TEXAS INSTRUMENTS

Series 2000 Reader System

RFM Sequence Control

Reference Manual

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TIRIS Technology by Texas Instruments™

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Edition One - October 1999

This is the first edition of this manual, it describes the timing and sequence of the radio communications between TIRIS LF transponders and the Radio Frequency Module.

PREFACE

Read This First

About This Guide

This guide describes the sequence control of the communication with TIRIS LF transponders.

Conventions

WARNING:

A WARNING IS USED WHERE CARE MUST BE TAKEN, OR A CERTAIN PROCEDURE MUST BE FOLLOWED IN ORDER TO PREVENT INJURY OR HARM TO YOUR HEALTH.

CAUTION:

This indicates information on conditions which must be met, or a procedure which must be followed, which if not heeded could cause permanent damage to the equipment or software.

Note:

Indicates conditions which must be met, or procedures which must be followed, to ensure proper functioning of the equipment or software.

Information:

Indicates information which makes usage of the equipment or software easier

If You Need Assistance

Application Centers are located in various countries in Europe, North and South America, Asia and Australia to provide direct support. For more information, please contact your nearest TIRIS Sales and Application Center. The contact addresses can be found on our home page:

http://www.tiris.com

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CHAPTER 1

Introduction

This chapter will introduce you to the Sequence Control and the products with which it works.

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CHAPTER 1

Introduction

1.1 General

This document provides information about the Sequence Control of the TIRIS Radio Frequency Modules (as listed under 1.1.1 Product Option Coding) and allows the user to design hardware and software for Control Modules, which are able to read TIRIS 64-bit Read Only transponders and to read and program TIRIS 64-bit Read/ Write transponders, TIRIS Multipage transponders and TIRIS Selective Addressable Multipage transponders.

1.1.1 Product Option Coding

This Reference Guide is applicable for use together with the following products:

RF Modules:

Series 2000 Standard RFM	RI-RFM-104B
Series 2000 Mini RFM	RI-RFM-003B
Series 2000 RFM IC	RI-RFM-006A
Series 2000 High Performance RFM	RI-RFM-007B
Series 2000 High Performance RA-RFM	RI-RFM-008B

Note:

For more information about the Radio Frequency Modules please refer to the relevent Reference Guide which is available at the TIRIS site on the internet.

Transponders:

RI-TRP-R…	64 bit	Read Only
RI-TRP-W…	80 bit	Read/Write
RI-TRP-D…	1360 bit	Multipage 17 pages Read/Write
RI-TRP-I…	1360 bit	Selective Addressable Multipage, 17 pages Read/Write, 24 bit selective address

1.2 RFM Functionality

In order to read TIRIS 64-bit Read Only transponders (RO), and to read and program TIRIS 64-bit Read/Write transponders (R/W) and TIRIS Multipage Transponders (MPT), the system must comprise the following parts (see Figure 1):

ANTENNA

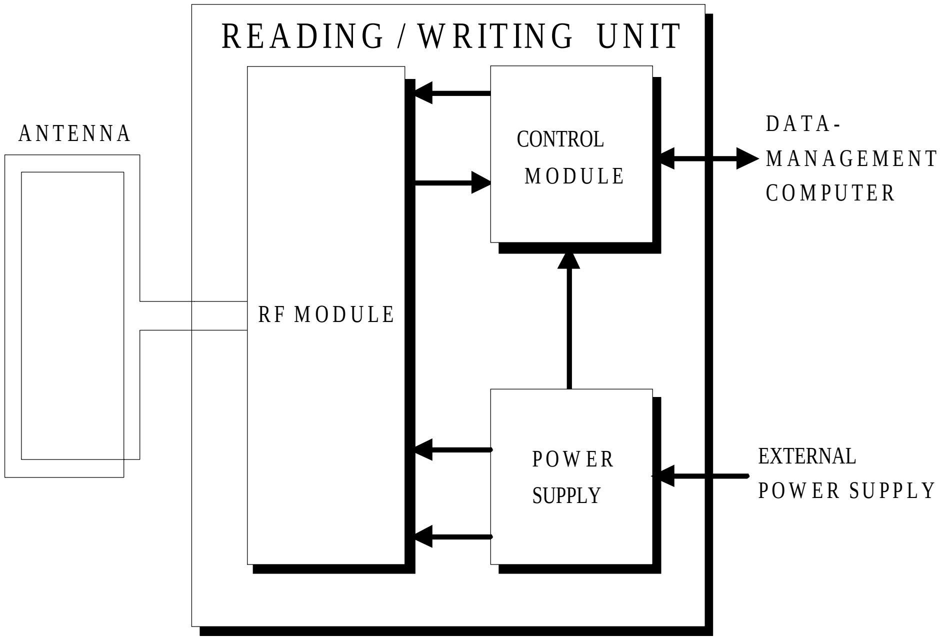
RF MODULE

CONTROL MODULE

POWER SUPPLY

The combination of these components are further referred to in this manual as Reading/Writing Units even though they can be designed for read only function or for read and write function, depending on the user requirements.

Figure 1: Block Schematic of a Reading/Writing Unit



The RF module contains the basic functions to allow data to be read from and written to the transponder. Inductive coupling principle is used for data transmission between the Reading/Writing Unit and the transponder.

The RF Module’s transmitter provides the following functions: wireless supply of the transponder power (Charge), writing data to the transponder using pulse width modulation (Write). Programming the transponder’s memory (Program).

The RF Module’s receiver demodulates the transponder response signal (Read), this response is modulated using Frequency Shift Keying (FSK). It provides a digital data output (RXDT). A divider by 16 generates a digital reference clock signal (RXCK) out of the received RF signal.

The Control Module provides all the functions for Sequence Control of the TIRIS RF Modules. The Sequence Control can be realized by using a micro-computer, by using a control logic or by a combination of both. A Control Module supervises the timing of the Charge, Write, Programming and Read functions. It generates and checks Protection Data and converts the received transponder Identification Data (response) to standard and user specific interface formats.

1.3 Overview of Functions

CHARGE-ONLY READ: The content of Page 1 can be read without addressing the page. Only the charge phase and the subsequent Read phase is required. Described in Chapter 2:

GENERAL READ PAGE: A certain page is addressed by sending a Page Address to the transponder. The content of the addressed page is returned during the subsequent Read phase. Described in Chapter 2:

PROGRAM PAGE: A Page Address or Initializing Data and 80 Data bits are sent to the transponder during the Write phase. The Data bits are programmed into the addressed EEPROM Page during the subsequent Program phase. The new content of the Page is returned during Read phase. Described in Chapter 3:

LOCK PAGE: The content of an EEPROM page is locked, that means the 80 Data bits are read only from now on. The response during Read phase is still using the Multipage R/W transponder Read Data Format.Described in Chapter 3:

SELECTIVE READ PAGE: To achieve readout of a page, a Selective Address must be sent to the transponder together with the Page Address. The transponder compares the Selective Address with the corresponding LSB's of the Identification in Page 1. The function is executed if all of the bits match. Otherwise the transponder does not respond. Described in Chapter 3:

SELECTIVE PROGRAM PAGE:In order to program a page, a Selective Address must be sent to the transponder together with the Page Address. The transponder compares the Selective Address with the corresponding LSB's of the Identification in Page 1. The function is executed if all of the bits match. Otherwise the transponder does not respond. Described in Chapter 3:

SELECTIVE LOCK PAGE: In order to lock a page, a Selective Address must be sent to the transponder together with the Page Address. The transponder compares the Selective Address with the corresponding LSB's of the Identification in Page 1. The function is executed if all of the bits match. Otherwise the transponder does not respond. Described in Chapter 3:

Table 1: Transponder Type Function Overview

Product Code	Type	Charge -only Read	Gen. Read Page	Prog. Page	Lock Page	Sel. Read Page	Sel. Progr. Page	Sel. Lock Page
RI-TRP-R...	RO	1		-	-	-	-	-
RI-TRP-W...	R/W	1		1	-	-	-	-
RI-TRP-D...	MPT	1	1-17	1-17	1-17	-	-	-
RI-TRP-I...	SAMPT	-	1-17	-	-	1-17	1-17	1-17

CHAPTER 2

Charge and Read Functions

This chapter will introduce you to the Charge and Read Functions, tell you about their Data Formats and their timings.

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2.1 Charge

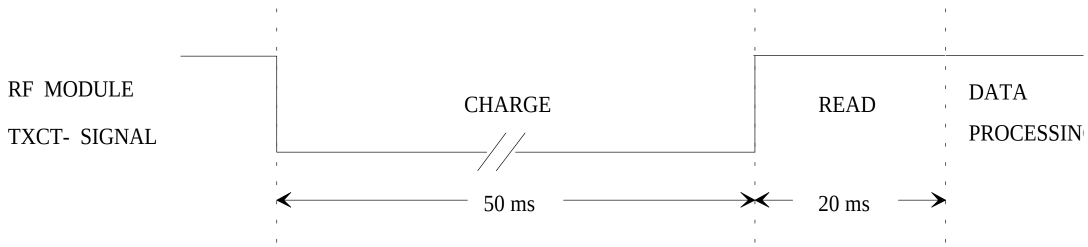
During Charge Time (see Figures 2 and 8), the RF Module's transmitter is continuously activated by the input signal TXCT- (active = low). As long as the transmitter is active, the antenna circuit resonates at a quartz-controlled frequency of 134.2 kHz and generates an electromagnetic field around the antenna. If a TIRIS transponder is within this field, it will accumulate energy from this field in its charge capacitor. That means, the transponder is charged. The required Charge Time (t_{TX}) is typically 50 ms, but it can be different ($t_{TX}S$, $t_{TX}C$) depending on the requirements of the application:

- Transponder type
- Antenna type
- Distance between transponder and antenna
- Moving speed of the transponder in relation to the antenna
- Allowed field strength (PTT/ FCC regulations)

The RF Module's receiver is not able to receive during the Charge phase. While the receiver clock output (RXCK) is disabled (low), the data output (RXDT) is active but undefined (low or high).

When the transmit signal is switched off (TXCT- = high), the transponder detects the end of RF burst and starts sending its data using Frequency Shift Keying and the Reading/Writing Unit starts with the read phase.

Figure 2: Charge Function



2.2 Read

A fixed Read Time (t_{RD}) of 20 ms, beginning with the deactivation of the TXCT- signal (see Figures 2 and 8), should be provided for the receiver. During this phase the transponder transmits one of the following Read Data Formats by using Frequency Shift Keying:

64-bit Read Only Data Format

64-bit Read/Write Data Format

Multipage Read/Write Data Format

The typical low bit frequency (fL) is 134.2 kHz, the typical high bit frequency (fH) is 123.2 kHz. Because each bit has 16 cycles, the low and high bits have different durations. The high bit has a typical duration of 130 µs, the low bit of 119 µs. The transponder response duration depends on the number of low and high bits; it is in any case always shorter than 20 ms.

All of the Data Formats consist of 128 bits which must be checked by a Control Module. Different Start Bytes, Stop Bytes and End Bits, respectively Read Address Byte and Frame Block Check Characters are used in order to distinguish between the transponder types.

2.2.1 64-bit Read Only Transponder Read Data Format

Description	Bits	Value (HEX)	Notes
		MSB . . . . LSB	
Pre Bits	16	0000	x: Identification Data y: Data BCC
Start Byte	8	7E	
Read Data	80	yyyyxxxxxxxxxxxxxxxx	
Stop Byte	8	7E	
End Bits	16	0000	
TOTAL	128		

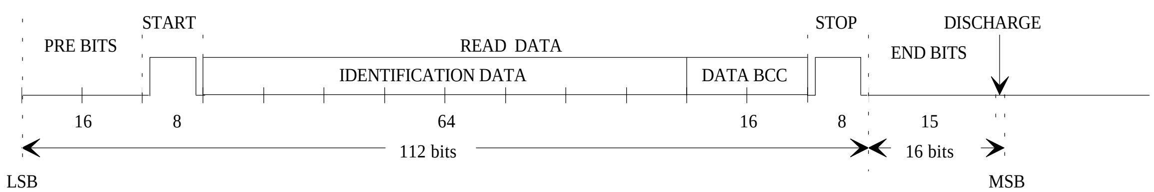
All parts of the 64-Bit Read Only transponder Read Data Format (see Figure 3) are transmitted with LSB first. The Data Format starts with 16 Pre Bits which are all zero (0000_{HEX}). The Start Byte 01111110_{BIN} ($7E_{HEX}$) is equal to the Stop Byte.

80 Read Data bits are located between the Start Byte and the Stop Byte, these bits are factory programmed into the transponder's memory and cannot be changed by the user. They comprise 64 Identification Data bits (unique identification), transmitted first, followed by 16 Protection Data bits (Data BCC).

After the Stop Byte (after 112 bits) 16 low bits are transmitted (End Bits). 15 of the End Bits, beginning with the LSB, must be checked by a Control Module.

During bit 128 (the 16th of the End Bits) the transponder terminates the Data Format by discharging its charge capacitor.

Figure 3: 64-bit Read Only Transponder Read Data Format



2.2.2 64-Bit Read/Write Transponder Read Data Format

Description	Bits	Value (HEX)	Notes
		MSB . . . . LSB	
Pre Bits	16	0000	x: Identification Data y: Data BCC
Start Byte	8	FE	
Read Data	80	yyyyxxxxxxxxxxxxxxxx	
Stop Byte	8	FE	
End Bits	16	xxxx	
TOTAL	128		

All parts of the 64-bit Read/Write transponder Read Data Format (see Figure 4) are transmitted with LSB first. The Data Format starts with 16 Pre Bits which are all zero

(0000_{HEX}). The Start Byte 11111110_{BIN} (FE_{HEX}) is equal to the Stop Byte.

80 Read Data bits are located between the Start Byte and the Stop Byte, these data bits can be programmed by the user. We recommend that you split the Read Data bits into 64 Identification Data bits (unique identification), transmitted first, followed by 16 Protection Data bits (Data BCC).

We recommend the CRC-CCITT as protection algorithm for the Data BCC. This algorithm gives optimum data security and is therefore explained in this Guide (see section 2.2.6).

After the Stop Byte (after 112 bits) 16 additional bits (End Bits) are transmitted. These bits reflect the 16 LSBs of the Read Data. 15 of these End Bits, beginning with the LSB, must be checked by a Control Module.

During bit 128 (the 16th of the End Bits) the transponder terminates the Data Format by discharging its charge capacitor.

Figure 4: 64-bit Read/Write Transponder Read Data Format

2.2.3 Multipage Read/Write Transponder Read Data Format

Description	Bits	Value (HEX)	Notes
		MSB . . . . LSB	
Pre Bits	16	0000	
Start Byte	8	7E	x: Identification Data y: Data BCC ps: Page + Status z: Frame BCC
Read Data	80	yyyyxxxxxxxxxxxxxxxx	
Read Address	8	ps	
Read Frame BCC	16	zzzz	
TOTAL	128		

All parts of the Multipage Read/Write transponder Read Data Format (see Figure 5) are transmitted with LSB first. The Data Format starts with 16 Pre Bits which are all zero (0000_{HEX}). The Start Byte 01111110_{BIN} ($7E_{HEX}$) is equal to the 64-bit Read Only Start Byte. Distinction between 64-bit Read Only transponder and Multipage Read/Write transponder is possible after reception of the Read Address and the Read Frame Block Check Character (Read Frame BCC).

80 Read Data bits are located between the Start Byte and the Read Address (these can be programmed and locked by the user). We recommend that you split the Read Data into 64 Identification Data bits, transmitted first, followed by 16 Protection Data bits (Data BCC). We recommend the CRC-CCITT as protection algorithm for the Data BCC. This algorithm gives optimum data security and is therefore explained in this Guide (see section 2.2.6).

The Read Address consists of a 2-bit Status field and a 6-bit Page field.

The Status field, which is transmitted first, informs the Control Module about the function the Multipage transponder has executed and which type of Page has been received.

If the Page field is zero, the Status field has another meaning.

```
READ ADDRESS
MSB                 LSB

P P P P P P  S S
     |         |
   PAGE     STATUS
```

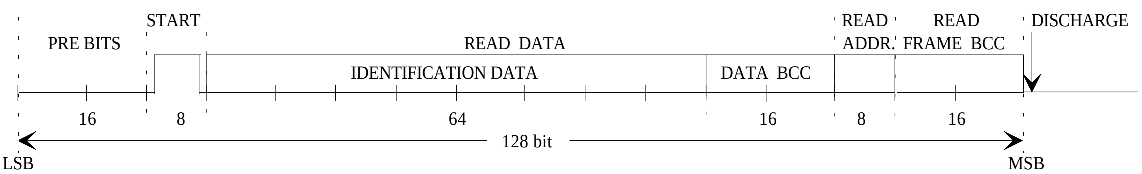
	MSB LSB	MSB LSB	
Page 1	000001	00	Read unlocked page
Page 2	000010	01	Programming done
. .	.	10	Read locked page
Page 16	010000	11	Reserved *)
Page 17	010001		
	000000	00	Read unlocked Page, locking not correctly executed
	000000	01	Programming done, but possibly not reliable
	000000	10	Read locked Page, but locking possibly not reliable

*) If the Status indicates 'Reserved', the Read Data cannot be interpreted as Identification Data.

The 16-bit Read Frame Block Check Character (Read Frame BCC), which protects the 80 bit Read Data and the 8 bit Read Address, is generated in the Multipage transponder by a CRC Generator using the CRC-CCITT algorithm (see Figure 7).

During bit 129 (1 bit after the End Bits) the transponder terminates the Data Format by discharging its charge capacitor.

Figure 5: Multipage Read/Write Transponder Read Data Format



2.2.4 Waiting Time

The Read Time (20 ms) starts with deactivation of the TXCT- signal (see Figure 6 and 8). Immediately after detecting the end of RF burst, the transponder starts transmitting 16 Pre Bits (low bits), in order to give the RF Module receiver enough time to recover from RF power burst overload.

The Pre Bit phase has a duration of approximately 1.9 ms. This is because the Low Bit Frequency (fL) of the transponder resonant circuit is approximately 134.2 kHz and that each bit has a duration of 16 RclkL-cycles. The Sequence Control should start to check the data output (RXDT) 1 ms at the earliest and 1.5 ms the latest, after the TXCT- signal is switched off (Waiting Time). The RXDT signal can be undefined in this period due to receiver overload during Charge Time.

2.2.5 Wait for Start Byte (Part 1 - Watching Time)

After the Waiting Time, the Sequence Control has to check the RXDT output during the Watching Time (see Figures 6, 8 and 9) to detect the first low-to-high transition of the Start Byte (2nd bit). The Watching Time must be limited depending on the selected Waiting Time. The sum of Waiting Time and Watching Time should be less than or equal to the total Read Time (20 ms).

With the first RXDT low-to-high transition (2nd bit) and all consecutive low-to-high transitions, the RF Module synchronizes its clock (RXCK) and its data (RXDT). Because of this, the positive transition of the clock is in the center of a bit period. One clock signal is generated for each data bit ($f_{RXCK}L = fL / 16$, $f_{RXCK}H = fH / 16$).

After the first low-to-high transition (2nd bit), the Sequence Control has to watch for positive transitions on the RXCK output and has to store the state of the RXDT output. Because the clock of the first bit could be asynchronous to the data, this bit should not be used.

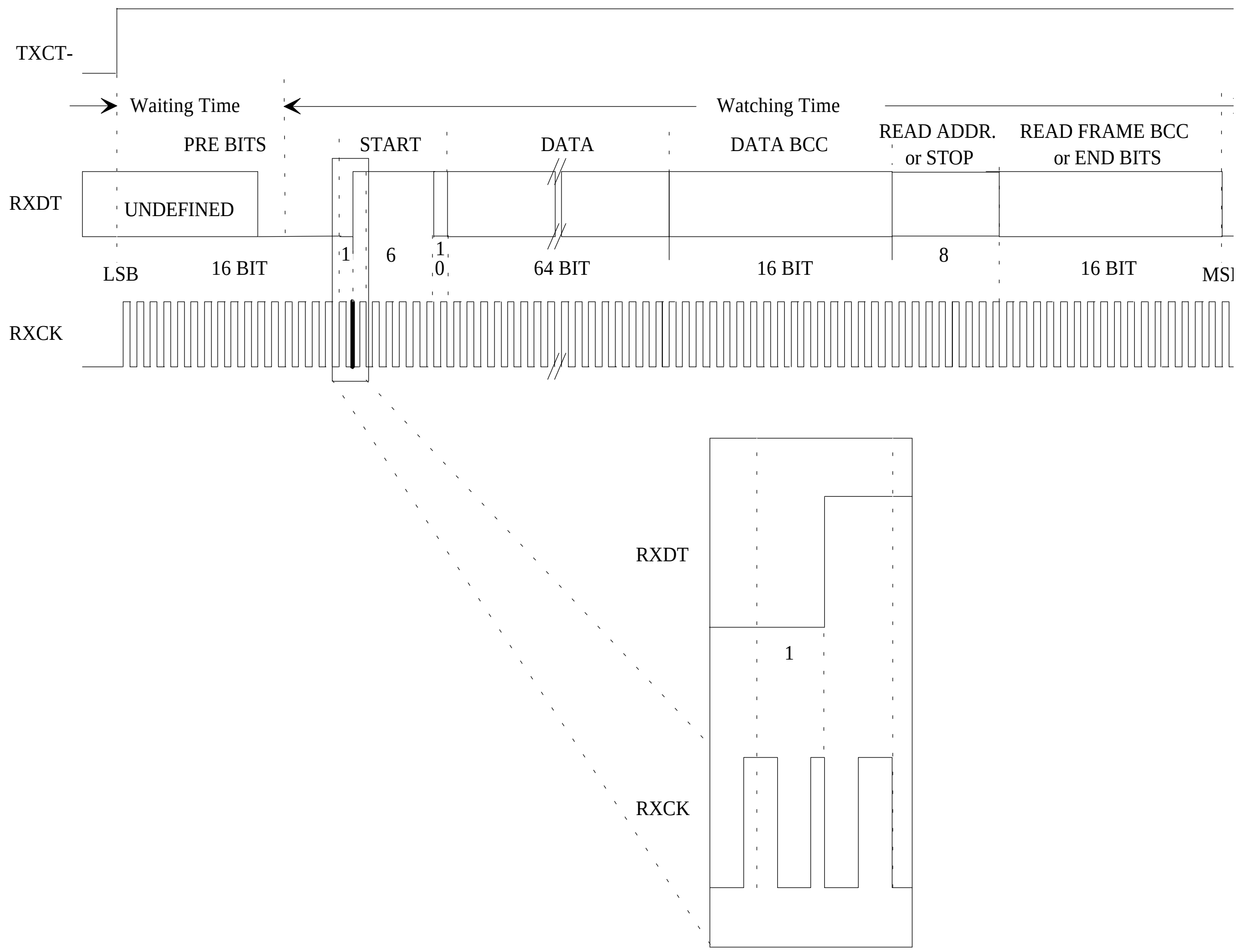
If 6 high bits are consecutively received (2nd to 7th bit), decoding can be continued. If at least one low bit is detected, the Control Module has to stop decoding immediately and has to continue watching the RXDT for high transitions (Watching Time).

The 8th bit of the Start Byte is stored in order to decide after the reception of the Stop Byte and the End Bits (respectively the Read Address and Read Frame BCC) which transponder type is recognized.

The Sequence Control can be realized by either using a micro-computer only or a microcomputer with external or internal hardware shift register function.

If hardware shift registers are used and a complete 8-bit Start Byte detection is required, it must be ensured that the data signal path to the shift register has the same or more delay than the clock signal path. This is necessary because a high bit instead of a low bit could be accidentally shifted as the first data bit if the low-to-high transition of the clock signal is very near to the low-to-high transition of the data signal (see Figure 6).

Figure 6: Data Format at the Receiver Outputs



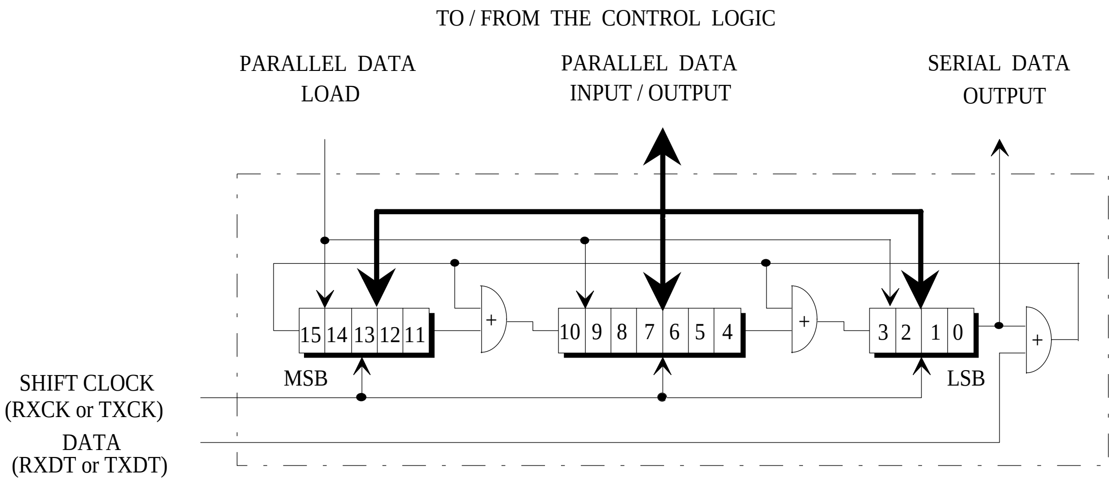
2.2.6 Store Data & Generate Block Check Character (Part 2 - Watching Time)

After detection of the Start Byte a further 104 bits must be received and stored in the Control Module’s microcomputer. Simultaneously a Cyclic Redundancy Check (CRC-CCITT) must be performed to check after the reception of the Data BCC, if the Read Data are valid or not. The CRC Generator can be realized by hardware or software and is the same for both the Read and Write functions (also see Chapter 3:).

A hardware CRC Generator can be realized using a feedback shift register and a control logic. A block schematic of the circuit in Figure 7 shows the principle of Cyclic Redundancy Check.

In most cases the Sequence Control is realized by using microcomputers which are not equipped with a hardware CRC Generator, in which case the CRC must be performed by software. Flowcharts in Figures 10 and 13 show a typical way to do the CRC.

Figure 7: Cyclic Redundancy Check Generator Block schematic



The CRC Generator includes a 16-bits shift register with its Serial Data Output (LSB), which is connected to an Exclusive-OR gate. Its output feeds back to other Exclusive-OR gates, which are located in between the sections of the shift register. Placement and quantity of Exclusive-OR gates define the so called CRC-CCITT generator polynomial $P(X)=X^{16}+X^{12}+X^{5}+1$.

From a mathematic point of view, the 64-bit Identification Data, which are serially shifted through the CRC Generator, are multiplied by x^{16} and divided by the generator polynomial P(X). The remainder from this division is the Block Check Character (BCC).

Before the Read function is started, the shift register value must be $0000_{HEX.}$. It is loaded via Parallel Data Input using the Parallel Data Load signal. Generation is started after the Start Byte. During the Read function the Identification Data and the received Data BCC are shifted through the CRC Generator. If neither the Identification Data nor the Data BCC (80 bits) have been changed in the memory or during data transfer, a constant 16-bit value (0000_{HEX}) must be in the shift register (Parallel Data Output).

The generation is continued until 104 bits are received.

2.2.7 Check Transponder Type (Part 3 - Watching Time)

After the reception of 104 bits, the transponder type can be determined (see Figure 12):

If the content of the CRC Generator is again 0000_{HEX}, a Multipage transponder is expected. To verify this, the following additionally checks must be performed:

- Read Only Start Byte was received
- The Page field in the Read Address is not equal to zero ($000000xx_{BIN}$)
- If the Charge-only function was used for this Read cycle, the Page field of the Read Address is one (000001_{BIN})
- The Page field of the Read Address is equal to the Page field of the Write Address

If the content of the CRC Generator is not 0000_{HEX}, the received Stop Byte must be equal to the Start Byte. In this case either a 64-bit Read Only transponder or a 64-bit Read/Write transponder is expected. 15 bits of the End Bits, beginning with the LSB must be checked to confirm which it is:

- If the 15 End Bits are zero, a 64-bit Read Only transponder is detected.
- If the 15 End Bits are equal to the 15 LSB of the Identification Data, a 64-bit Read/Write transponder is detected.

Bit 16 of the End Bits is not used for check, because the bit duration is shorter. This is caused by the discharge of the transponder charge capacitor.

After the transponder type is detected, the Sequence Control has to wait until the Read Time is exceeded.

The transponder type information is reported to the subsequent software routines by flags.

Figure 8: Sequence Control Software Overview

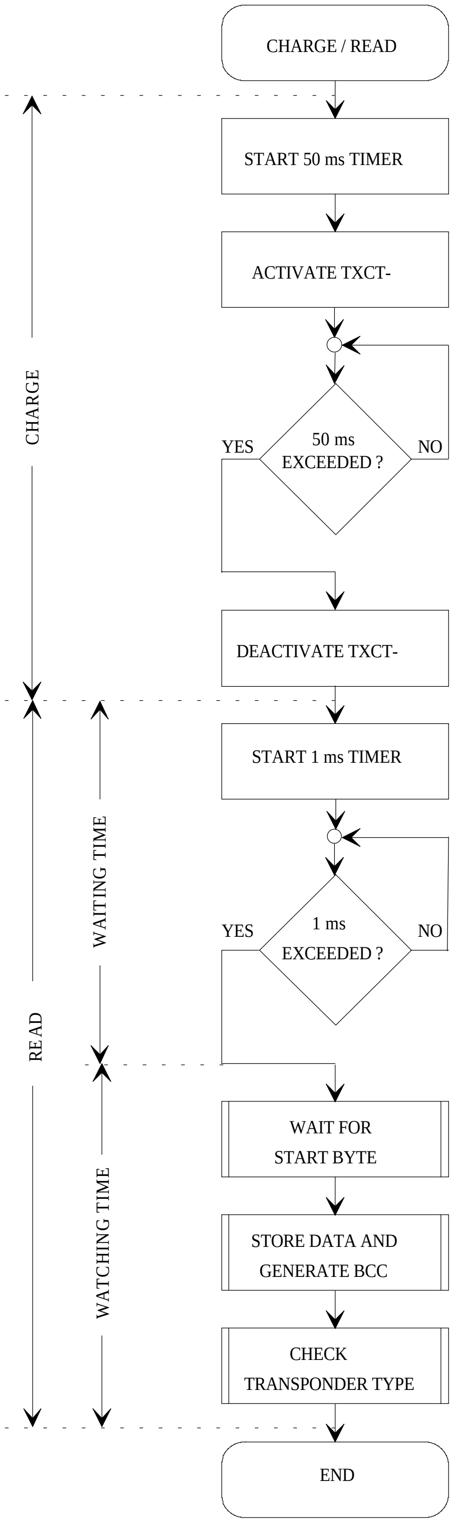


Figure 9: Wait for Start Byte

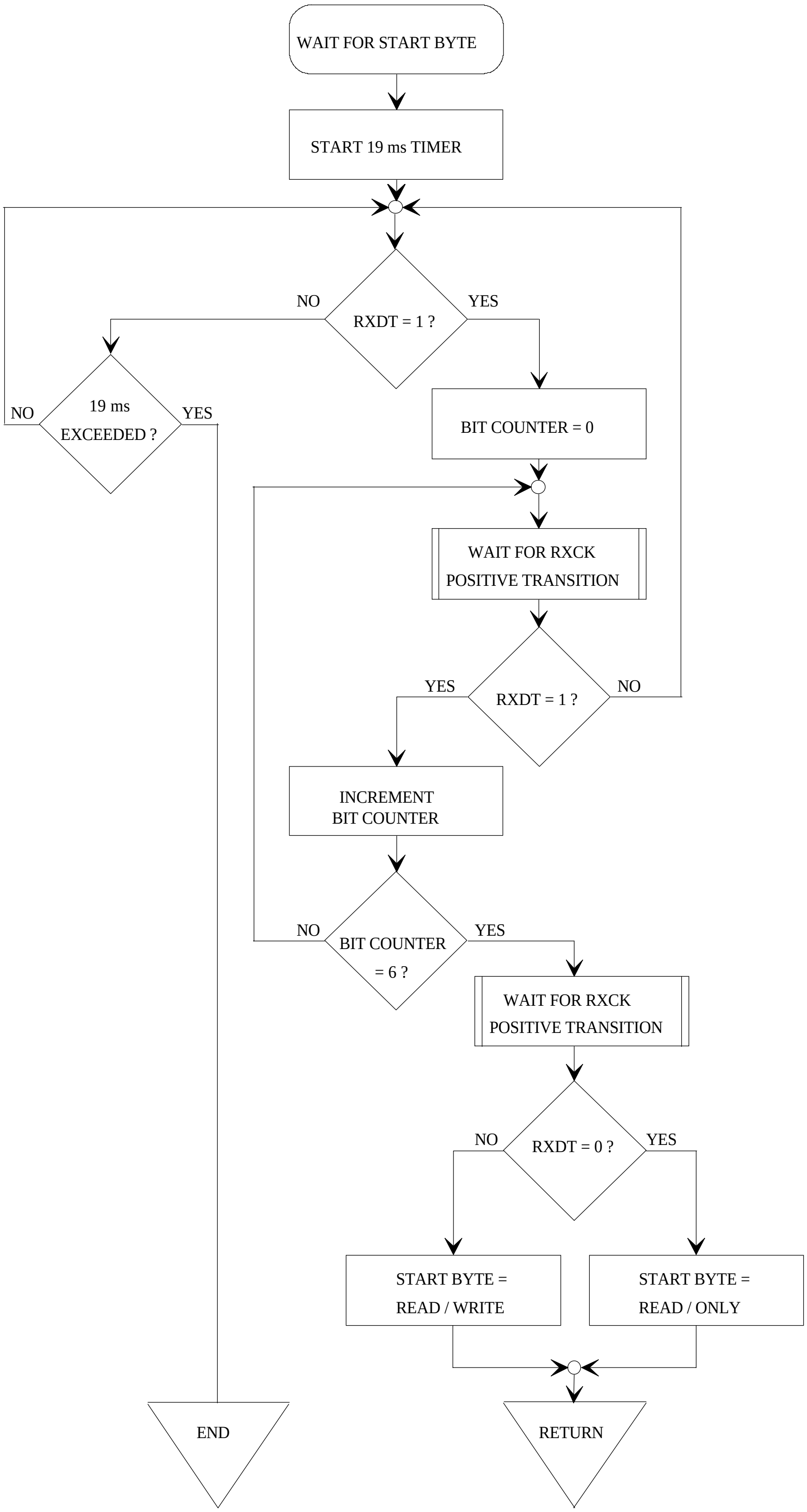


Figure 10: Store Data and Generate Block Check Character

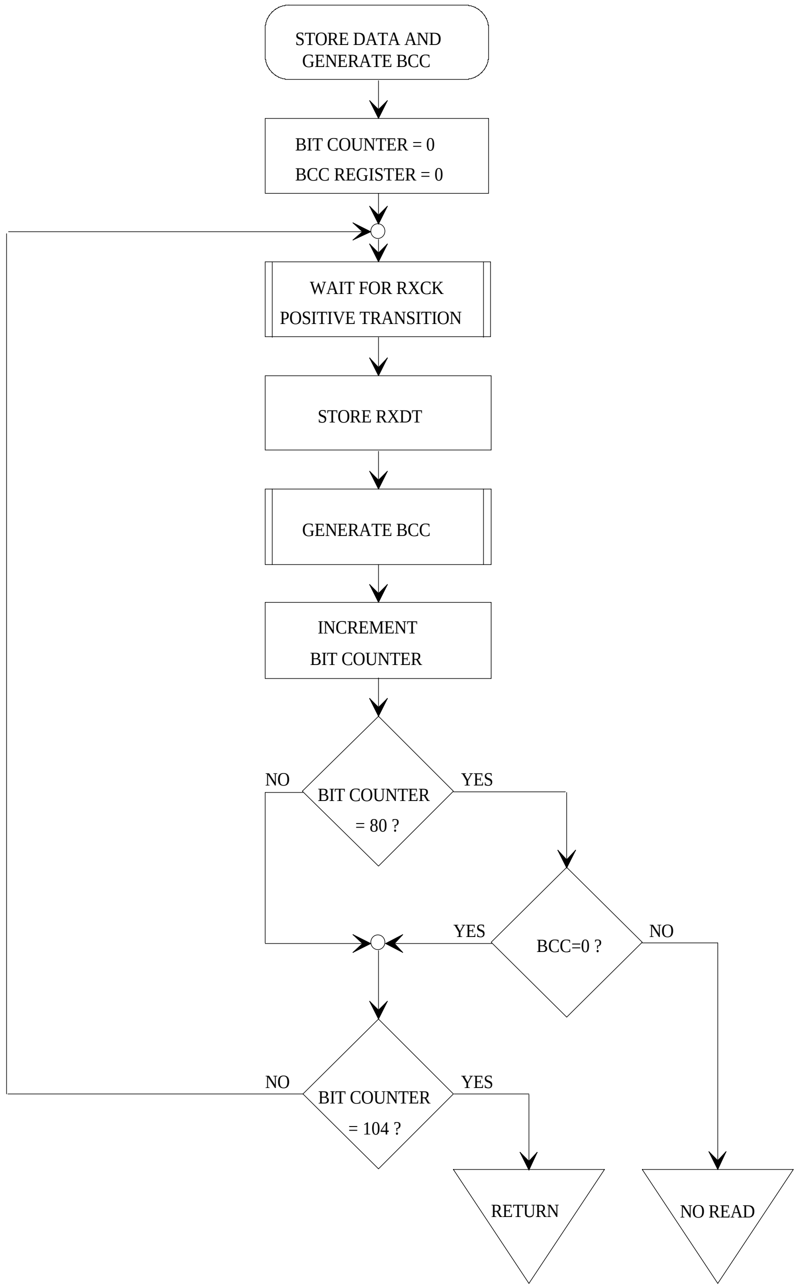


Figure 11: Check Transponder Type

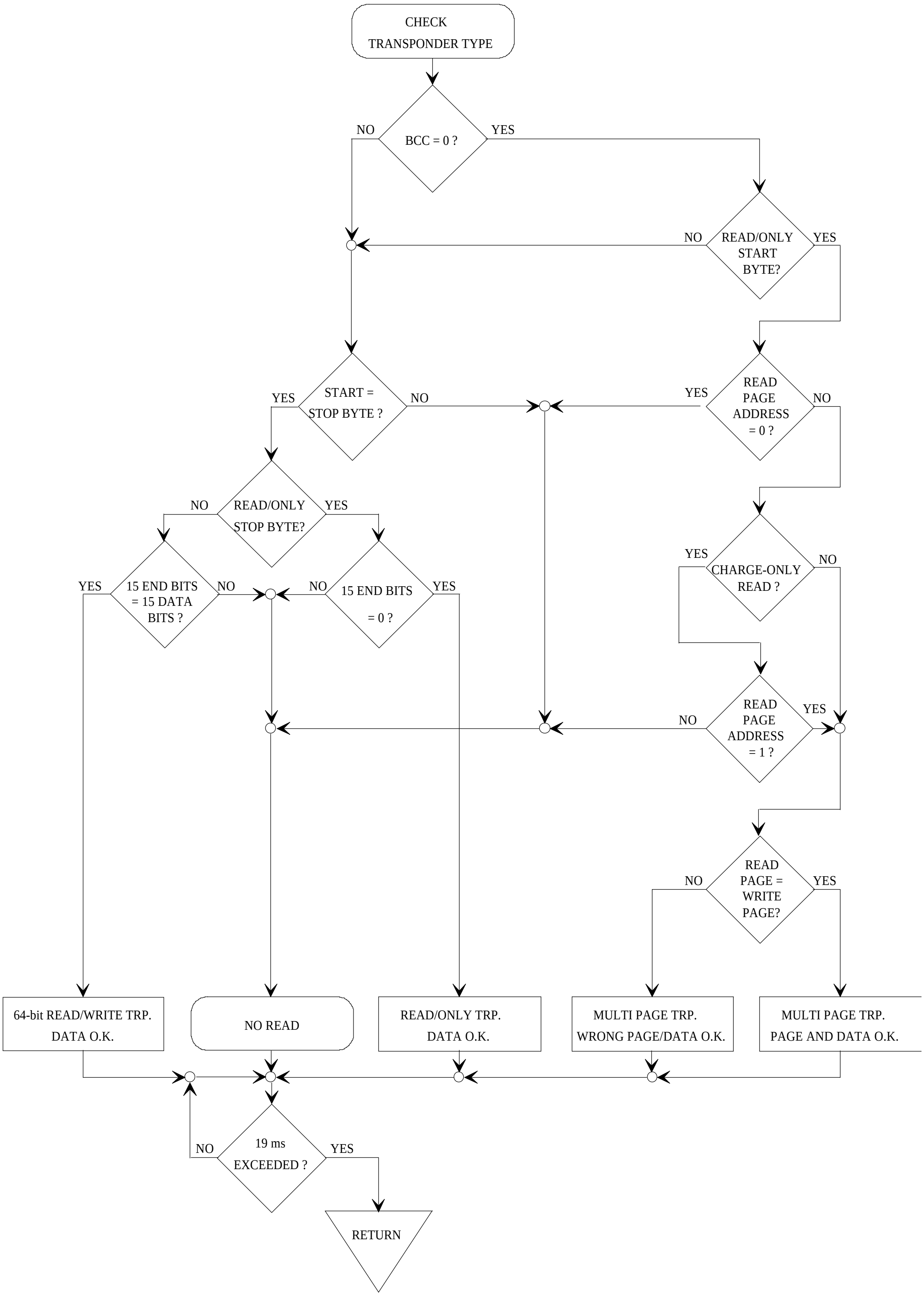


Figure 12: Subroutine 'Wait for RXCK Positive Transition'

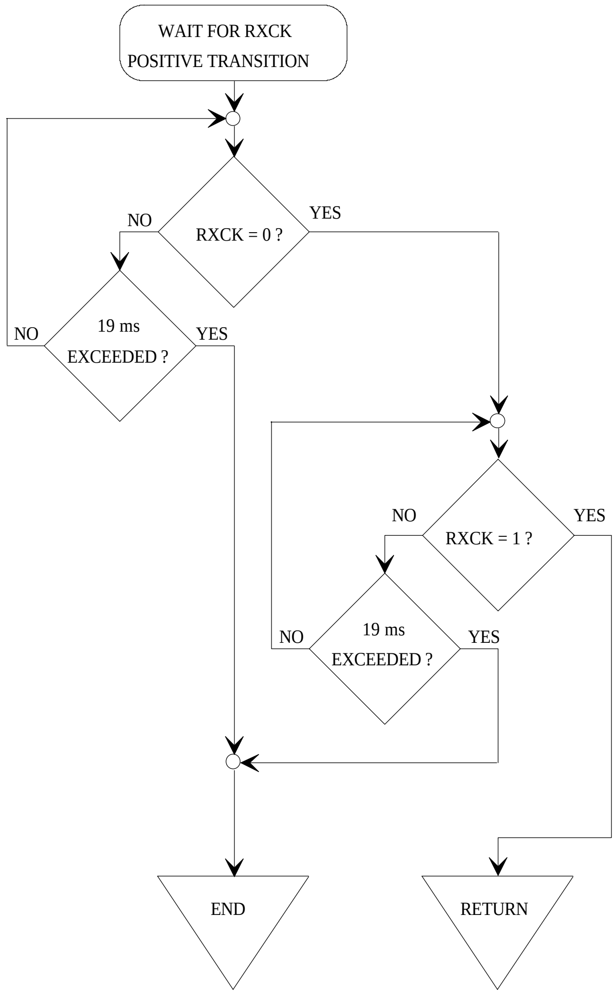
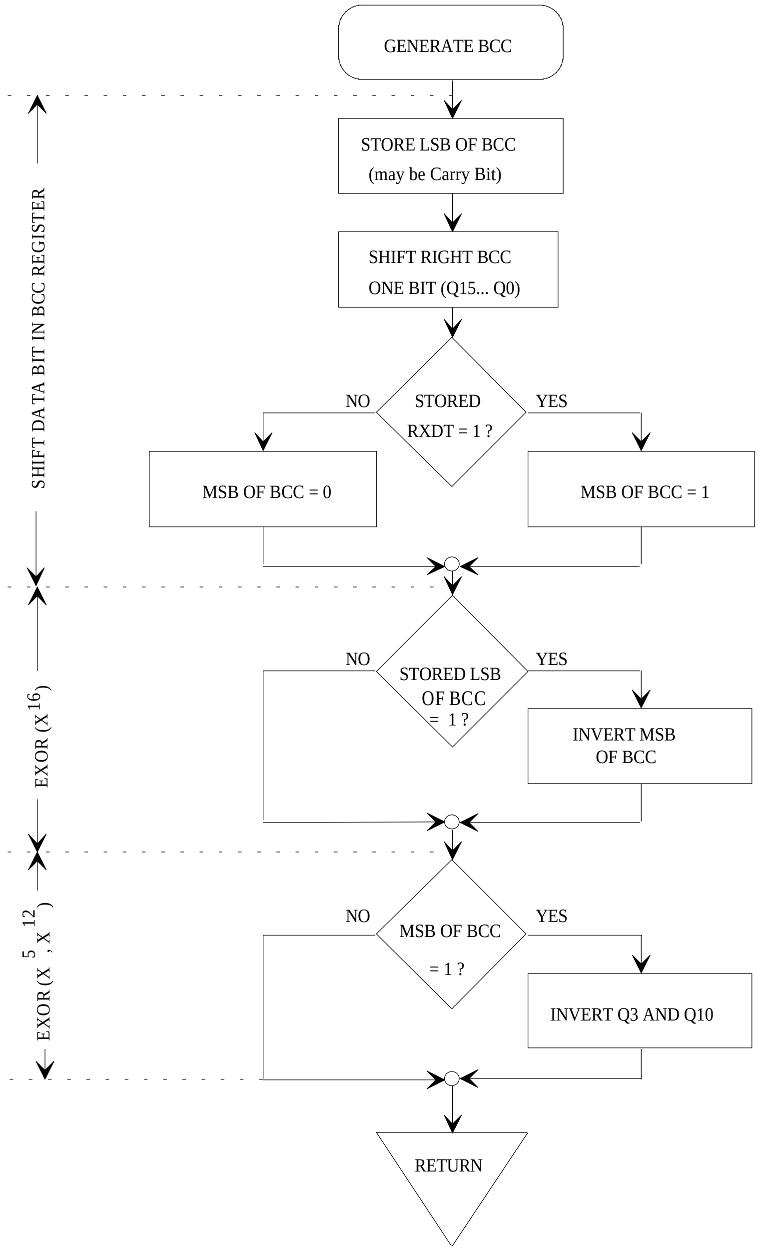


Figure 13: Subroutine 'Generate Block Check Character'



CHAPTER 3

Write and Program Functions

This chapter will introduce you to the Write and Program Functions, tell you about their Data Formats and their timings.

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3.1 General

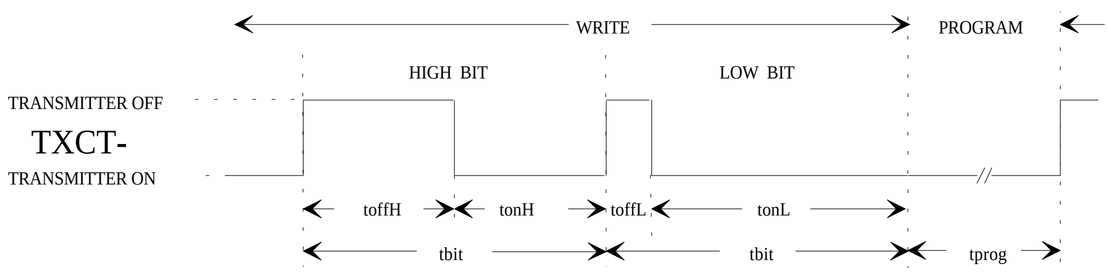
The Write function (see Figure 15) is used to transfer commands, addresses and data to the transponder in order to activate certain functions. Writing is started after the Charge Time. It is done by switching the RF Module’s transmitter (TXCT-) off and on in accordance with the data bits.

A Write Bit has (independent of its state) a typical duration of tbit = 2 ms. The duration of the transmitter deactivation defines whether it is a low bit or a high bit.

During a High Bit the transmitter is deactivated for toffH and activated afterwards for tonH.

During a Low Bit the transmitter is deactivated for toffL and activated afterwards for tonL.

Figure 14: The Write and Program Function



RF Module	toffH	tonH	toffL	tonL	tbit	tprog	Unit
RI-RFM-104B	1	1	0.3	1.7	2	15	ms
RI-RFM-006A	1	1	0.3	1.7	2	15	ms
RI-RFM-007B	1	1	0.3	1.7	2	15	ms
RI-RFM-008B	1	1	0.3	1.7	2	15	ms
RI-RFM-003B	1.2	0.8	0.5	1.5	2	15	ms

The 64-bit Read/Write transponder has a different Write Data Format to the Multipage Read/Write transponder. With the 64-bit Read/Write transponder only one data format is required (Programming). However, the Multipage Read/Write transponder provides different data formats for the functions Program Page, Read Page and Lock Page.

To program the Write Data into the transponder’s memory, the Program function must be executed. For this purpose the RF Module’s transmitter must be switched on for at least tprog = 15 ms (Programming Time), immediately after the Write function is finished. The Program function is enabled within the transponder if the RF field strength is high enough and it lasts as long as the RF Module’s transmitter is switched on. It must be ensured that the RF field strength does not drop significantly during the Programming Time, because the programming reliability cannot be checked by the Sequence Control. The Sequence Control has to check during the subsequent Read phase, if the Read Data are valid and equal to the Write Data. If required the Read and/or Write and Program function must be repeated.

If the Write and Program function are used together with a 64-bit Read Only transponder, the transponder will still respond during the Read phase. The Sequence Control detects the transponder type. This must be reported to the user to avoid wrong data interpretation.

3.2 64-Bit Read/Write Transponder Write Data Format

To program data in the memory of the 64-bit Read/ Write transponder (see Figure 15) the user has to write the following data:

Description	Bits	Value (HEX)	Duration (ms)	Notes
		MSB . . . . LSB		
Write Keyword	8	BB	16	x: Identification Data y: Data BCC
Write Password	8	EB	16	
Write Data	80	yyyyxxxxxxxxxxxxxxxx	160	
Write Frame	16	0300	32	
TOTAL	112		224	

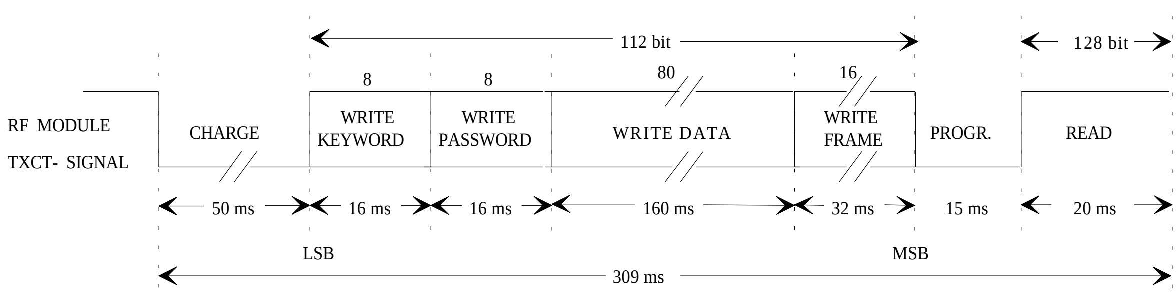
All parts of the Write Data Format are transmitted to the transponder with LSB first.

An 8-bit Write Keyword 10111011_{BIN} (BB_{HEX}) and an 8-bit Write Password 11101011_{BIN} (EB_{HEX}) initiates the transponder to accept the 80-bit Write Data.

The Write Data can be determined by the user. We recommended that you split the Write Data into 64 Identification Data bits transmitted first, followed by 16 Protection Data bits (Data BCC). As previously stated we recommend CRC-CCITT as the protection algorithm for the Data BCC. The generation of the Data BCC can be done by hardware or by software as already described in section 2.2.6.

The Write data format is terminated by a 16-bit Write Frame which must be set to 0000001100000000_{BIN} (0300_{HEX}).

Figure 15: 64-bit Read/Write Transponder Programming Data Format



Programming is executed if:

- Write Keyword and Write Password are received
- the Write Data Format has the correct number of bits
- the RF field strength is high enough to generate a reliable programming voltage.

During Read phase the 64-bit Read/Write transponder Read Data Format is returned (see Figure 5).

If the read data differs from the write data, programming has been denied.

If valid Read Data are received (Data BCC O.K.) the Identification Data of the Read Data must be compared to the Identification Data of the Write Data, to be sure that the Write Data have not been accidentally changed during transmission. The 64-bit Read/Write transponder do not check the validity of the received Write Data.

If invalid Read Data are received, programming must be repeated.

3.3 Multipage Read/Write Transponder Write Data Format

The memory of the Multipage Read/Write transponder is structured into several pages, each of which contains Identification Data and Protection Data. In order to read a page (General Read), to program (Program Page) or to lock data in a page (Lock Page), the user has to send (Write) a Write Address to the transponder.

WRITE ADDRESS

MSB LSB

P P P P P P CC

Page Command

	MSB LSB	MSB LSB	
Page 1	000001	00	General Read
Page 2	000010	01	Program Page
. .	.	10	Lock page
Page 16	010000	11	Selective Read
Page 17	010001		

The Write Address byte consists of a 2-bit Command field and a 6-bit Page field.

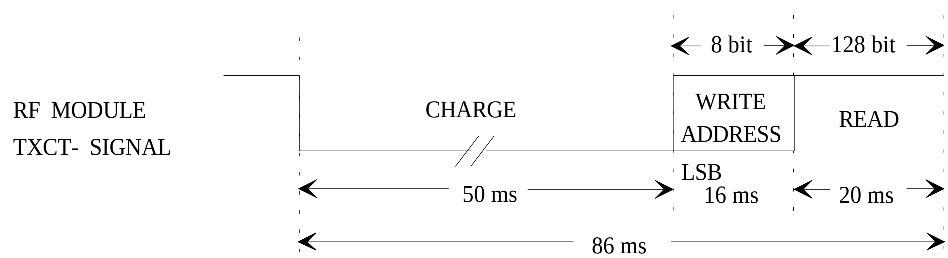
The Command field which is transmitted first (LSB first), determines the function to be executed.

The Page field defines the affected page.

3.3.1 General Read

The General Read function is required to Read a Page other than Page 1. While Page 1 requires only a Charge Time to be addressed (see Figure 2), all other pages must be addressed by the Page field of the Write Address (see Figure 17). It is also possible to address Page 1 by addressing it.

Figure 16: Multipage R/W Transponder General Read Function



Because the Write Address is not protected by Protection Data, the Sequence Control must check during the Read phase that the correct Page is returned and the Status of the Read Address is valid. The Status of the Read Address must be: Read unlocked Page, or Read locked Page.

If a Page which has a Page address higher than addressed page is returned, the Page address was not correctly received by the transponder, in which case the Read-out must be repeated.

If a Page which has a Page address lower than the addressed page is returned, the Page address was either not correctly received by the transponder or a non-existent page was addressed. In this instance the Read-out must be repeated.

If a non-existent page is addressed the highest available Page is returned.

If the Status of the Read Address indicates 'Reserved', the data of the defined Page cannot be interpreted as Identification Data.

If Page 0 is addressed, the transponder discharges its charge capacitor (no response), because this page is not valid.

If a Command is received which is not valid (disabled) or the number of bits in the Write Data Format are not correct, the transponder discharges its charge capacitor (no response).

Table 2: Read Responses

WRITE ADDRESS		**READ ADDRESS**		**DESCRIPTION**
COMMAND	PAGE	STATUS	PAGE	
General Read	x	Read unlocked Page	x	General Read of unlocked Page x executed
General Read	x	Read locked Page	x	General Read of locked Page x executed
General Read	x	Read unlocked Page	y	General Read of unlocked Page y executed, y>x, Write Address was not correctly received
General Read	x	Read locked Page	y	General Read of locked Page y executed, y>x, Write Address was not correctly received
General Read	x	Read unlocked Page	z	General Read of unlocked Page z executed, z<x, z=max. Page or Write Address was not correctly received
General Read	x	Read locked Page	z	General Read of locked Page z executed, z<x, z=max. Page or Write Address was not correctly received
General Read	x	Reserved	x	No Identification Data in Page x
General Read	x	Reserved	y	No Identification Data in Page y, y>x, Write Address was not correctly received
General Read	x	Reserved	z	No Identification Data in Page z, z<x, z=max. Page or Write Address was not correctly received
General Read	0	No response		Page 0 is not valid
General Read	x	No response		Command not valid or wrong bit count

3.3.2 Program Page

The Program Page function (see Figure 17) initiated by the Command 01_{BIN}, is used to program the Write Data into a certain Page of the transponder memory. You have to use the following data format:

Description	Bits	Value (HEX)	Duration (ms)	Notes
		MSB . . . . LSB		
Write Address	8	pc	16	pc: Page + Command x: Identification Data y: Data BCC
Write Data	80	yyyyxxxxxxxxxxxxxxxx	160	
Write Frame BCC	16	zzzz	32	
TOTAL	104		208	

If the Selective Program Page function (see Figure 19) is activated, an additional Selective Address must be included in the Write Data Format after the Write Address:

Description	Bits	Value (HEX)	Duration (ms)	Notes
		MSB . . . . LSB		
Write Address	8	pc	16	pc: Page + Command x: Page 1 Identification x: Identification Data y: Data BCC
Selective Address	24	xxxxxxxx	48	
Write Data	80	yyyyxxxxxxxxxxxxxxxx	160	
Write Frame BCC	16	zzzz	32	
TOTAL	128		256	

All parts of the Write Data Format are transmitted to the transponder with LSB first.

The Write Address is explained in section 3.3.

The Selective Address (if necessary) is compared bit-by-bit with the least significant bits of Page 1. Only if all bits are matching is the Program function executed.

The Write Data can be determined by the user. We recommend that you split the Write Data into 64 Identification Data bits, transmitted first, followed by 16 Protection Data bits (Data BCC).We recommend the CRC-CCITT as protection algorithm for the Data BCC. This algorithm gives optimum data security and is therefore explained in this Guide (see section 2.2.6).

The 16-bit Write Frame Block Check Character (Write Frame BCC), which protects the 8-bit Write Address, the Selective Address and the 80-bit Write Data, must be generated by the Sequence Control using the CRC-CCITT algorithm.

Figure 17: Program Page Function Data Format

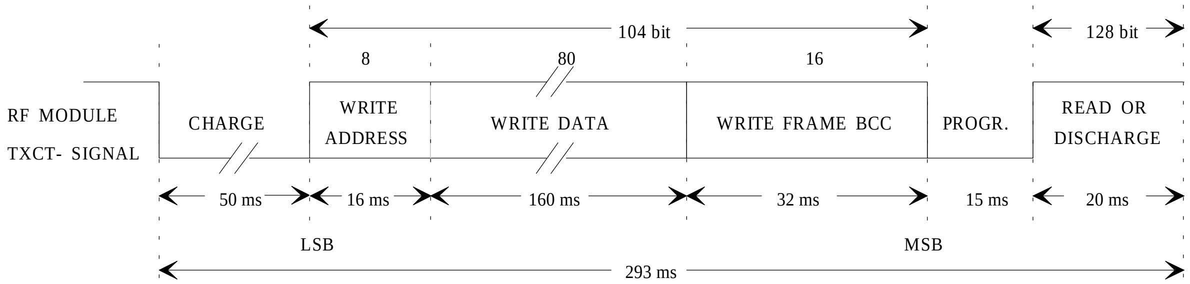
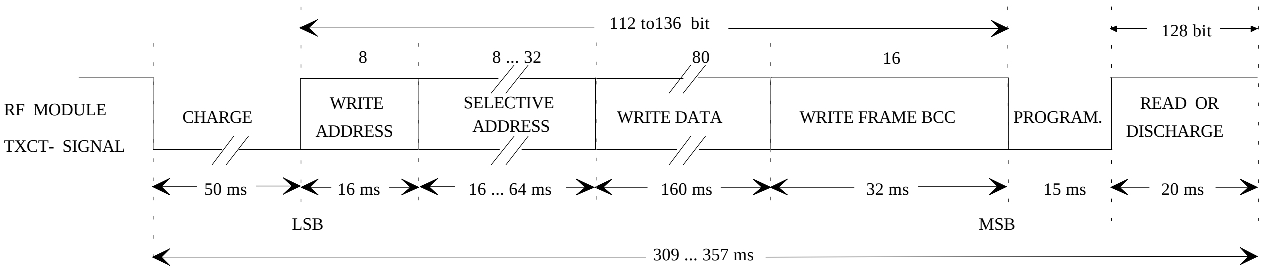


Figure 18: Selective Program Page Function Data Format



The Multipage transponder checks the received data using a hardware CRC Generator. Program Page function is executed if:

- the Program Page Command is detected

- the Selective Address is O.K. (Selective Program Page function only)

- the Write Data Format has the correct number of bits

- the Write Frame BCC check is positive

- the RF field strength is high enough to generate a reliable programming voltage

If the Status of the Read Address indicates 'Programming done', the Page field of the Read Address is equal to the Page field of the Write Address and the Read Data are equal to the Write data, the Programming was correctly executed.

If the Status of the Read Address indicates 'Programming done' and the Read Page field is zero, the Programming was executed, but possibly not reliably. Programming must be repeated in this case.

If the Status indicates 'Read locked Page', the Programming could not be executed.

If the Status indicates 'Read unlocked Page', Programming was not executed, because RF field strength was too low.

If there is no response, the transponder had detected a CRC or framing error or the Selective Address was not valid.

If a lower Page is returned, Programming was not carried out, because the addressed Page was not available. The returned Page is the maximum Page (page 17).

If the Status indicates 'Reserved' the Read Data cannot be interpreted as Identification Data.

Table 3: Program Page Responses

WRITE ADDRESS		READ ADDRESS		DESCRIPTION
COMMAND	PAGE	STATUS	PAGE	
Program Page	x	Programming done	x	Programming of Page x correctly executed
Program Page	x	Programming done	0	Programming of Page x executed, but probably not reliable
Program Page	x	Read locked Page	x	Programming of locked Page x not executed
Program Page	x	Read unlocked Page	x	Programming of unlocked Page x not executed, RF field strength too low
Program Page	x	no response		Programming not executed, CRC or framing error or Selective Address not O.K. during Write function
Program Page	x	Read unlocked Page	z	Programming not executed, z<x, Page x not available, Page z = max. Page
Program Page	x	Read locked Page	z	Programming not executed, z<x, Page x not available, Page z = max. Page
Program Page	x	Reserved	x	No Identification Data in Page x
Program Page	x	Reserved	z	No Identification Data in Page z, z<x, z=max. Page
Program Page	0	No response		Page 0 is not valid

3.3.3 Lock Page

The Lock Page function (see Figure 19) initiated by the Command 10_{BIN} is used to lock the content of a certain addressed Page. The user has to use the following data format:

Description	Bits	Value (HEX)	Duration (ms)	Notes
		MSB . . . . LSB		
Write Address	8	pc	16	pc: Page + Command z: Frame BCC
Write Frame BCC	16	zzzz	32	
TOTAL	24		48	

If the Selective Lock Page function (see Figure 20) is activated, an additional Selective Address must be included in the Write Data Format after the Write Address.

Description	Bits	Value (HEX)	Duration (ms)	Notes
		MSB . . . . LSB		
Write Address	8	pc	16	pc: Page + Command x: Page 1 Identification z: Frame BCC
Selective Adress	24	xxxxxxxx	48	
Write Frame BCC	16	zzzz	32	
TOTAL	48		96	

The Write Address is explained in section 3.3.

The Selective Address (if necessary) is compared bit-by-bit with the least significant bits of Page 1. Only if all bits are matching is the Lock Page function executed.

The 16-bit Write Frame Block Check Character (Write Frame BCC), which protects the 8-bit Write Address and eventually the Selective Address, must be generated by the Sequence Control using the CRC-CITT algorithm.

Figure 19: Lock Page Function Data Format

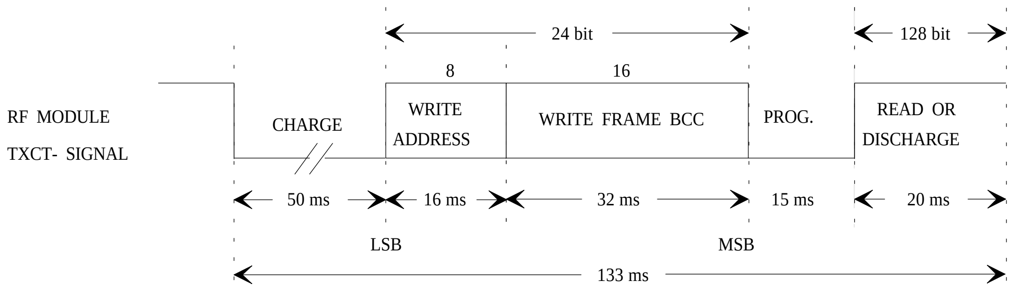
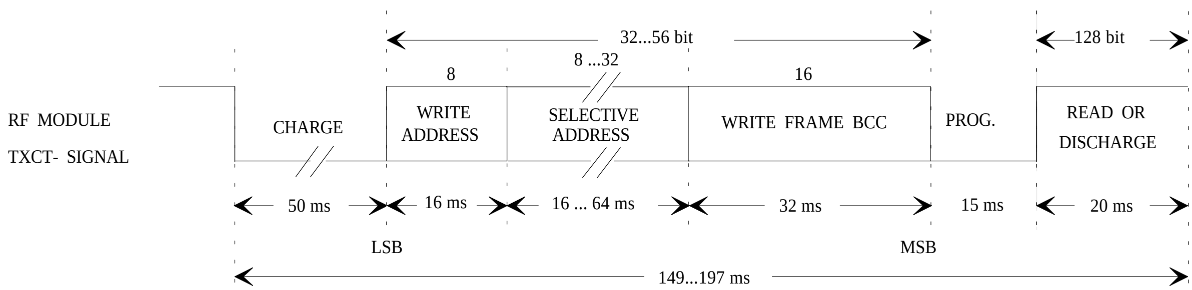


Figure 20: Selective Lock Page Function Data Format



The data format of the Lock Page function is checked by the transponder using the hardware CRC Generator. Lock Page function is executed by the transponder if:

- the Lock Page Command is detected
- the Selective Address is O.K. (Selective Lock Page function only)
- the Write Data Format has the correct number of bits
- the Write Frame BCC check is positive
- the RF field strength is high enough to generate a reliable programming voltage

If the Status field of the Read Address indicates 'Read locked Page' and the Page of the Read Address is equal to the Page of the Write Address, the Page was correctly locked.

If the Status field of the Read Address indicates 'Read locked Page' and the Page field of the Read Address is zero, the Page is probably unreliable locked, because of RF field strength dropped.

If there is no response, Lock Page was not executed, because a CRC or framing error was detected or the Selective Address was not valid during Write function.

If the transponder responds with the Status 'Read unlocked page' and the Page of the Read Address is equal to the Page of the Write Address, Lock Page was not executed because the RF field strength was too low.

If the transponder responds with the Status 'Read unlocked page' and the Page field of the Read Address is zero, Lock Page was executed but did not succeed, because the RF field strength dropped.

If the Page of the Read Address is lower than the Page of the Write Address, the Page to be locked was not available. The returned Page is the maximum Page.

If the Status field of the Read Address indicates 'Reserved', the Read Data can not be interpreted as Identification Data.

Table 4: Lock Page Responses

WRITE ADDRESS		READ ADDRESS		DESCRIPTION
COMMAND	PAGE	STATUS	PAGE	
Lock Page	x	Read locked Page	x	Lock Page was executed. Page x is locked.
Lock Page	x	Read locked Page	0	Lock Page was executed.Page x is locked, but probably not reliable.
Lock Page	x	no response		Lock Page was not executed. CRC or framing error occurred during Write function.
Lock Page	x	Read unlocked Page	x	Lock Page x was not executed. Field strength was too low. Page is unlocked.
Lock Page	x	Read unlocked Page	0	Lock Page x was executed without success because field strength dropped. Page is unlocked.
Lock Page	x	Read unlocked Page	z	Read unlocked Page z, z<x, z = max. Page. Page x not available. Lock Page was not executed.
Lock Page	x	Read locked Page	z	Read locked Page z, z<x, z = max. Page. Page x not available. Lock Page was not executed.
Lock Page	x	Reserved	x	No Identification Data in Page x
Lock Page	x	Reserved	z	No Identification Data in Page z, z<x, z = max. Page

3.3.4 Selective Read

The Selective Read function (see Figure 21) which is initiated by a Command (11_{BIN}) of the Write Address causes the transponder to either respond during the Read phase or to discharge the charge capacitor (no response). You must use the following data format:

Description	Bits	Value (HEX)	Duration (ms)	Notes
		MSB . . . . LSB		
Write Address	8	pc	16	pc: Page + Command x: Page 1 Identification z: Frame BCC
Selective Adress	24	xxxxxxxx	48	
Write Frame BCC	16	zzzz	32	
TOTAL	48		96	

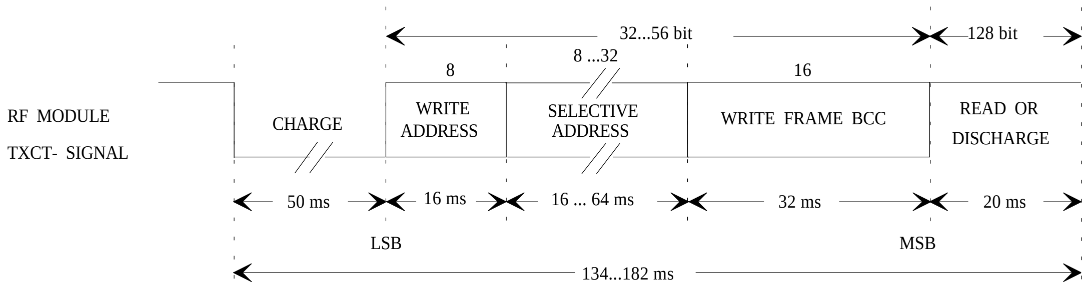
The Write Address is explained in section 3.3.

The Selective Address is compared bit-by-bit with the least significant bits of Page 1.

Only if all bits are matching is the Selective Read function executed.

The 16-bit Write Frame Block Check Character (Write Frame BCC), which protects the 8-bit Write Address and the Selective Address, must be generated by the Sequence Control using the CRC-CCITT algorithm.

Figure 21: Selective Read Function Data Format



The data format of the Selective Read function is checked by the transponder using the hardware CRC Generator. Selective Read function is executed by the transponder if:

- the Selective Read function is enabled
- the Selective Read Command is detected
- the Selective Address is O.K.
- the Write Data Format has the correct number of bits
- the Write Frame BCC check is positive

If a Page is returned which has a Page address lower than addressed, a non-existent page was addressed. If a non-existent page is addressed the highest available Page is returned.

If the Status of the Read Address indicates 'Reserved', the data of the defined Page cannot be interpreted as Identification Data.

If there is no response, the transponder had detected a CRC or framing error or the Selective Address was not valid.

Table 5: Selective Address Read Responses

WRITE ADDRESS		**READ ADDRESS**		**DESCRIPTION**
COMMAND	PAGE	STATUS	PAGE	
Selective Read	x	Read unlocked Page	x	Selective Read of the unlocked Page x was executed
Selective Read	x	Read locked Page	x	Selective Read of the locked Page x was executed
Selective Read	x	Read unlocked Page	z	Selective Read of the unlocked Page z was executed, z<x, z=max. Page
Selective Read	x	Read locked Page	z	Selective Read of the locked Page z was executed, z<x, z=max. Page.
Selective Read	x	Reserved	x	Selective Read of Page x was executed. No Identification Data in Page x!
Selective Read	x	Reserved	z	Selective Read of Page z was executed. No Identification Data in Page z, z<x, z=max. Page.
Selective Read	x	No response		Selective Read was not executed, because a CRC or framing error occurred or the Selective Address was not valid during Write function.

CHAPTER 4

Synchronization

This chapter will tell you about Synchronizing different Reading/Writing units to each other when they are working together in the same application. It is NOT Applicable to systems using the RI-RFM-006A.

Topic **Page**

4.1 Introduction

If several Reading/Writing Units are in use in the same area, care must be taken that a Reading/Writing Unit does not activate its transmitter, if another Reading/Writing Unit is receiving at that moment. Otherwise the transponder response signal will be covered by the RF transmit burst and cannot be demodulated by the receiver.

This problem can be overcome by utilizing either wired or wireless Synchronization of the Reading/Writing Units controlled by the Sequence Control Software.

4.2 Sensitivity Adjustment

The RF Module is equipped with the output RXSS- to enable wireless Synchronization. If a pre-determined field strength is exceeded at the receiver input, RXSS- is activated (active = low). Depending on the application and the antenna type, the threshold level must be adjusted by means of a potentiometer. For this purpose a small screwdriver can be used. The opening for the adjustment is in one of the small side walls of the RF Module:

Turning the screwdriver all the way counter-clockwise results in maximum sensitivity, (activation of RXSS- at low field strength). This is the default position when the RFM is delivered. Sensitivity must be reduced, if the RXSS- signal is not statically high.

Be sure that the Reading/Writing Unit which is in the adjustment process and all other Reading/Writing Units in the application area are deactivated ('X'-Command)! Data Management Computers monitors and/or other RF interference sources must be far away from the antenna (>3 m)!

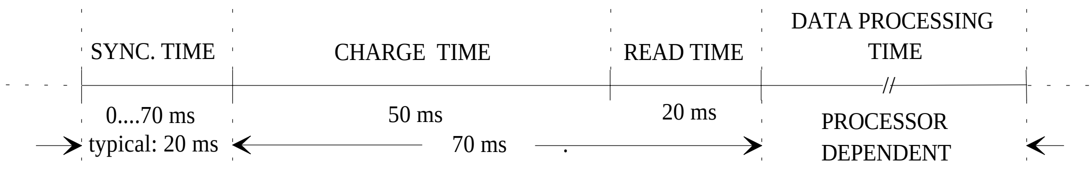
Turn the potentiometer clockwise until the RXSS- signal is just statically high (inactive).

Synchronization distance depends on the antenna type and the transmitted field strength. The distance decreases, if sensitivity is reduced too much.

4.3 Synchronization Timing

In order to synchronize the Reading/Writing Units a Synchronization Time (SYNC. TIME, t_{SYNC}) must be provided in the Sequence Control. If there is one Reading/Writing Unit in use and the RXSS- threshold level is correctly tuned, the typical Synchronization Time is 20 ms. A complete readout cycle is shown in Figure 22.

Figure 22: Readout Cycle of a TIRIS Reading/Writing Unit



The Synchronization Procedure (see Figure 23 and Table 6) allows all Reading/Writing Units in an application area to detect each other by watching the RXSS- signal. A Reading/Writing Unit is able to delay the transmitter activation until other Reading/Writing Units nearby have completed their Read function. Therefore the Synchronization Time varies depending on the system configuration (0...70 ms). Depending on the Processor Data Processing Time, the Reading/Writing Units transmit either alternately (Figure 24) or simultaneously (Figure 25).

These Synchronization Procedures can only be used for systems where only single or continuous Read functions are used. During Write function the RF Module transmitter is pulsed and activated over a period which is longer than the timeout of the Synchronization Procedure. Therefore other Reading/Writing Units cannot synchronize and its read-outs will be interfered.

If a reader which processes reading functions and a reader which also processes writing functions are used together in a system, a common Sequence Control should be used to secure that reading and writing is not executed simultaneously.

Figure 23: Synchronization Procedure Flowchart

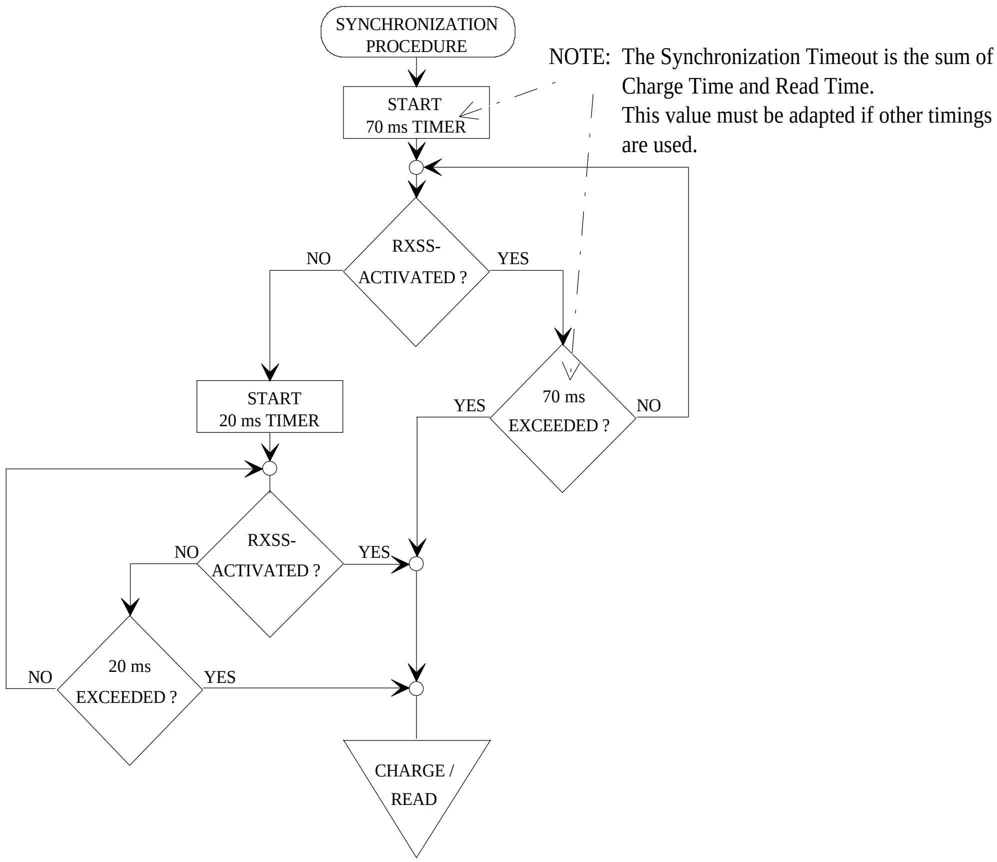


Table 6: Explanation of Synchronization Procedure

1) If RXSS- is deactivated then: wait for maximum 20 ms because another unit could be in the read phase. - If RXSS- is activated in the meantime: start transmission immediately. - If RXSS- has not been activated in the meantime: start transmission as soon as 20 ms have elapsed. 2) If RXSS- is activated then: wait for maximum 70 ms because another unit could be in the transmit phase. - If RXSS- is deactivated in the meantime: proceed as described in Section 1). - If RXSS- has not been deactivated in the meantime: start transmission after 70 ms have elapsed.

Figure 24: Reading/Writing Units 1 and 2 Transmit Alternately

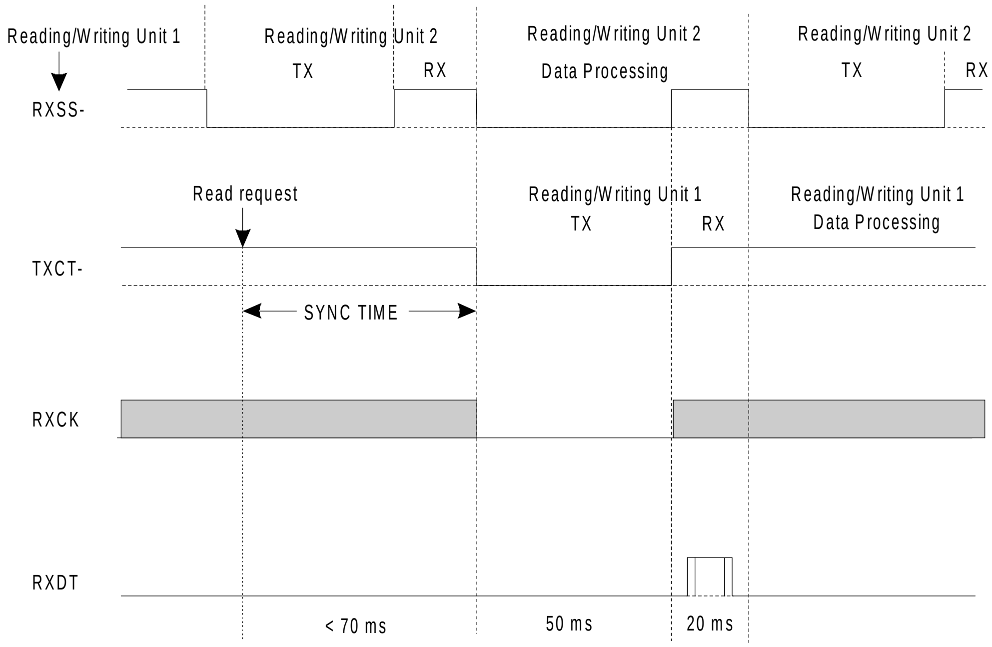
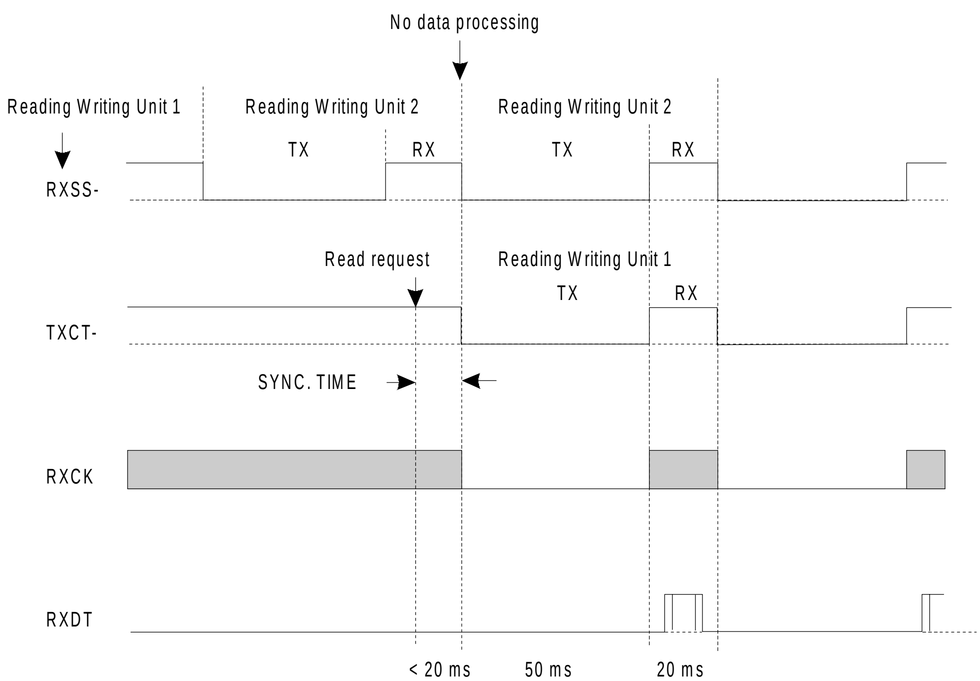


Figure 25: Units 1 & 2 Transmit Simultaneously



CHAPTER 5

Parameters

5.1 Timing Requirements

Parameter	Note	Min	Nom	Max	Unit
Synchronization Time, t_{SYNC}		-	20	-	ms
Charge Time/ read, t_{TX}		15	50	100	ms
Charge Time / read, t_{TX}	RI-RFM-003B t_{on} / t_{off} = 1/2	15	50	100	ms
Read Time, t_{RD}			20		ms
Waiting Time		1		1.5	ms
Watching Time				Read Time minus Waiting Time	ms
Write Bit Duration, tbit		1.95	2	2.1	ms
Write Pulse Pause/Low bit, toffL	RI-RFM-104/-006/-007/-008..	0.29	0.3	0.31	ms
Write Pulse Pause/Low bit, toffL	RI-RFM-003B	0.49	0.5	0.51	ms
Write Pulse Pause/High bit, toffH	RI-RFM-104/-006/-007/-008..	0.99	1.0	1.01	ms
Write Pulse Pause/High bit, toffH	RI-RFM-003B	1.19	1.2	1.21	ms
Programming Time, t_{PROG}		15			ms

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