TLE5014 Programmer

Application Note

About this document

Scope and purpose

This document describes the Evaluation Kit for the TLE5014 GMR based angle sensor.

The purpose of this manual is to describe the software installation process and how to use the TLE5014 angle sensor Evaluation Kit.

Intended audience

This document is intended for anyone who wants to use the TLE5014 Evaluation Kit.

Table of contents

1 General description

The programmer consists of an Infineon XMC1100 Boot Kit and a “shield”, which can be plugged onto the Boot Kit.

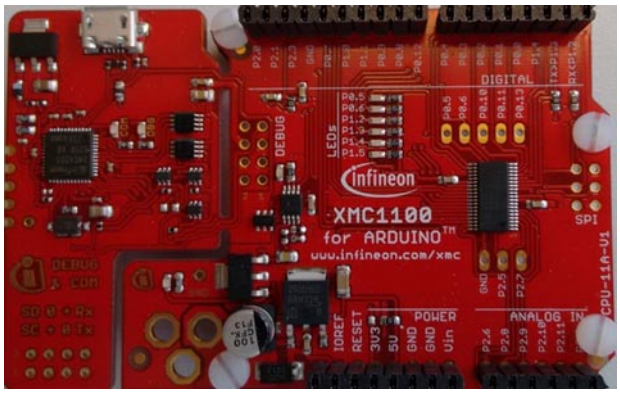


Figure 1 Infineon XMC1100 Boot Kit

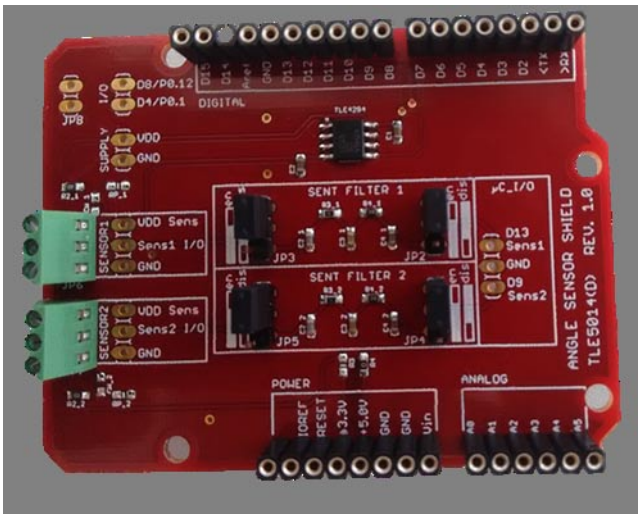


Figure 2 TLE5014 programmer shield

The software consists of one file: TLE5014 - **BootKit – V2.x.x.zip**

For connection to a PC, a USB cable is required.

1.1 Sensor connection

The shield has to be plugged onto the Boot Kit. Care has to be taken that the correct pins are connected.

The TLE5014 can be connected via a cable to the shield.

Three connections are required:

- VDD
- I/O
- GND

The shield supports two sensors with separated connectors.

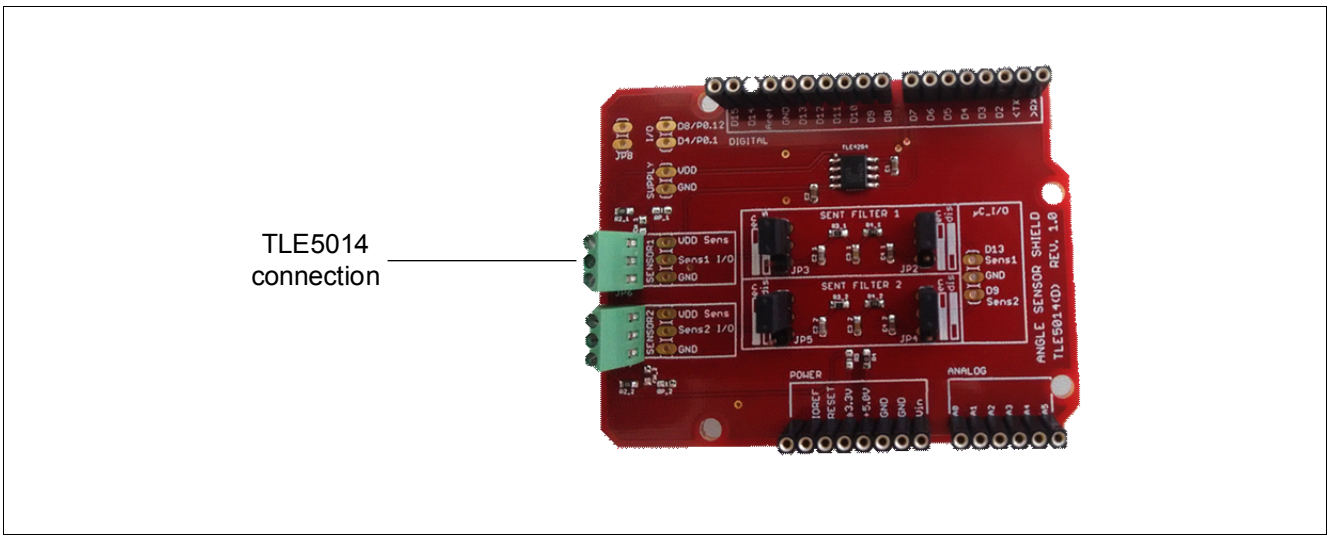


Figure 3 TLE5014 sensor connection

Care has to be taken that all pins of the TLE5014 are connected according to the TLE5014 datasheet.

1.2 TLE5014 satellite board

A satellite board is provided with a TLE5014D dual channel angle sensor which can be connected to the shield of the Eval Kit. The TLE5014 on this board is pre-programmed with the following settings:

- SENT single secure sensor (incl. rolling counter and inverted nibble)
- UT=3.0 µs, pause pulse, no short serial message

The sensor is fully configurable and can be set to different protocol options and interfaces (SENT, SPC, PWM).

For a SPC bus mode:

- channel 1 has the default hard-wired address ID=0
- channel 2 has ID =1

It is possible to change the address by changing the “zero-ohm” resistors on the board (see figure and table below).

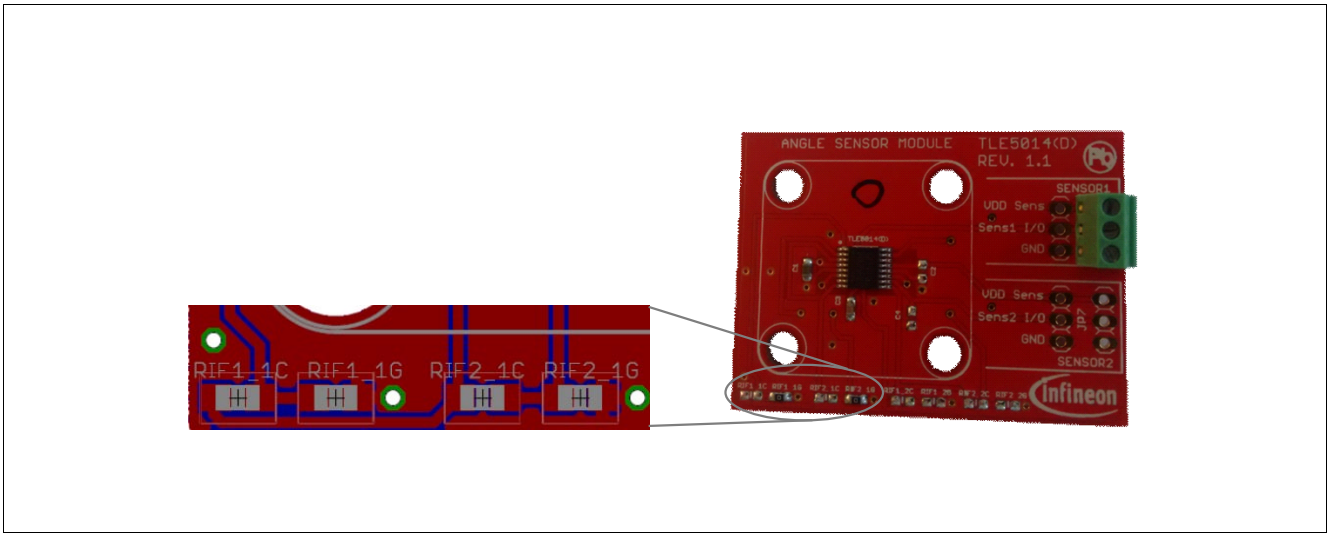


Figure 4 Satellite board

Table 1 Change the address

	RIF1_1C	RIF1_1G	RIF2_1C	RIF2_1G
ID = 0		x		x
ID = 1	x			x
ID = 2		x	x	
ID = 3	x		x	

1.3 Jumper setting

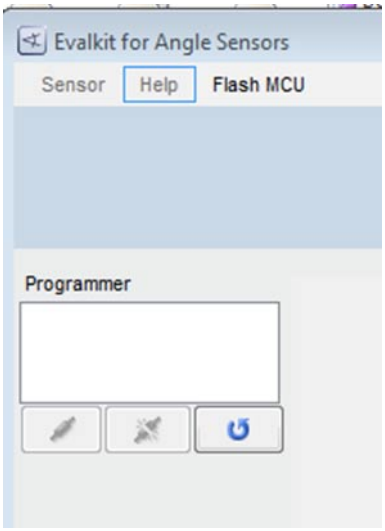
Table 2 Jumper setting

Jumper	Position	Description
J2/J3	en	SENT filter for sensor 1 enabled
J2/J3	dis	SENT filter for sensor 1disabled
J4/J5	en	SENT filter for sensor 2 enabled
J4/J5	dis	SENT filter for sensor 2 disabled

Note: For reading/writing the EEPROM the SENT filter has to be disabled.

2 Installation

1. Download and install the Seeger driver from following web page:
   https://www.segger.com/downloads/jlink/JLink _Windows.exe
2. Connect the programmer with an USB cable to an USB 2.0 port.
3. Install the programmer software by double-clicking on the file: TLE5014 **– BootKit – V2.x.x.msi**.
4. Start the installed software TLE5014 – BootKit.
5. If you use the microcontroller the first time or if you use a new software revision, click on the **Flash MCU** button (µC is flashed with firmware).



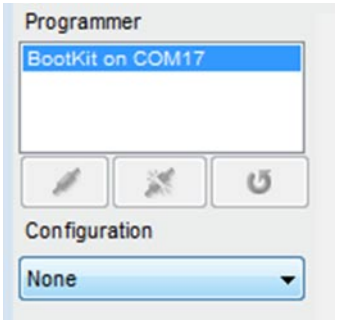
3 Programming

3.1 Programmer connection

After starting the software, click the **Connect** button to connect the Programmer. 

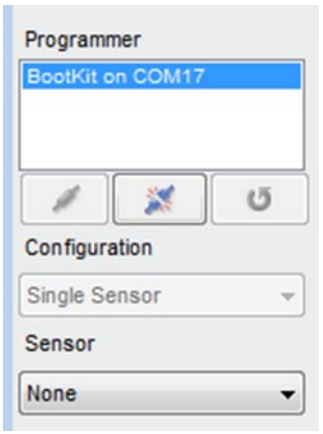
In the **Configuration** drop-down list select your configuration:

- Single sensor (= no bus operation)
- Bus operation (several sensors on one SPC line)



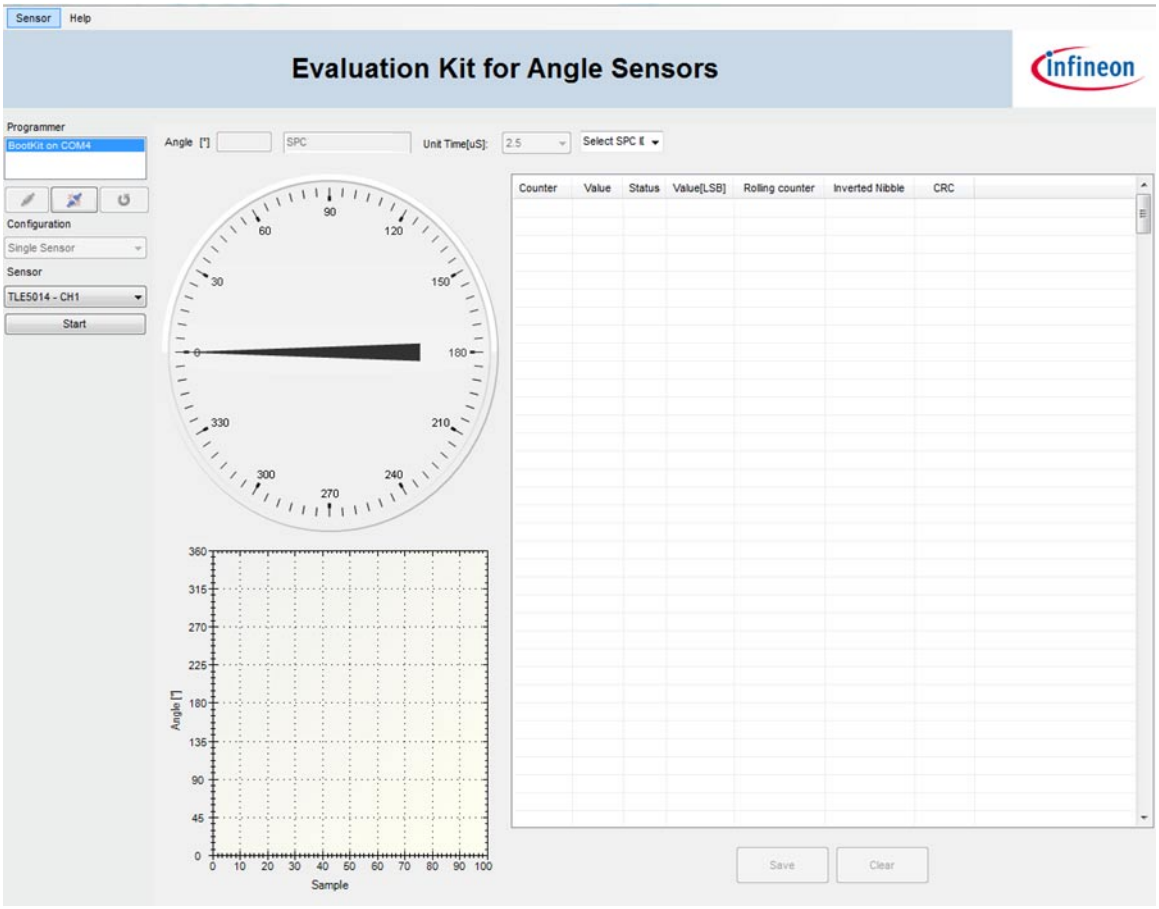
In the **Sensor** drop-down list select the sensor which you want to read. The Eval Kit supports two channels which correspond to the two connectors on the PCB:

- TLE5014 CH1 = Sens1
- TLE5014 CH2 = Sens2



3.2 Angle read-out

Click the **Start** button to start the angle read-out. The display shows the real time angle read-out of the sensor and other protocol related values (e.g. status nibble for SENT/SPC).



Click the **Stop** button to stop the sensor read-out.

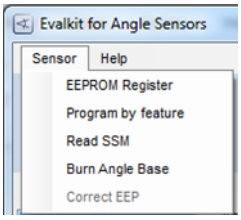
The tool automatically displays the preprogrammed sensor interface and unit time.

The SPC address has to be set manually:

3.3 User menu

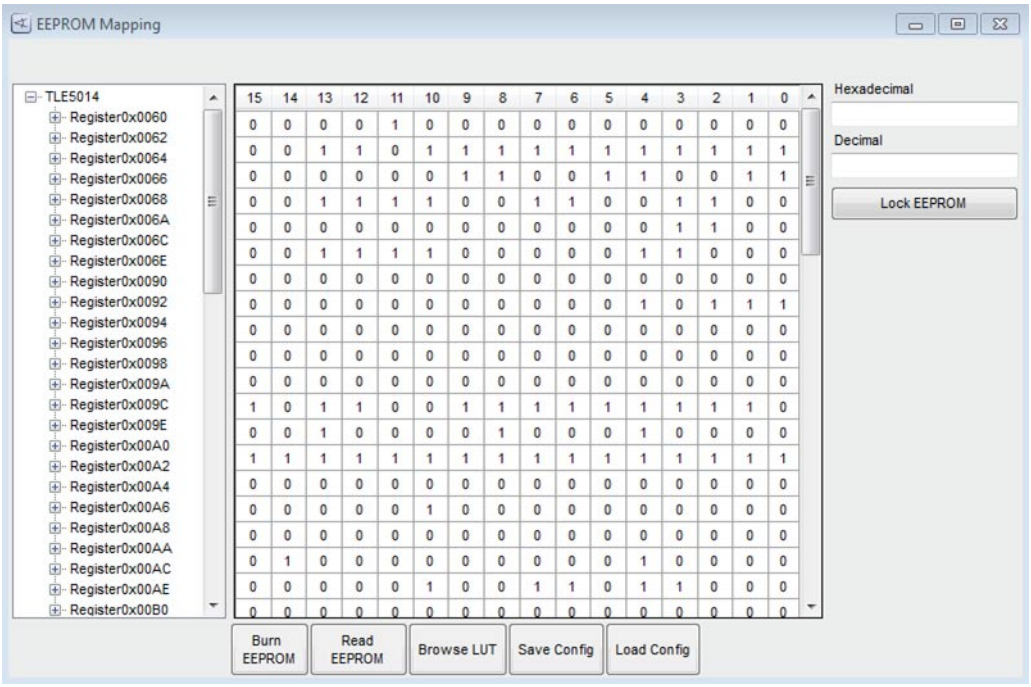
Click on the **Sensor** menu and select one of the following options:

- EEPROM Register
- Program by feature
- Read SSM
- Burn Angle Base



3.3.1 EEPROM Register

Select **Sensor > EEPROM Register** in the menu bar on the top to display the EEPROM register mapping. Click on the register in the left column to highlight the register and to display the content on the right.

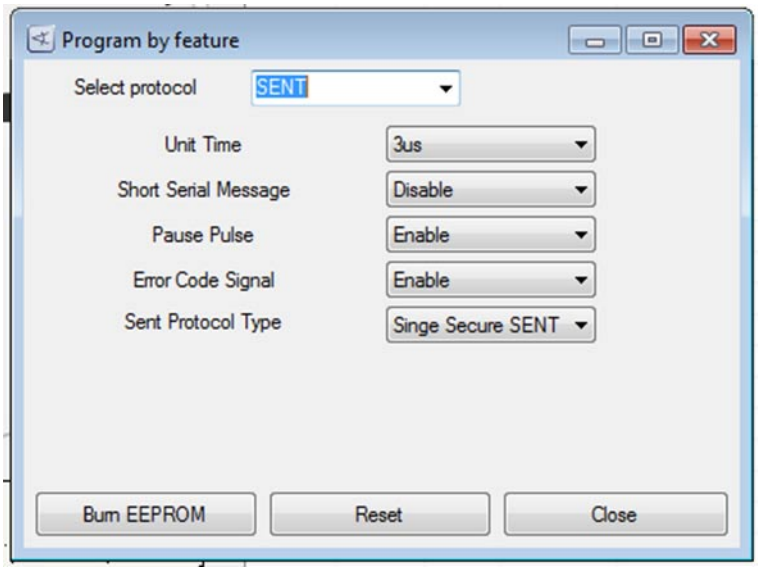


Button	Description
Read EEPROM	Read the current EEPROM values and update the displayed EEPROM content. A register content can be modified by editing the value on the right either in a hexadecimal or a decimal value and pressing RETURN.
Burn EEPROM	Burn the displayed content to the TLE5014 EEPROM. A successfully EEPROM burning is indicated with a “Burn successful!” message. *Note: Care has to be taken not to modify EEPROM registers which change the sensor configuration. This could result in a wrong function of the device.*
Browse LUT	Browse for a .txt file which contains the values intended to be used in the look-up table. See Chapter 3.4 for more details. *Note: After re-loading LUT values (Browse LUT) or EEPROM content (Load Config) the EEPROM has to be burned by pressing Burn EEPROM.*

Button	Description
Save Config	Save the actual EEPROM settings in a .txt file.
Load config	Load the EEPROM content from a .txt file. *Note: After re-loading LUT values (Browse LUT) or EEPROM content (Load Config) the EEPROM has to be burned by pressing Burn EEPROM.*
Lock EEPROM	Locks the EEPROM. A further re-programming is not possible. *Note: There is no "Unlock" function implemented.*

3.3.2 Program by feature

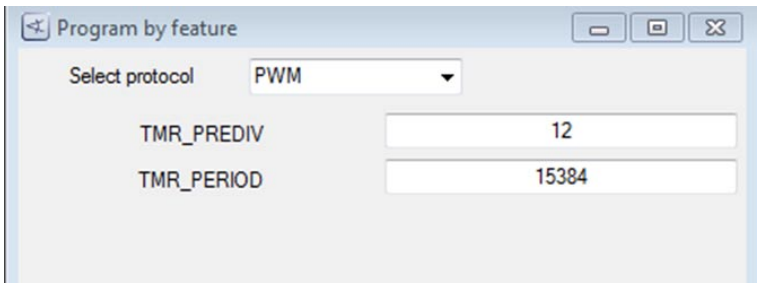
Select **Sensor > Program by feature** in the menu bar on the top to display the actual sensor configuration. Modifications can be done and then burned to the EEPROM.



Button	Description
Burn EEPROM	Burn the EEPROM.
Reset	Restore the default configuration but only as long as the EEPROM has **NOT** be burned.

3.3.2.1 PWM frequency calculation

When setting the **Select protocol** to **PWM**, two parameters have to be specified which give the PWM frequency.



The PWM frequency is calculated according following formula:

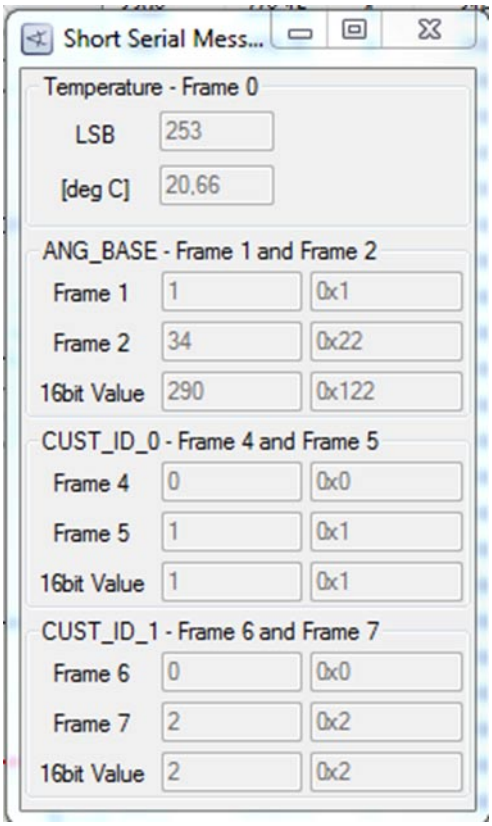
(3.1)

$$f[\mathrm{Hz}] = \frac{40000000}{(1 + \mathrm{TMR\_PREDIV})(\mathrm{TMR\_PERIOD})}$$

3.3.3 Read SSM

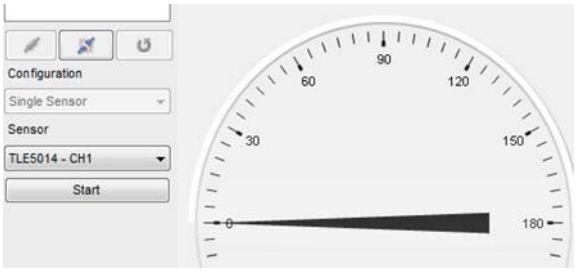
Select **Sensor > Read SSM** in the menu bar on the top to display the actual content of the short serial message SSM:

- Temperature
- Angle base & rotation direction
- 32-bit customer ID



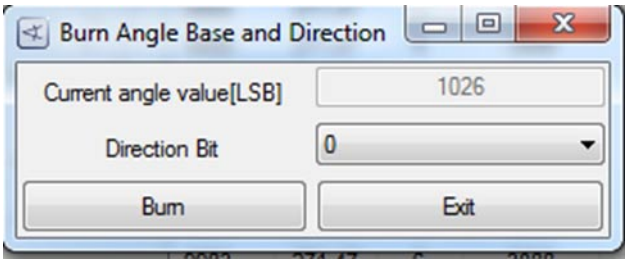
3.3.4 Burn Angle Base

To define a new angle base, first **Start** the read-out of angle values.



The application has to be turned to the desired new zero-value and read-out has to be stopped by clicking **Stop**.

Select **Sensor > Burn Angle Base** in the menu bar on the top to display the Burn Angle Base window.



Click **Burn** to burn the value to the EEPROM as new angle base.

3.4 Look-up table programming

The **Browse LUT** button opens a window to select a .txt file with the data which should be programmed into the look-up table (LUT).

Opening the .txt file loads the content in the displayed EEPROM mapping.

After loading the file press **Burn EEPROM** to burn the LUT values to the EEPROM.

txt file with values for LUT

The .txt file for the LUT values consists of a header and 32 pair of data, separated by a comma. One pair consists of the real angle value and the read out of the sensor at this position as a 12-bit value. The 32 real angle values can not be modified and have to be 0°, 11.25°, 22.5°, … 348.75°.

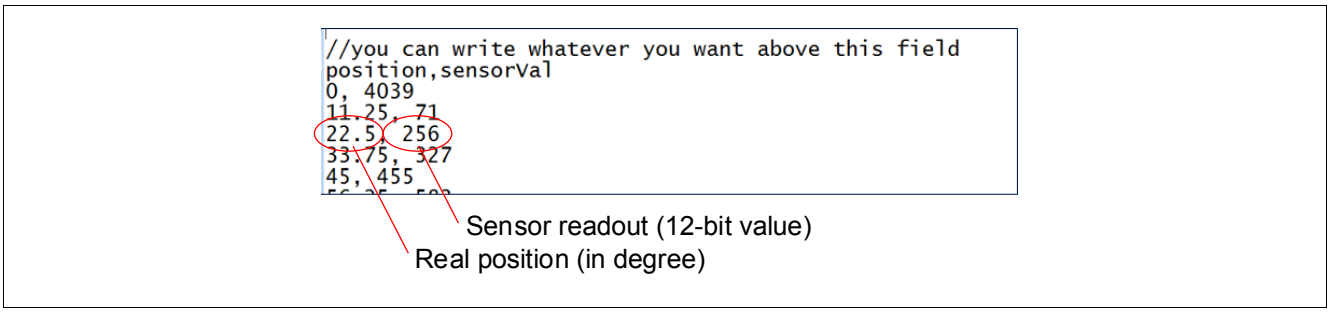


Figure 5 Pair of data

4 EEPROM map PWM interface

Table 3 EEPROM map PMW interface

Register address	Register name	Bit	Description
$0x0060_H$	Data duty cycle min. value	[13:0]	0% … 100% mapped to 0 … 16383
$0x0062_H$	Data duty cycle max. value	[13:0]	0% … 100% mapped to 0 … 16383
$0x0064_H$	Diagnostic value low	[13:0]	0% … 100% mapped to 0 … 16383
$0x0066_H$	Diagnostic value high	[13:0]	0% … 100% mapped to 0 … 16383
$0x0068_H$	PWM predevider	[7:0]	TMP_PREDIV
$0x006A_H$	PWM period	[13:0]	TMP_PERIOD

Example: Data duty cycle range

$0x0060_H$ = 2048 → 12.5%
$0x0062_H$ = 14335 → 87.5%

0° … 360° mapped to 12.5% … 87.5%

Example: Diagnostic range

$0x0064_H$ = 819 → 5% (diagnostic low value)
$0x0066_H$ = 15564 → 95% (diagnostic high value)

4.1 EEPROM map

Only a few registers should be modified by the user, all others are pre-programmed. Changing these registers might change sensor behavior and accuracy.

The following registers can be changed by the user:

Table 4 EEPROM map overview

Register address	Register name	Bit	Description
$0x00A0_H$	ANG_BASE	[15:2]	14-bit angle base
$0x00A0_H$	ANG_BASE	[1]	Rotation direction
$0x00A2_H$	PWI_MD_USR	[15:0]	Protocol and interface settings
$0x00A4_H$	SPC_ADDR	[9:8]	Determines the SPC address of the sensor
$0x00B0_H$ … EE_H	LUT	[15:0]	Look-up table, 32 registers in total
$0x00F2_H$	Cust_ID	[15:0]	Customer ID, will be transmitted via SSM
$0x00F4_H$	Cust_ID	[15:0]	Customer ID, will be transmitted via SSM
$0x00F6_H$ … FE_H	Cust_ID	[15:0]	Customer ID

4.2 TLE5014 EEPROM $0x00A2_H$: PWI_MD_USR

Table 5 PWI_MD_USR

Name	Bit	Description	Value
PWI_MODE	[15:13]	Interface selection	100_B: PWM 010_B: SENT 001_B: SPC
PWM_EDGE	[12]	PWM starting edge	0_B: Rising 1_B: Falling
SENT/SPC_LT_5_3	[11]	SENT/SPC low time	0_B: 5UT 1_B: 3UT
SPC_TEMP	[10]	Temperature information	0_B: No temp. nibble 1_B: Temperature nibble
SPC_RCNIB	[9]	Rolling counter	0_B: RC nibble enabled 1_B: No RC nibble
SPC_RCCRC	[8]	Rolling counter in CRC	0_B: No RC in CRC 1_B: RC in CRC
SPC_TRIG	[7]	SPC bus mode	0_B: 90 µs trigger length fix 1_B: variable trigger length
SENT_PROMO	[6]	SENT protocol type	0_B: Single secure sensor 1_B: Standard SENT
SENT_ERR_SIG	[5]	SENT Error indication	0_B: error code “4091” in data range and status nibble 1_B: Error in status nibble only
SENT_PAPU	[4]	Pause pulse activation	0_B: No pause pulse 1_B: Pause pulse
SENT/SPC_PWI_SSM	[3]	SENT/SPC short serial message	0_B: No short serial message 1_B: Short serial message
SENT/SPC_UT	[2:0]	Unit time setting	000_B: 3.0 µs 001_B: 2.5 µs 010_B: 2.0 µs 011_B: 1.5 µs 100_B: 1.0 µs

Note: Depending on the software version not all interface settings may be supported and the angle value and/or additional protocol information may not be displayed EEPROM reading and programming is possible in any case, however.

4.3 Angle base calculation

For PWM/SPC protocol and SENT when feature error code “4091” is disabled

- Determine the position were “0°” should occur.
- Read out the 12-bit angle value at this position (in LSB).
- Multiply this value by 16.
- Write this (decimal) value in register $0x00A0_H$ and burn EEPROM.
- To change the rotation direction:
  - Add “2” to this value in case bit[1] in $0x00A0_H$ is “0” and burn EEPROM again.
  - Subtract “2” from this value in case bit[1] in $0x00A0_H$ is “1” and burn EEPROM again.

For SENT protocol when feature error code “4091” is enabled

- Determine the position were “0°” should occur.
- Read out the 12-bit angle value at this position (in LSB) -> LSB12’.
- Calculate: 4 * trunc[16384/4088 * (LSB12’ - 1)].
- Write this (decimal) value in register $0x00A0_H$ and burn EEPROM.
- To change the rotation direction:
  - add “2” to this value in case bit[1] in $0x00A0_H$ is “0” and burn EEPROM again
  - subtract “2” from this value in case bit[1] in $0x00A0_H$ is “1” and burn EEPROM again

4.4 SPC address configuration

If SPC in bus mode is used it is mandatory that the address of each sensor is written in the corresponding EEPROM. This address must match with the address which is assigned via hardware pinout to this sensor.

Following values have to be written to address $0x00A4_H$:

- For ID = 0: $0x0400_H$
- For ID = 1: $0x0500_H$
- For ID = 2: $0x0600_H$
- For ID = 3: $0x0700_H$

Note: The bit [7:0] of register $0x00A4_H$ contain the CRC for protecting the sensor configuration. After a change of the configuration (e.g. angle base or SPC ID) is written to the EEPROM (EEPROM is burned) the CRC is updated automatically.

4.5 Comments

If using SPC bus mode, the first step should be to write the corresponding SPC ID in address $0x00A4_H$ (Chapter 4.4).

The sensor comes with an enabled, default programmed look-up table (LUT) to reach the specified accuracy.

The default LUT values may not be changed as long as no own data are available. A change causes an increased angle error.

The default values of the LUT can be overwritten in case own data are generated (for e.g. to correct for magnetic circuit assembly tolerances).

If look-up table is used, the angle base correction (bit [15:2] of address $0x00A0_H$) has to be performed before look-up table values are modified.

No other bits as the described may be changed as this could cause an unpredictable sensor behavior.

5 Revision history

Revision	Date	Changes
Rev. 1.0	2017-08-02	Initial creation.

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