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Features and Benefits

- Versatile A/D interface for resistive sensors
- ISO-15693 13.56MHz transponder
- Slave / Master SPI interface
- 4 k-bit EEPROM with access protection
- Standalone data-logging mode
- Ultra low power
- Battery or battery-less applications
- Low cost and compact design

Application Examples

- Medical and health monitoring sensor tags
- Cold chain monitoring
- Temperature sensor tags
- Asset management and monitoring (security and integrity)
- Industrial, residential control and monitoring

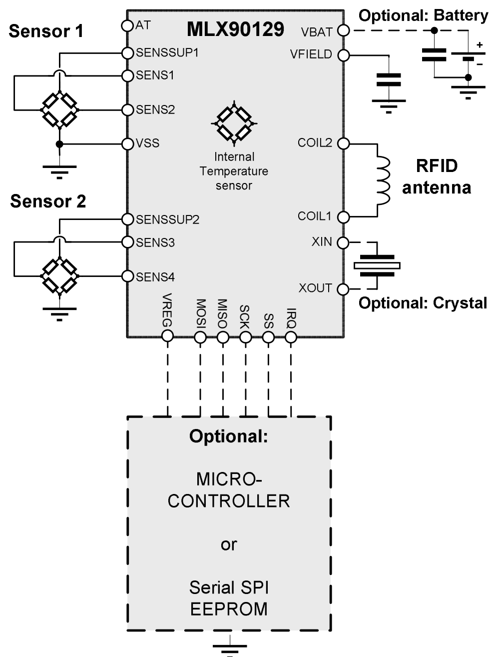
Ordering Code

Product Code	Temperature Code	Package Code	Option Code	Packing Form Code
MLX90129	R	GO	CAA-000	TU
MLX90129	R	GO	CAA-000	RE
MLX90129	R	UC	CAA-000	WB
MLX90129	R	US	CAA-000	WP

Legend:
Temperature Code: R for Temperature Range -40°C to 105°C
Package Code: GO for TSSOP, UC for die on wafer, US for single die
Packing Form: RE for Reel, TU for Tube, WB for waferbox, WP for waffle pack

Ordering example: MLX90129RGO-CAA-000-TU

1 Functional Diagram



2 General Description

The MLX90129 combines a precise acquisition chain for external resistive sensors, with a wide range of interface possibilities.

It can be accessed and controlled through its ISO15693 RFID front-end or via its SPI port.

Without any other components than a 13,56MHz tuned antenna, it becomes an RFID temperature sensor.

For measuring other physical parameters, one or two resistive sensors can be connected to make battery-less sensing point. Also, the chip can supply a regulated voltage to other components of the application.

Adding a battery will enable the use of the standalone data logging mode. The sensor output data is stored in the internal 3.5kbits user memory. One can extend the storage capacity by connecting an external EEPROM to the SPI port.

The SPI port can also connect the MLX90129 to a microcontroller which allows more specific applications, like adding actuating capability, LED driving

The MLX90129 has been optimized for low power, low voltage battery and battery-less applications.

3 Glossary of Terms

EEPROM	Electrically Erasable Programmable Read-Only Memory
DMA	Direct Memory Access (It is the digital unit managing data-logging)
PGA	Programmable Gain Amplifier
LFO	Low Frequency Oscillator
XLFO	Crystal Low Frequency Oscillator
CTC	Contactless Tuning Capacitance
HFO	High Frequency Oscillator

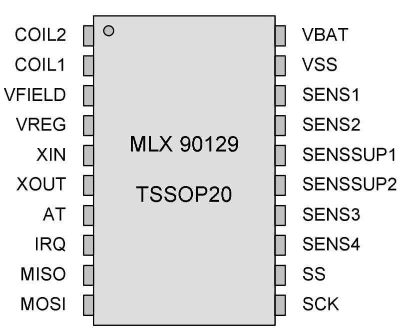
4 Absolute Maximum Ratings

Parameter	Value	Unit
Supply Voltage, V_{BAT} (maximum rating)	5.5	V
Maximum Voltage on any Pin except VFIELD, COIL1 & COIL2	V_{BAT} + 0.5	V
Reverse Voltage Protection	-0.5	V
Maximum voltage on Pin VFIELD	6	V
Maximum voltage on Pin COIL1 & COIL2	7	V
Operating Temperature Range, T_A	-40 to +105	°C
Storage Temperature Range, T_S	150	°C
ESD Sensitivity (AEC Q100 002)*	1.5	kV

* All pin except Pin No 6 (VFIELD limited to 1,5kV) and Pin No 15 (SENSSUP2 limited to 3,5kV)

Exceeding the absolute maximum ratings may cause permanent damage.
Exposure to absolute-maximum-rated conditions for extended periods may affect the device's reliability.

5 Pin definition



Pin	Symbol	I/O	Description
1	COIL2	B	Coil terminal 2 for RFID interface
2	COIL1	B	Coil terminal 1 for RFID interface
3	VFIELD	O	Unregulated supply voltage (from RF field)
4	VREG	O	Regulated supply voltage
5	XIN	I	Crystal oscillator input 1
6	XOUT	I	Crystal oscillator input 2
7	AT	I	Anti Theft (to be connected to ground)
8	IRQ	O	Interrupt output
9	MISO	B	SPI Master In Slave Out
10	MOSI	B	SPI Master Out Slave In
11	SCK	B	SPI Serial Clock
12	SS	B	SPI Slave Select
13	SENS4	I	Sensor 2 input 2
14	SENS3	I	Sensor 2 input 1
15	SENSSUP2	O	Sensor 2 supply
16	SENSSUP1	O	Sensor 1 supply
17	SENS2	I	Sensor 1 input 2
18	SENS1	I	Sensor 1 input 1
19	VSS	I	Ground
20	VBAT	I	Battery supply

TABLE OF CONTENT

6 General Electrical and Timing Specifications

DC Operating Parameters T_A = -40°C to 105°C, V_{VBAT}=4V (unless otherwise specified)

6.1 Power consumption

DC Operating Conditions (T = -40°C to 105°C, V_{VREG} = 2.0V to 3.2V)

Parameter	Conditions	Min	Typ	Max	Unit
Current consumption in “Stand-by” mode		-	0.5*	14**	µA
Current consumption in “Sleep” mode	Using the RC-oscillator Using external oscillator	-	1.5* 2*	15** 16**	µA
Current consumption in “Watchful” mode		-	100*	160**	µA
Current consumption in “Run” mode (with internal temperature sensor)	Sense & Convert	300	700	800**	µA µA

* at 25 °C
**at 105°C

6.2 RFID interface

DC Operating Conditions (T = -40°C to 105°C)

Parameter	Conditions	Min	Typ	Max	Unit
Internal resonance capacitance	Once trimmed	72	75	77	pF
Minimum coil AC voltage (for operation)			3		Vpp
Maximum voltage on Coil1, Coil2	Induce voltage on VFIELD is below 6V			7	Vpp
ISO/IEC 15693-3 data rate			26		Kbits/s
Vfield external Capacitor			100		nF

6.3 SPI: electrical specification

DC Operating Conditions (T = -40°C to 105°C) and Low-volt option not activated

Parameter	Description	Min	Typ	Max	unit
VIH	Input High Voltage (SPI slave)	2.5	3.0	3.5	V
VIL	Input Low Voltage (SPI slave)	-0.5	0	0.5	V
VOH	Output High Voltage (I sunk = -1 mA)	2.5		-	V
VOL	Output Low Voltage (I forced = 1 mA)	-		0.4	V

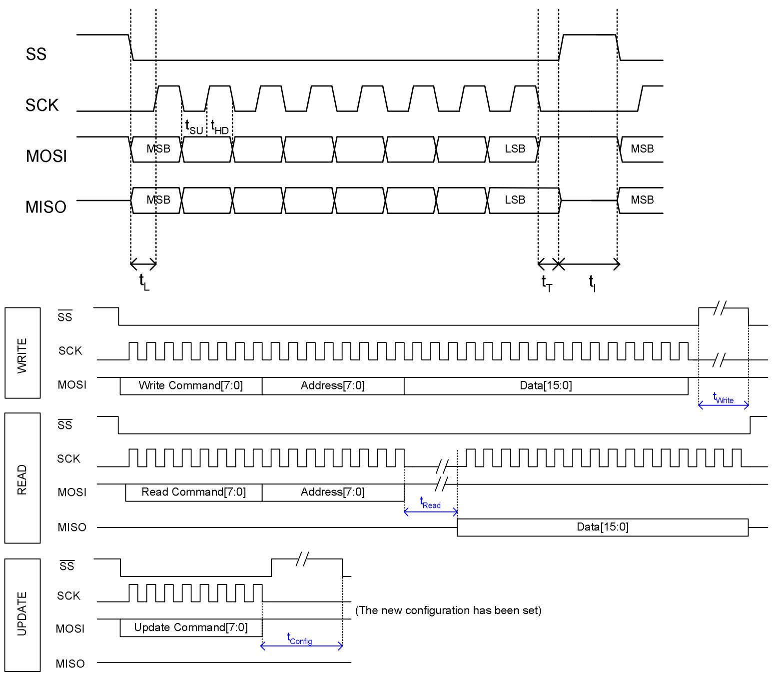
DC Operating Conditions (T = -40°C to 105°C) and Low-volt option activated

Parameter	Description	Min	Typ	Max	unit
VIH	Input High Voltage (SPI slave)	1.4	2.0	2.5	V
VIL	Input Low Voltage (SPI slave)	-0.3	0	0.6	V
VOH	Output High Voltage (I sunk = -1 mA)	1.2		-	V
VOL	Output Low Voltage (I forced = 1 mA)	-		0.4	V

6.4 Non-volatile memories

Parameter	Description	Min	Typ	Max	unit
DataRet85	Data retention at 85°C	10			year
Cyclenb25	Number of program cycles at 25°C	100000			-
Cyclenb125	Number of program cycles at 125°C	10000			-

6.5 Slave SPI: timing specification



Timing specifications

Parameter	Description	Slave side		Units
		Min	Max	
tch	SCK high time	500	-	ns
tcl	SCK low time	500	-	ns
t_{Read} (**)	Delay to read a register word Delay to read an EEPROM word Delay to read an EE-Latch word Delay to get the ADC output code	2.3 80 2.3 2300	- - - (*)	µs
t_{Write} (**)	Delay to write a register word Delay to write an EEPROM word Delay to write an EE-Latch word	2.2 18 11	- - -	us ms ms
t_{Config}	Execution delay for commands *Update*	2.2	-	ms
t_{SU}	Setup time of data, after a falling edge of SCK	100	-	ns
t_{HD}	Hold time of data, after a rising edge of SCK	500	-	ns
t_L	Leading time before the first SCK edge _ when the MLX90129 is not in sleep mode _ when the MLX90129 is in sleep mode (***)	 600 1.5	 - -	 ns ms
t_T	Trailing time after the last SCK edge	500	-	ns
t_I	Idling time between transfers (SS=1 time)	500	-	ns

(*) – The conversion time depends on the programmed initialization time and on the ADC options.
(**) For the Read/Write Internal Devices commands, the delay depends on the nature of the so-called Internal Device: (Register, EE-Latch bank, ADC,…)
(***) – See the power management chapter to know when the MLX90129 may be in sleep mode

6.6 Master SPI timing specifications

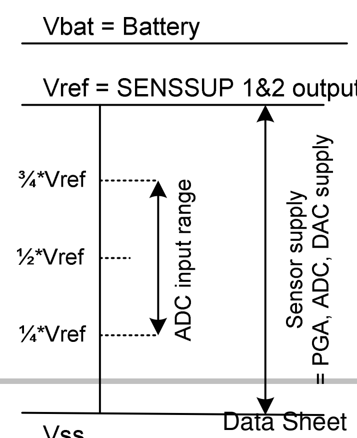
Parameter	Description	Master side			Units
		Min	Nom	Max	
tch	SCK high time		400		ns
tcl	SCK low time		400		ns
t_{SU}	Setup time of data, after a falling edge of SCK		400		ns
t_{HD}	Hold time of data, after a rising edge of SCK		400		ns
t_L	Leading time before the first SCK edge		400		µs
t_T	Trailing time after the last SCK edge		1		µs
t_I	Idling time between transfers (SS=1 time)		1600		ns

6.7 Sensor Signal Conditioner: electrical specifications

-40°C < Temp < 105°C, unless otherwise specified. The sensor is supplied by a regulated voltage called $V_{ref.}$

Parameter	Symbol	Conditions / Comment	Min	Typ	Max	Units
GENERAL CHARACTERISTICS						
Battery voltage	Vbat	Low-volt option deactivated Low-volt option activated	3.8 2.7		5.5 5.5	V V
SENSOR ADJUSTMENT CAPABILITY						
Sensor Reference voltage V_{ref} (2)	SENSSUP1 SENSSUP2	Low-volt option = 0 Low-volt option = 1	3.0 2.0	3.1 2.1	3.2 2.2	V
Full Span (3)	Sens_FS	Full scale of the sensor output voltage (Sens_CM is at the specified value)	V_{ref} /1200	-	V_{ref} /16	V
Zero offset (1)(3)	Sens_Off	Maximum sensor offset that can be compensated	- $V_{ref}/32$	-	$+V_{ref}/32$	V
Common-mode voltage	Sens_CM		$1/3*V_{ref}$	½* V_{ref}	$2/3*V_{ref}$	V
SENSSUP1 output impedance	Sens1_Z			7		Ω
SENSSUP2 output impedance	Sens2_Z			15		Ω

Notes:
(1): The capability of adjustment of the input offset depends on the selected gain of the first Programmable Gain Amplifier (PGA1) and on the sensor output span.
(2): The reference voltages of the ADC, of the DAC and the supply voltage of the sensors are ratio-metric.
(3): Full span is defined as the maximal sensor differential output voltage: $\Delta V(\text{sensor output})_{max}$, i.e the maximum voltage range allowed on the MLX90129 sensor interface inputs SENS1, SENS2, SENS3 and SENS4.



Parameter	Conditions / Comment	Min	Typ	Max	Units
PROGRAMMABLE-GAIN AMPLIFIER PGA1					
Gain accuracy	Code PGA1gain[3:0] = 0000 (gain=8) -> 1010 (gain=75)	95	100	105	%typ
PROGRAMMABLE-GAIN AMPLIFIER PGA2					
Gain accuracy	Code PGA2gain[2:0] = 000 (gain=1) -> 111 (gain=8)	95	100	105	%typ
PGA1 + PGA2 + DAC					
Gain range		8		600	V/V
Sensor offset trimming range	(= offset max of the sensor)	$-V_{ref}/32$		$+V_{ref}/32$	V
Sensor offset trimming step	8-bits DAC (7 bits + sign) Ratio-metric, to cancel the offset of the sensor		$V_{ref}/128$		V
Differential input range	Gain (PGA) = 8 (if higher, PGA_Dir should be Vref/2 divided by the gain)		$V_{ref}/16$		V
ADC differential input range			$½.V_{ref}$		V
DAC (differential outputs)					
Resolution	7 bits + 1 bit sign		8		bit
INL		0		0.5	lsb
DNL		0		0.5	lsb

Parameter	Conditions / Comment	Min	Typ	Max	Units
BRIDGE SUPPLIES & REFERENCES					
Reference serial resistance (Rv1, Rv2)	6 bits-programmable: Min Max		0.5 63.5		kΩ
Serial resistance accuracy	Above code 0b000111 (7.5 kΩ)	80	100	120	%typ
Serial resistance step			1		kΩ
Matching between Rv1 and Rv2	Above code 0b000111 (7.5 kΩ)			1	%
INTERNAL TEMPERATURE SENSOR					
Full scale		-40		+105	°C
Output range	ΔTemp = 145°C,	-	155	-	mV
Offset	ΔVout at T = 25°C		45		mV
Sensitivity	ΔVout / ΔTemp	-	1.06	-	mV/°C
Non-linearity (*)	ΔTemp = 145°C	-	±2.65	-	mV

(*) The internal temperature sensor requires a calibration. On the full range the calibration allows an accuracy of ±2.5°C. This can be improved within a reduced temperature range (e.g. ±1°C within -30 and 30°C), or by using a remote (external) temperature probe (+/-0.5° over the full range)

ADC
The ADC data output is a 16bit data. The *MODE[1:0]* bits controls the tradeoff between the duration of the counting phase and the resolution. Mode 00 is the fastest but also the least accurate mode whereas the mode 11 is the most accurate but the slowest. The *LOW_POWER* bit allows the user to reduce the power consumption of the ADC

ADC parameter	Mode 00	Mode 01	Mode 10	Mode 11	Units
ENOB: effective number of bits	8	9	10	11	bit
Conversion time (*) in normal power mode Conversion time (*) in low power mode	3.2 6.4	5.8 11.6	11.3 22.6	21 42	ms

(*): To get the sampling rate of the system, the initialization time must be added to the conversion time. This time is programmable as it depends on the selected sensor (by default it is 150 µs).

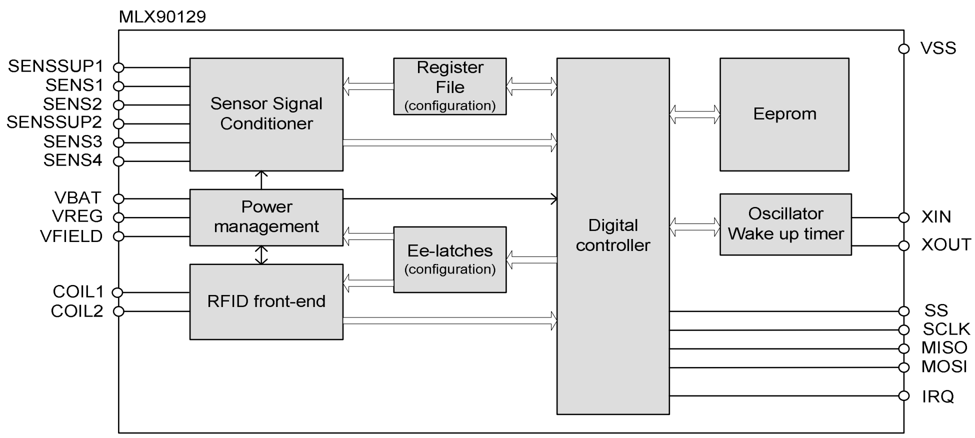
6.8 VREG regulator, and Oscillators: electrical specifications

-40℃ < Temp < 105℃, unless otherwise specified.

Parameter	Conditions / Comment	Min	Typ	Max	Units
VREG REGULATOR					
VREG Output voltage	Low-volt option = 0 Low-volt option = 1 / Vbat>= 3V Low-volt option = 1 / Vbat< 3V	2.8 2.0 2.0	3.0 2.2 2.2	3.2 2.4 2.7	V V V
VREG Output max. current	Low-volt option = 0 Drop 7% VREG Drop 25% VREG Low-volt option = 1 Drop 7% VREG Drop 17% VREG			 2.0 5.0 2.0 5.0	 mA mA mA mA
VREG External capacitor	Stable smoothed signal	0	-	10	µF
OSCILLATORS (time base for datalogging)					
Accuracy with Internal Low Frequency Oscillator				±15	%
IAccuracy with External Crystal Oscillator	With an ideal external 32,768kHz crystal			±0.5	%

7 General Description

7.1 Block diagram



The ***sensor signal conditioner*** is used to amplify, filter and convert the output voltage of resistive sensors. There may be an external single-ended or differential resistive sensor, or the internal temperature sensor. The two external sensors are supplied by a stable reference voltage, provided by an integrated voltage regulator. The sensor output voltage is amplified thanks to a programmable-gain amplifier, and has its offset voltage compensated. Then, the conditioned sensor signal fits the input range of the A/D converter. The ADC converts the signal in a 16-bits code that can be stored or transmitted.

The ***power management*** unit deals with the different power modes of the chip: it monitors the battery level, scavenges the energy coming from a RFID 13,56MHz field and makes the power-on reset signal. A regulator is used to supply the digital parts, but can also be used to supply some other external devices.

The ***Oscillators' block*** contains different kinds of oscillators: a very low power, low frequency 1kHz RC oscillator used as a wake-up timer, a low-power 32.768kHz quartz oscillator that can be used for an accurate time basis, and a high frequency 5MHz RC oscillator used for the digital controller.

The ***Register File*** contains all the configuration parameters of the chip. It may be loaded from the EEPROM after power-on, or as the result of a specific request from RFID or SPI.

The ***EE-Latches*** are used when device configuration parameters have to be immediately available.

The ***RFID front-end*** receives an external 13,56-MHz magnetic field, sensed on an external antenna coil. The antenna design is made easy thanks to an internal programmable high-Q capacitance (tuned during the test phase). From the antenna output voltage, it makes a stable clamped DC supply voltage, recovers the clock, and controls the modulation of the carrier and the demodulation of the incoming signal.

The ***EEPROM*** is a 4-kbits non-volatile memory, organized as 256 words of 16 bits divided in 39 reserved for configuration, 2 for default trimming value (*EE-Latches #03,#04 and #09*) backup and 215 available for the application (around 3.4 kbits user memory). Its access is protected by several security levels.

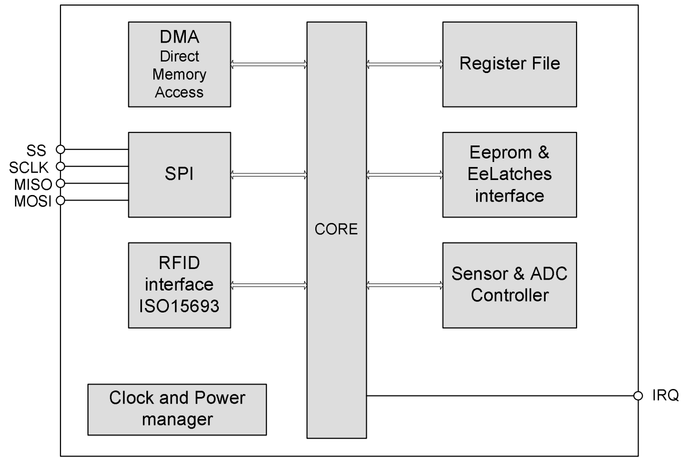
The ***Digital Controller*** manages the accesses of the different interfaces (SPI, RFID) with the different memories (EEPROM, register file) and the sensor. It comprises the RFID ISO-15693 and SPI protocols, controls the sensor signal conditioner and stores or sends the ADC output code. It can also run some standalone applications, thanks to its unit called *Direct Memory Access* (DMA).

7.2 Digital Controller and memory domains

7.2.1 Digital controller

The main features of the digital part of MLX90129, called *Digital Controller* are:

- Slave / Master SPI interface
- RFID interface
- DMA: Direct Memory Access
- Register File controller
- EEPROM controller
- Sensor interface controller
- Clock and Power management
- Core: transactions arbiter and interrupt manager



The digital controller manages the transactions between the communication interfaces, the memories and the sensor. It allows also a standalone mode with its DMA unit. All these blocks are described in the next chapters.

The SPI and RFID communication ways can be used concurrently. The *Core transaction arbiter* handles the priorities and the interrupts. It updates some status bits that may be used by the external microcontroller or the RFID base-station to optimize the communication.

The *Digital Controller* of the MLX90129 allows the user to do the following tasks, via SPI or RFID:
_ Configure the sensor interface and the communication media.
_ Manage the power consumption, the interrupts, the security items,…
_ Run A/D conversions of the selected sensors.
_ Store (or read) data in the internal or in an external EEPROM.
_ Configure and start a standalone process (sleep – sense – interrupt or store – sleep - …)
_ Get the status of the current process.

All these tasks may be done by simply reading or writing the different memories: EEPROM, registers, ee-Latches, internal devices. Thus, several address domains are defined to access them in an easy way.

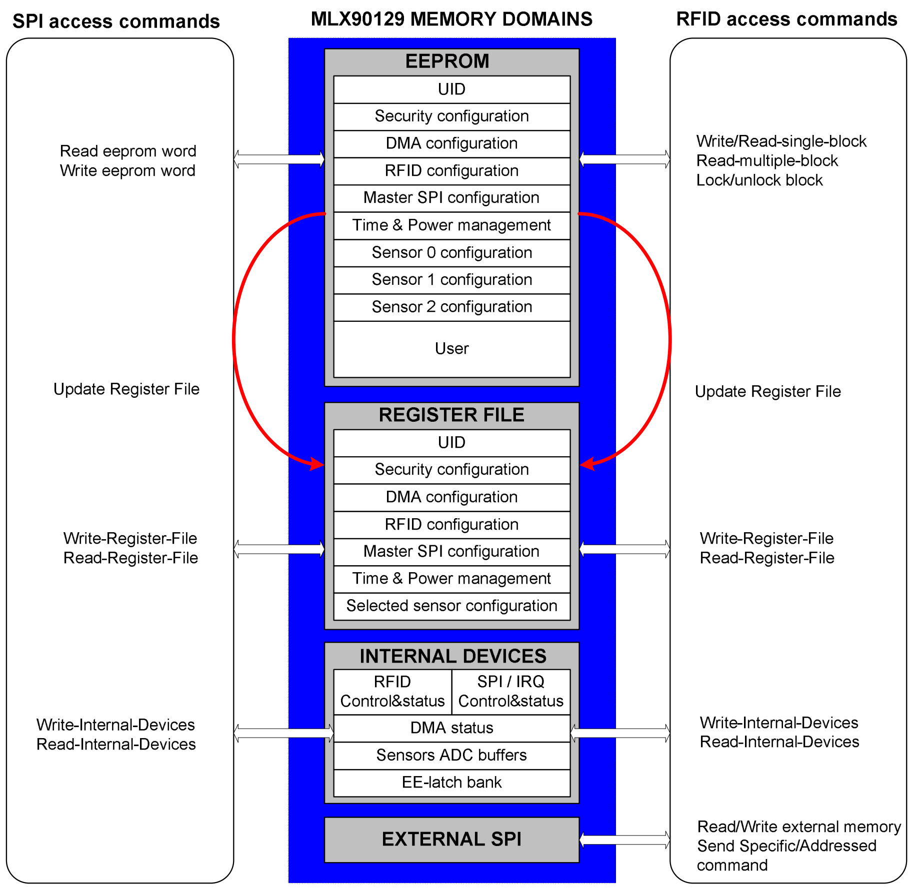
7.2.2 Address domains

Four address domains have been defined to designate the memory and the non-memory devices that act during the requested transactions:

- ***EEPROM address domain****:*
This domain addresses the non-volatile EEPROM. It is used to store the user-defined data and the image of the *Register File* that can be automatically downloaded after a power-on. This memory block is energy independent and can store data even when the MLX90129 is no longer powered.

- ***Register File address domain****:*
This memory domain is used to store the current configuration information of all internal MLX90129 devices (Sensor interface, Power management …). This memory is energy-dependent and must be updated each time the MLX90129 is turned-on.
- ***Internal Devices address domain***:
This domain allows accessing the registers linked to the so-called *internal devices* like the ADC buffers, the status words of the *Core Transaction Arbiter* and the EE-Latches. They may be accessed with the appropriate SPI / RFID commands including its address. The difference with the Register File is the fact that they are not copied from the EEPROM at the start-up and they may be used during the requested transaction.

- ***External memory address domain***:
This domain addresses the external memory which can be connected to the MLX90129, using the SPI in master mode.



7.3 Internal Devices

The term *Internal Devices* designates the registers used to configure the main "non-memory" digital units: sensor interface, SPI / RFID interfaces, DMA … All these registers are part of the *Internal Device Address Domain*:

The registers linked to the SPI and RFID interfaces, called *SPI/RFID core control word* and *SPI/RFID core interrupt/status word* have the same definition, but are physically different and may contain some different data. The content of these registers are explained in the following chapters (SPI, RFID). Some of these bits may be used to avoid conflicts for the memories access, when communicating with SPI and RFID at the same time. For that, they can be accessed at any time via SPI or RFID.

The SPI / RFID local buffers store the result data of the last transaction. They are useful for example when the A/D conversion time is too long and does not fit the timing requirements of the RFID protocol.

The *EE-Latches* contain some non-volatile data, immediately available (no delay, no supply), used for the options of the clock and power management.

The registers of the DMA unit called *Current destination address* are used to give a status of the process (the number of words that have been registered).

The *ADC buffer* sensor 0, sensor 1 and sensor 2 allow to start a sensor conversion according to the sensor configuration saved in EEPROM in the sensor 0, 1 and 2 configuration are. The conversion starts with the reading of the buffer. The output of the conversion is available in the SPI / RFID local buffer.

Map of the *Internal Device Address Domain*

Addr	From SPI side	From RFID side	Link
	SPI / RFID		
0x00	SPI core control word	RFID core control word	Page 33 / 29
0x01	SPI core interrupt/status word (read only)	RFID core interrupt/status word (read only)	Page 33 / 29
0x02	SPI local buffer (read only)	RFID local buffer (read only)	Page 33 / 29

Addr	Access by SPI and RFID	Link
	Non-volatile memory	
0x03	EE-Latches word 0	Page 14 / 53
0x04	EE-Latches word 1	Page 14 / 52
	Direct Memory Access (DMA)	
0x05	Current destination address (read only)	Page 40
	Sensors	
0x06	ADC buffer sensor 0	Page 15
0x07	ADC buffer sensor 1	Page 15
0x08	ADC buffer sensor 2	Page 15
	Contactless-tuning capacitance (CTC)	
0x09	CTC code	Page 14

Note:
The *internal devices* having the addresses 0x00, 0x01, 0x02, 0x05 are registers. Those having the addresses 0x03, 0x04, 0x09 are EE-Latches, and those whose addresses are 0x06, 0x07, and 0x08 refer to the ADC output buffers. The read / write delays are specified for all kind of *internal devices*, when accessing them via SPI.

7.3.1 EE-Latches

Another kind of non-volatile memory is used to store the trimming / configuration bits that should be immediately available: the EE-Latch bank. They are mainly used for the trimming of the oscillators and the capacitance of the antenna, for security and power management.
/!\ It is important to read its value before re-programming it, in order to not erase some trimming bits.

EE-Latches map: (*Internal Devices Domain*, Address #03, #04 and #09, read/write)

Bits	Name	**Description** (when the bit is asserted high)
#03 - *EE-Latches word 0*		
4:0	**LFO_Freq_Trim** (Trimming bits)	(used by Melexis)
6:5	**Bias_Cur_Trim** (Trimming bits)	(used by Melexis)
7	**DisableAutoLoading**	Disables the automatic loading of the Register File with its image from the EEPROM after a power-on reset from the battery
10:8	**HFO_Freq_Trim** (Trimming bits)	(used by Melexis)
13:11	**VReg_Trim** (Trimming bits)	(used by Melexis)
14	**RCb_Quartz**	Selects the low-frequency RC-oscillator LFO (=0) or the quartz-oscillator XLFO (=1)
15	**Disconnect_Vfield_Vbat**	Disconnects the pads VFIELD and VBAT, when not using the energy from the field to supply the whole device.
#04 - *EE-Latches word 1*		
1:0	**Mod_Res**	11: default modulator resistance
2	**VReg_Dis**	Disables the VReg regulator and shorts-cut its output to Vbat
3	**VReg_LV**	Low-voltage option for the VREG regulator and the sensor regulator
7:4	Reserved	(Must be 0)
14:8	**RFID_EEPROM_Lock_Map****	Map of pages in EEPROM, to be locked for RFID write, using the "*Lock*" command
15	**RFID_Device_Lock****	Locks the RFID device
#09 - *CTC code*		
4:0	**CTC_Trim** (Trimming bits)	(used by Melexis)
15:5	Not used	(Must be 0)

(**) - following fields are not accessible for write from RFID interface via device write command.

EE-Latches backup in EEPROM
The content of EE-Latches (Internal devices #03, #04 and #09) are copied in the EEPROM for backup:

EEPROM #27 and #28

Bits	Description
#27 - *Internal device backup word 1*	
15:0	Copy of internal device #03 bits [15:0]
#28 - *Internal device backup word 2*	
3:0 15:4	Copy of internal device #04 bits [3:0] random

Ex: The command read ADC buffer sensor 0 (Read Internal Device #06) sent by RFID or by SPI loads the configuration of the sensor 0 from EEPROM (address #15 to #1A) into the register file and start the A/D conversion. The output of the conversion is available in the *internal device* #02 (local buffer).

7.3.2 Sensors ADC buffers

In order to read the output data of a sensor, the SPI master or the RFID base-station has to access one of the 3 *ADC buffer* in the *Internal Device address domain*. Accessing (read command) this buffer makes:

- Load the selected sensor configuration into the register file
- Start the A/D conversion and the data processing.

Then the command read ADC buffer sensor 2 (Read Internal Device #08) sent by RFID or by SPI overwrite the register file with the configuration of the sensor 2 (EEPROM from #21 to #26).

To make sure that all operations are done, it is enough to:

- Wait for a specific period of time and read the *internal device* #02 (local buffer).
- Periodically monitor the *SPI/RFID Core status word* and check the bit: *Sensor interrupt: Data ready*.

7.4 Configuration EEPROM & Register files

The MLX90129 embeds a 4kbits EEPROM memory. This non-volatile memory contains the configuration parameters and some identification numbers. The configuration part of the EEPROM consists of 45 words of 16 bits. The 210 other words are available for the specific needs of the application or may be used for data-logging or for the configuration of the external devices. The read and write access rights are defined for each page and depends on the device wanting to access it: a microcontroller, a RFID base-station or the internal DMA unit of the MLX90129. The user can also lock and unlock some pages by sending the appropriate RFID commands.

7.4.1 EEPROM Map

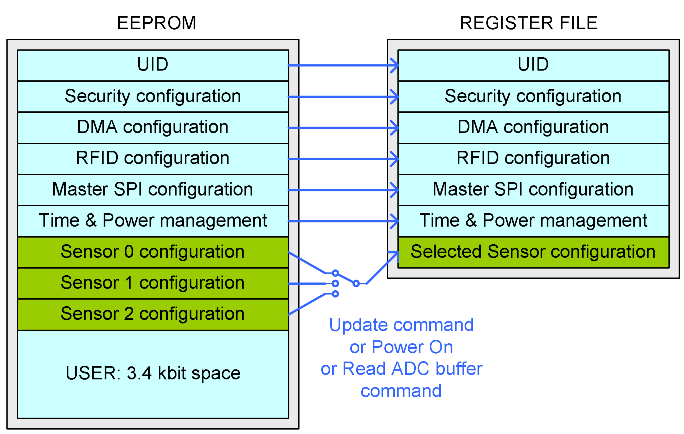
Address	Description	Link
	UID (Unique Identifier)	
#00	UID: bits 15:0	Page 18
#01	UID: bits 31:16	Page 18
#02	UID: bits 47:32	Page 18
#03	UID: bits 63:48	Page 18
	Security configuration space	
#04	EEPROM security map	Page 54
#05	Device security map	Page 54
#06	Password RFID	Page 54
#07	(not used)	
#08	(not used)	
	DMA configuration space	
#09	DMA: Control word	Page 40
#0A	DMA: Source address word	Page 40
#0B	DMA: Destination address word	Page 40
#0C	DMA: Length	Page 40
	SPI (External memory) configuration space	
#0D	External memory: Control word	Page 42
#0E	External memory: Command codes word	Page 42
	Timer (power control) configuration space	
#0F	Timer: Period	Page 41
#10	Timer: control word	Page 41
	Address space always accessible from RFID interface	
#11	RFID user register: its purpose is user-defined.	Page 18

Address	Description	
	Sensors common configuration space	
#12	Sensor power configuration word	Page 47
#13	(reserved)	
#14	Sensor trimming configuration word	Page 47
	Sensor 0 configuration space	
#15	*Sensor 0*: Sensor control word	Page 48
#16	*Sensor 0*: Sensor low threshold word	Page 48
#17	*Sensor 0*: Sensor high threshold word	Page 48
#18	*Sensor 0*: Sensor signal conditioner configuration word	Page 48
#19	*Sensor 0*: Sensor connections configuration word	Page 48
#1A	*Sensor 0*: Sensor resistance configuration word	Page 48
	Sensor 1 configuration space	
#1B	*Sensor 1*: Sensor control word	Page 48
#1C	*Sensor 1*: Sensor low threshold word	Page 48
#1D	*Sensor 1*: Sensor high threshold word	Page 48
#1E	*Sensor 1*: Sensor signal conditioner configuration word	Page 48
#1F	*Sensor 1*: Sensor connections configuration word	Page 48
#20	*Sensor 1*: Sensor resistance configuration word	Page 48
	Sensor 2 configuration space	
#21	*Sensor 2*: Sensor control word	Page 48
#22	*Sensor 2*: Sensor low threshold word	Page 48
#23	*Sensor 2*: Sensor high threshold word	Page 48
#24	*Sensor 2*: Sensor signal conditioner configuration word	Page 48
#25	*Sensor 2*: Sensor connections configuration word	Page 48
#26	*Sensor 2*: Sensor resistance configuration word	Page 48
	EE-Latches backup space	
#27	Internal device backup word 1	Page 14
#28	Internal device backup word 2	Page 14

(**) In the register file, this configuration space is updated from the appropriate part of the *Extended sensor configuration space* at each access to one of the three sensors. This configuration space and all others with higher addresses are not updated during a *Register File Update* operation.

7.4.2 Update of the Register File

The EEPROM contains the initial image of the *Register File*. This image is copied after the power-on, upon a SPI / RFID *Update* request. The sensor configuration in the *Register File* depends on the currently selected sensor. The sensor is selected either manually by reading the ADC buffer corresponding or automatically during a standalone application.



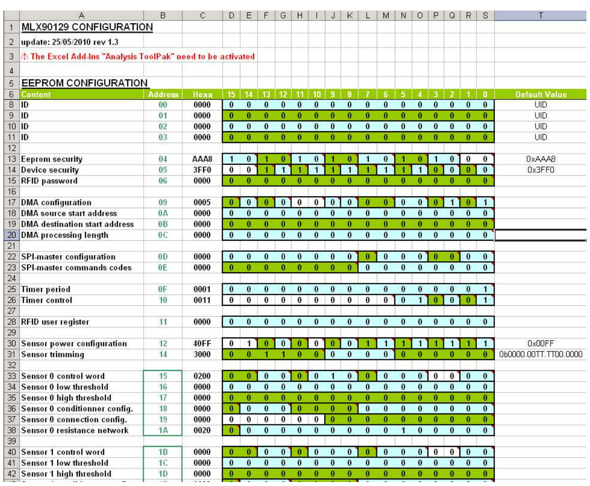
7.5 EE-Latches and EEPROM Melexis default configuration

The MLX90129 is pre-set with the following configuration.

Address	Default value	Description
EEPROM		
[#03 - #00]	0xXXXX	Unique ID set by Melexis
#04	0xAAA8	Refer to EEPROM security map
#05	0x3FF0	Refer to device security register
[#0B - #06]	0x0000	
#0C	0xXXXX	Random value, can be replaced by 0x0000
[#10 - #0D]	0x0000	
#11	0xXXXX	Random value, can be replaced by 0x0000
#12	0x00FF	Refer to sensor power configuration
#13	0x0000	
#14	0b0000.00TT.TT00.0000	
[#FF - #15]	0xXXXX	Random value, can be replaced by 0x0000
EE-Latches		
03	0b00TT.TTTT.0TTT.TTTT	Data loading enabled / LFO selected / Vfield connected to Vbat
04	0x000B	Low volt option =1
09	0b0000.0000.000T.TTTT	Reading gives 0x001F

'T' are Melexis trimming bits

In order to configure the registers of the MLX90129 easily, a configuration tool can be downloaded from the Melexis web site, www.melexis.com.



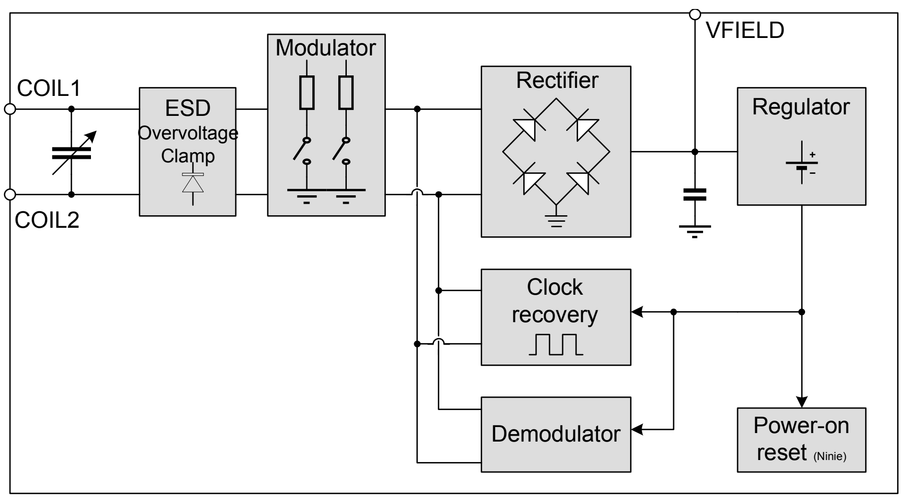
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	MLX90129 CONFIGURATION																			
2	update: 25/05/2010 rev 1.3																			
3	/!\ The Excel Add-Ins "Analysis ToolPak" need to be activated																			
4																				
5	EEPROM CONFIGURATION																			
6	Content	Address	Hexa	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Default Value
8	ID	00	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	UID
9	ID	01	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	UID
10	ID	02	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	UID
11	ID	03	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	UID
12																				
13	Eeprom security	04	AAA8	1	0	1	0	1	0	1	0	1	0	1	0	1	0	0	0	0xAAA8
14	Device security	05	3FF0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0x3FF0
15	RFID password	06	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
16																				
17	DMA configuration	09	0005	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	
18	DMA source start address	0A	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
19	DMA destination start address	0B	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
20	DMA processing length	0C	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
21																				
22	SPI-master configuration	0D	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
23	SPI-master commands codes	0E	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
24																				
25	Timer period	0F	0001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
26	Timer control	10	0011	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	
27																				
28	RFID user register	11	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
29																				
30	Sensor power configuration	12	40FF	0	1	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0x00FF
31	Sensor trimming	14	3000	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0b0000.00TT.TT00.0000
32																				
33	Sensor 0 control word	15	0200	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
34	Sensor 0 low threshold	16	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
35	Sensor 0 high threshold	17	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
36	Sensor 0 conditionner config.	18	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
37	Sensor 0 connection config.	19	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
38	Sensor 0 resistance network	1A	0020	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	
39																				
40	Sensor 1 control word	1B	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
41	Sensor 1 low threshold	1C	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
42	Sensor 1 high threshold	1D	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

8 Communication

8.1 RFID communication

8.1.1 RFID analog front-end

The MLX90129 RFID interface complies with the ISO15693 requirements. It is accessed by the RFID base-station (reader) in modulating the 13.56 MHz carrier frequency. The data are recovered from the signal amplitude modulation (ASK, Amplitude Shift Keying 10% or 100%). The Data transfer rate is 26 kBit/s using the 1/4 pulse-coding mode.
The outgoing data are generated by an antenna load variation, using the Manchester coding, and using one or two sub-carrier frequencies at 423 kHz and 484 kHz. The data transfer rate is 26 k-Bit/s. From the incoming field, the RFID interface recovers the clock and makes its own power supply. The rectified voltage may also be used to supply the whole device in battery-less applications.



8.1.2 ISO-15693 Features and Command set

For complete information about the communication protocol, please refer to the standard document:
ISO/IEC FCD 15693-2 and ISO/IEC FCD 15693-3: **Identification cards- contactless integrated circuit(s) cards - Vicinity cards -** It is available on the website: http://www.iso.org
Some of the features of the protocol are not supported. Furthermore, some “custom” commands have been defined (see Command set). The MLX90129 is provided with a Unique IDentifier compliant with the ISO standard.

Summary of the main, supported features

Features	Supported	Not supported
Reader to Tag Modulation Index	10% and 100%	
Reader to Tag Coding	Pulse Position Modulation: 1 out of 4	PPM: 1 out of 256
Tag to Reader Modulation	Single and dual Sub-carrier	
Tag to Reader Sub-Carrier	423 kHz / 484 kHz	
Tag to Reader Coding	Manchester	
Tag to Reader Data-rate	High Data-rate 26 kBit	Low Data-rate 6 kBit

Summary of the main, supported protocol parts

- Data element

Data Element	Supported
UID (Unique Identifier)	Yes
AFI (Application Family Identifier)	No
DSFID (Data Storage Format Identifier)	No
CRC	Yes
Security status	No

- Protocol

Request Flag	Supported
Sub-Carriers	Yes
Data-rates	No
Inventory	Yes
Protocol extension	No
Select	Yes
Address	Yes
Options (write single block command only)	Yes
Response Flag	**Supported**
Error	Yes

- Anti-collision: Supported

Command frame

The content of the data included in the frame of a communication request, and the response from the MLX90129 to the base-station depends on the command opcode. The meaning of the flags, the equation of the CRC, the description of the Start-Of-Frame, the End-Of-Frame and the unique identifier number (UID), the meaning of the error codes… are included in the standard ISO-15693 layers 2 and 3.

Request format for ISO15693 commands:

SOF	Flags	Command code	(UID)	(Data)	CRC 16	EOF
	8 bits	8 bits	64 bits	x bits	16 bits	
	0XXX 0X1X (bin)	XX (hex)	Optional			

Request format for MLX90129commands:

SOF	Flags	Command code	(UID)	(Data)	CRC 16	EOF
	8 bits	16 bits	64 bits	x bits	16 bits	
	00XX 0X1X (bin)	XX1F (hex)	Optional	Optional		

Response format without data when Error_flag is NOT set:

SOF	Flags	CRC 16	EOF
	8 bits	16 bits	
	0000 0000		

Response format with data when Error_flag is NOT set:

SOF	Flags	(Data)	CRC 16	EOF
	8 bits	x bits	16 bits	
	0000 0000			

Response format with error when Error_flag is set:

SOF	Flags	Error code	CRC 16	EOF
	8 bits	8 bits	16 bits	
	0000 0001			

Command set

The command set lists the mandatory commands defined in the standard ISO-15693 layer 3. It comprises also some custom commands used for some specific applications: access the sensor buffer, access an external device via SPI, handles the security options, etc.

ISO-15693 mandatory and optional commands

Commands	**code**	**Description**
Inventory	01	Enable an anti-collision sequence
Stay quiet	02	Enable the '*Stay Quiet'* mode
Read single block	20	Read a single word from EEPROM
Write single block	21	Write a single word to EEPROM (only mode with Option_flag set is supported)
Read multiple block	23	Read one or several contiguous blocks of the EEPROM
Select	25	Enter the "Selected" state (anti-collision)
Reset to ready	26	Return to the '*Ready*' mode

MLX90129 custom commands

Commands	**code**	**Description**
Read register file	A01F	Read one word from the *Register file*
Write register file	A11F	Write one word to the *Register file*
Read internal device	A21F	Read the content of an *internal device* identified by an address byte
Write internal device	A31F	Write the register word of an *internal device*, identified by an address byte
Read external memory	A41F	Read a word from an external memory (via SPI)
Write external memory	A51F	Write a word into an external memory (via SPI)
Send specific command	A61F	Send a command via SPI to an external device, whose code is appended to the frame (e.g. Write Enable for an external EEPROM).
Send addressed specific command	A71F	Send a command via SPI to an external device, whose code and address are appended to the frame (e.g. *Lock Block* for an external EEPROM)
Write external memory status	A81F	Send a command via SPI, to write an external memory status register (The op-code of this command is stored in a register)
Read external memory status	A91F	Send a command via SPI, to read an external memory status register (The op-code of this command is stored in a register)
Lock device	B01F	Lock an *internal device* (EEPROM, ADC, …), preventing its access.
Unlock device	B11F	Unlock an *internal device*
Update Register File	C01F	Fill the *Register File* with the image from the EEPROM, without re-boot
Lock Page	D01F	Lock a page of EEPROM
Unlock Page	D11F	Unlock a locked page of EEPROM.

0x1F corresponds to the RFID manufacturer code of Melexis

ISO-15693 mandatory and optional commands frame content

- **INVENTORY (01)**

When receiving the Inventory request, the transponder shall perform the anti-collision sequence. The Inventory flag shall be set to 1.

Request format:

SOF	Flags	Inventory command	Mask length	Mask value	CRC 16	EOF
	8 bits	8 bits	8 bits	0 - 64 bits	16 bits	
	00x0 011x	0000 0001				

Response format (if no error):

SOF	Flags	DSFID	UID	CRC 16	EOF
	8 bits	8 bits	64 bits	16 bits	
	0000 0000	0000 0000			

- **STAY QUIET (02)**

When receiving the Stay Quiet command, the transponder shall enter the Quiet state and shall not send back a response. This command shall always be executed in Addressed mode (Select flag=0 and Address flag= 1). To exit the Quiet state with a MLX90129 battery powered, the command “Reset to ready” has to be sent by the reader.

Request format:

SOF	Flags	Stay Quiet command	UID	CRC 16	EOF
	8 bits	8 bits	64 bits	16 bits	
	001x 001x	0000 0010			

- **READ SINGLE BLOCK (20)**

When receiving the Read single block request, the transponder shall read the requested block from internal EEPROM and send back its value in the response.

Request format:

SOF	Flags	Read Single Block	UID	Block address	CRC 16	EOF
	8 bits	8 bits	64 bits	8 bits	16 bits	
	00xx 001x	0010 0000	(Optional)			

Response format (if no error):

SOF	Flags	Data	CRC 16	EOF
	8 bits	16 bits	16 bits	
	0000 0000			

- **WRITE SINGLE BLOCK (21)**

When receiving the “Write Single Block” request, the transponder shall write the requested block into internal EEPROM with the data contained in the request and report the success of the operation in the response. Only the mode with Option_flag set is supported. That means, the MLX90129 shall wait for the reception of an end of frame (EOF) from the ISO15693 reader and upon such reception shall return its response.

Request format:

S	Flags	Read Single Block	UID	Block address	Data	CRC 16	E
O	8 bits	8 bits	64 bits	8 bits	16 bits	16 bits	O
F	01xx 001x	0010 0001	(Optional)				F

- **READ MULTIPLE BLOCKS (23)**

When receiving the "Read Multiple Block" command, the transponder shall read the requested block(s) and send back their value in the response. The blocks are numbered from '00' to 'FF'. The number of blocks in the request is one less than the number of blocks that the 90129 shall return in its response.

Request format:

S	Flags	Read Multiple Block	UID	First block address	Number of blocks	CRC 16	E
O	8 bits	8 bits	64 bits	8 bits	8 bits	16 bits	O
F	00xx 001x	0010 0011	(Optional)		N		F

Response format (if no error):

S	Flags	Data	CRC 16	E
O	8 bits	(N+1)*16 bits	16 bits	O
F	0000 0000			F

- **SELECT (25)**

When receiving the Select command:
_ if the UID is equal to its own UID, the 90129 shall enter the selected state and shall send a response.
_ if it is different, the 90129 shall stay at previous state and shall not send a response. The Select command must be always in Addressed mode. (The Select_flag is set to 0. The Address_flag is set to 1.)

Request format:

S	Flags	Read Single Block	UID	CRC 16	E
O	8 bits	8 bits	64 bits	16 bits	O
F	0010 001x	0010 0101			F

- **RESET TO READY (26)**

When receiving the Reset To Ready command, the transponder shall return to the Ready state

Request format:

S	Flags	Reset to ready	UID	CRC 16	E
O	8 bits	8 bits	64 bits	16 bits	O
F	01xx 001x	0010 0110			F

MLX90129 custom commands frame contents

- **READ REGISTER FILE (A01F)**

When receiving the Read register file request, the transponder shall read the requested block from Register File and send back its value in the response.

Request format:

S	Flags	Read Register File	UID	Block address	CRC 16	E
O	8 bits	8 bits	64 bits	8 bits	16 bits	O

F	00xx 001x	1010 0000 0001 1111	(Optional)				F

Response format (if no error):

S	Flags	Data	CRC 16	E
O	8 bits	16 bits	16 bits	O
F	0000 0000			F

- **WRITE REGISTER FILE (A11F)**

When receiving the Write register file request, the transponder shall write the requested block into Register File with the data contained in the request and report the success of the operation in the response.

Request format:

S	Flags	Write Register File	UID	Block address	Data	CRC 16	E
O	8 bits	8 bits	64 bits	8 bits	16 bits	16 bits	O
F	00xx 001x	1010 0001 0001 1111	(Optional)				F

- **READ INTERNAL DEVICE (A21F)**

When receiving the “Read Internal Device” request, the transponder shall read a word of the addressed internal device and send back its value in the response. The internal device is selected thanks to the address byte taking part of the command frame.

Request format:

S	Flags	Read Internal Device	UID	Block address	CRC 16	E
O	8 bits	8 bits	64 bits	8 bits	16 bits	O
F	00xx 001x	1010 0010 0001 1111	(Optional)			F

Response format (if no error):

S	Flags	Data	CRC 16	E
O	8 bits	16 bits	16 bits	O
F	0000 0000			F

- **WRITE INTERNAL DEVICE (A31F)**

When receiving the “Write Internal Device” request, the transponder shall write the addressed internal device word. If the address corresponds to the EE-Latches of the Internal Device (Internal Device #03 and #04) the RFID acknowledgment can be missing or the RFID communication can be disabled depending the settings. The MLX90129 has to be reset (power off) in order to take into account the modifications. The MLX90129 behaviour without reset can not be guaranteed.

Request format:

S	Flags	Write Internal Device	UID	Block address	Data	CRC 16	E
O	8 bits	8 bits	64 bits	8 bits	16 bits	16 bits	O
F	00xx 001x	1010 0011 0001 1111	(Optional)				F

- **READ EXTERNAL MEMORY (A41F)**

When receiving the “Read External Memory” request, the transponder shall read the requested block from external memory via SPI and send back its value in the response.

Request format:

S	Flags	Read External Memory	UID	Block address	CRC 16	E