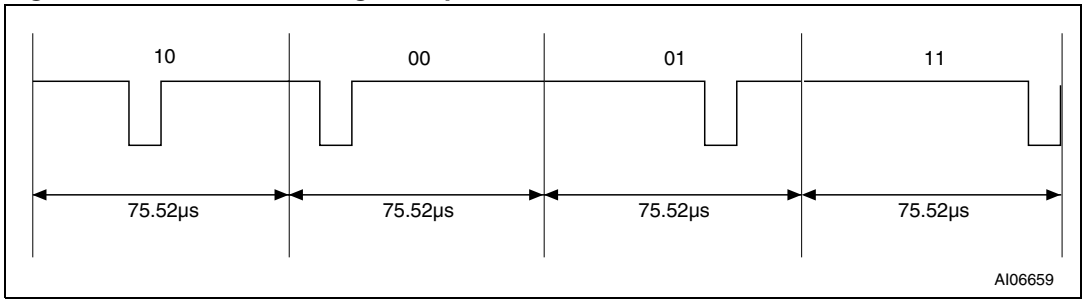


Figure 7. 1 out of 4 coding example



5.3 VCD to LRIS2K frames

Frames are delimited by a start of frame (SOF) and an end of frame (EOF). They are implemented using code violation. Unused options are reserved for future use.

The LRIS2K is ready to receive a new command frame from the VCD 311.5 µs (t_2) after sending a response frame to the VCD.

The LRIS2K takes a power-up time of 0.1 ms after being activated by the powering field. After this delay, the LRIS2K is ready to receive a command frame from the VCD.

5.4 Start of frame (SOF)

The SOF defines the data coding mode the VCD is to use for the following command frame. The SOF sequence described in *Figure 8* selects the 1 out of 256 data coding mode. The SOF sequence described in *Figure 9* selects the 1 out of 4 data coding mode. The EOF sequence for either coding mode is described in *Figure 10*.

Figure 8. SOF to select 1 out of 256 data coding mode

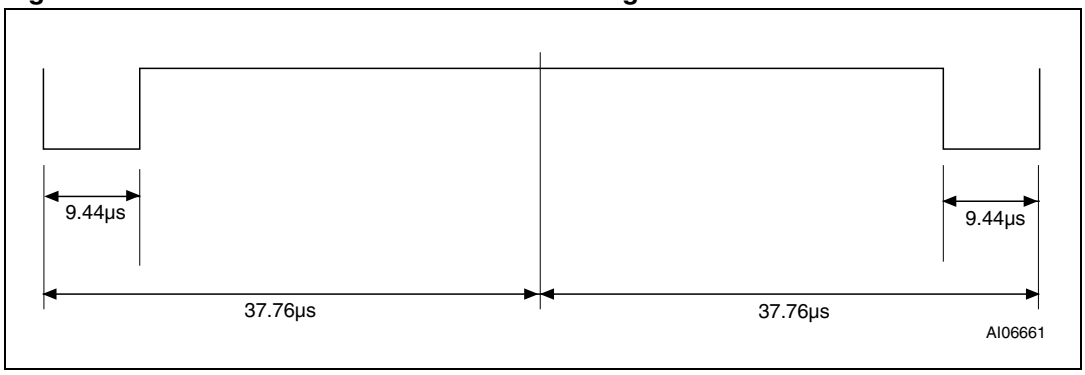


Figure 9. SOF to select 1 out of 4 data coding mode

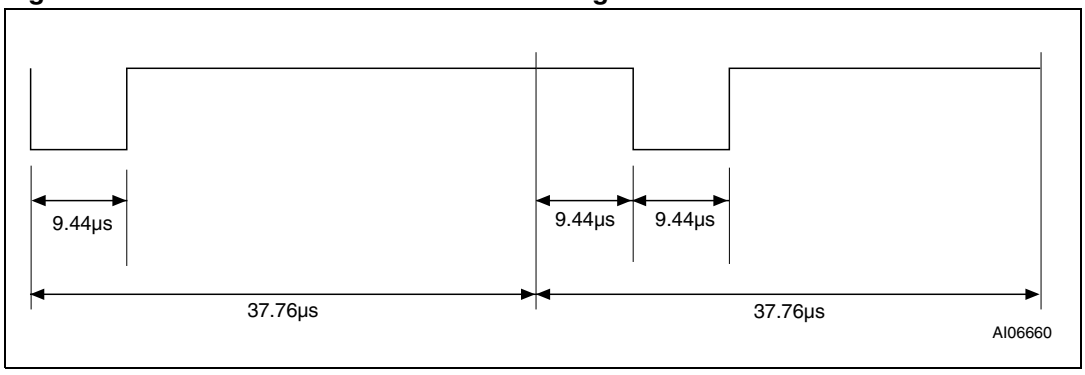
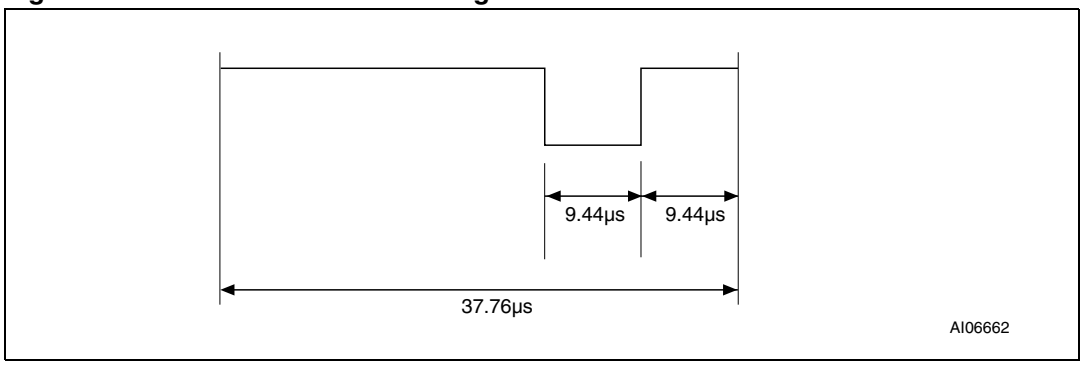


Figure 10. EOF for either data coding mode



6 Communications signal from LRIS2K to VCD

The LRIS2K has several modes defined for some parameters, owing to which it can operate in different noise environments and meet different application requirements.

6.1 Load modulation

The LRIS2K is capable of communication to the VCD via an inductive coupling area whereby the carrier is loaded to generate a subcarrier with frequency f_S. The subcarrier is generated by switching a load in the LRIS2K.

The load-modulated amplitude received on the VCD antenna must be of at least 10mV when measured as described in the test methods defined in International Standard ISO10373-7.

6.2 Subcarrier

The LRIS2K supports the one-subcarrier and two-subcarrier response formats. These formats are selected by the VCD using the first bit in the protocol header. When one subcarrier is used, the frequency f_{S1} of the subcarrier load modulation is 423.75 kHz (f_C/32). When two subcarriers are used, the frequency f_{S1} is 423.75 kHz (f_C/32), and frequency f_{S2} is 484.28 kHz (f_C/28). When using the two-subcarrier mode, the LRIS2K generates a continuous phase relationship between f_{S1} and f_{S2}.

6.3 Data rates

The LRIS2K can respond using the low or the high data rate format. The selection of the data rate is made by the VCD using the second bit in the protocol header. It also supports the x2 mode available on all the Fast commands. *Table 10* shows the different data rates produced by the LRIS2K using the different response format combinations.

Table 10. Response data rates

Data rate		One subcarrier	Two subcarriers
Low	Standard commands	6.62 Kbits/s (f_c/2048)	6.67 Kbits/s (f_c/2032)
	Fast commands	13.24 Kbits/s (f_c/1024)	not applicable
High	Standard commands	26.48 Kbits/s (f_c/512)	26.69 Kbits/s (f_c/508)
	Fast commands	52.97 Kbits/s (f_c/256)	not applicable