EVB90609 Evaluation Board User Manual

Author	Borys Tsukanov
Date	May 22, 2006
Version	1.01

REVISION HISTORY

Revision	Date	Sections	Description
1.00	October 28, 2005	–	Official document release
1.01	May 22, 2006	2, 5, 14	Changed PCB and procedure of the EVB90609 installation, add explanation of power supply and bandwidth jumpers and other.

TABLE OF CONTENTS

GLOSSARY OF TERMS

ADC – Analog-to-Digital Converter;
BMP – Bit Map;
BW – Bandwidth;
EVB – Evaluation Board;
EEPROM – Electrically Erasable Programmable Read-Only Memory;
GHz – Giga Hertz;
JPEG – Joint Photography Experts Group;
IBM PC – International Business Machines Personal Computer;
MB – Megabyte;
MHz – Mega Hertz;
OEM – Original Equipment Manufacture;
OUTAR – Output voltage of Angular Rate;
OUTTEMP – Output voltage of Temperature;
PCB – Printed Circuit Board;
RAM – Random-Access Memory;
R&D – Research and Development;
SPI – Serial Peripheral Interface;
SVGA – Super Video Graphics Array;
VCP – Virtual Communication Port;
VREF – Voltage Reference;
USB – Universal Serial Bus.

1 General description

The EVB90609 Evaluation Board is designed to support the MLX90609 family of Angular Rate Sensor ICs. This board which acts as an interface between the USB port of a PC and the MLX90609 can work in the following modes:

1. Digital mode (SPI only Interface);
2. Analog mode (only OUTAR, OUTTEMP, VREF, SELFTEST and ERROR pins);
3. Mixed mode (digital and analog mode);
4. Demo mode (direction indicator).

When the EVB90609 is used as a demo board, it works as a direction indicator (i.e. a compass).

Power for the MLX90609 and EVB come from the computer USB port or from an additional power supply (range from 4.75V up to 5.25V).

The EVB90609 is designed to allow customers to quickly configure the MLX90609 family of Angular Rate Sensor ICs. Customers can quickly experiment with temperature ranges, power supply, EEPROM settings, etc.

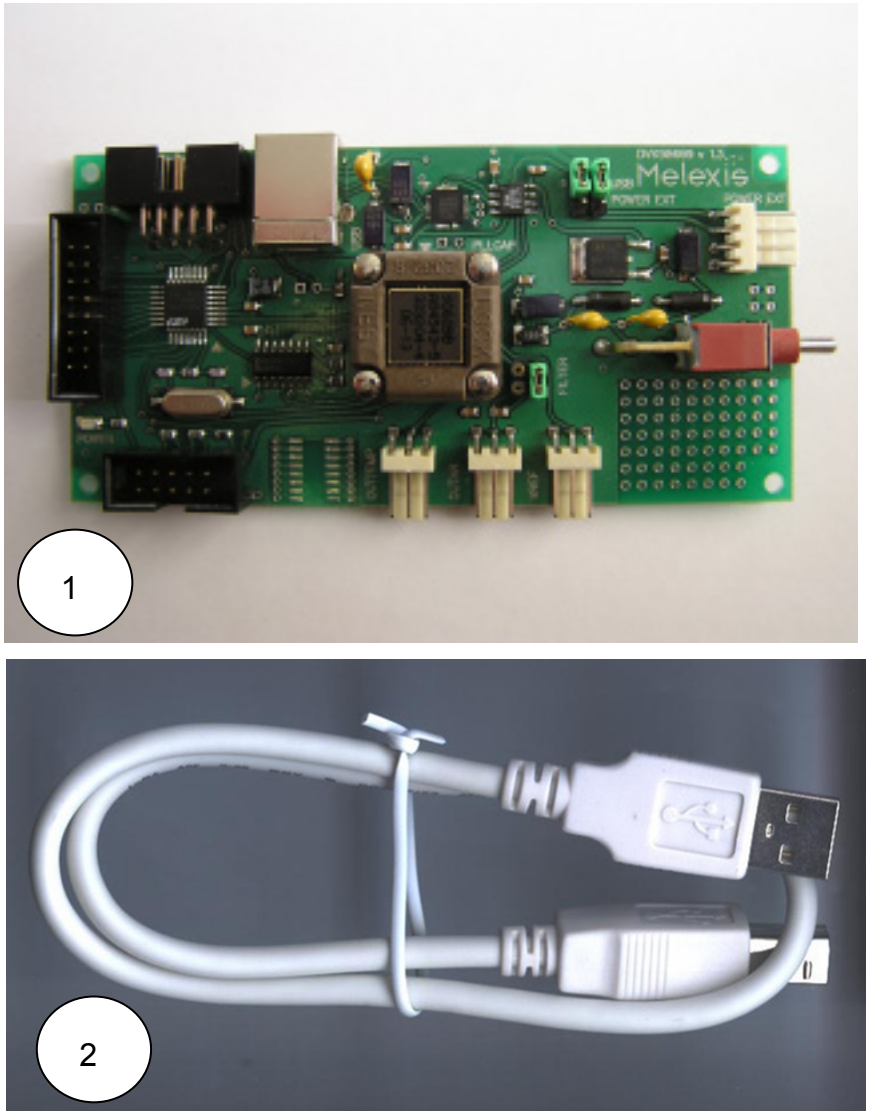
The kit contains:

- Main board;
- USB cable to connect to a PC;
- Sample MLX90609;
- Software (EVB90609 Software, VCP driver) and documentation.

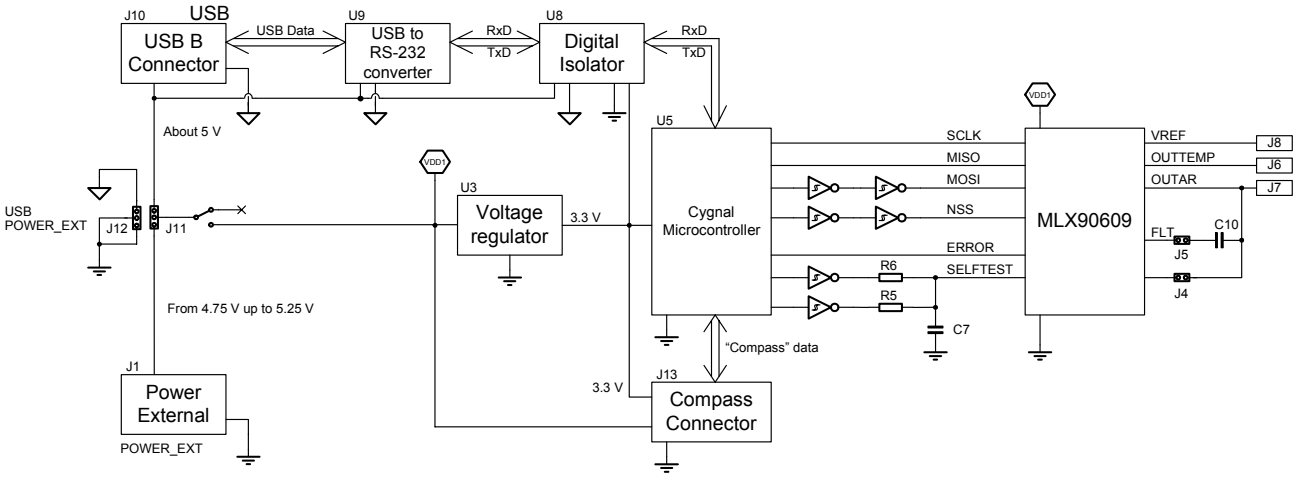
2 Hardware

Hardware contains:

1. Main board;
2. USB cable.



Pic. 1. The EVB90609 Hardware and USB cable.

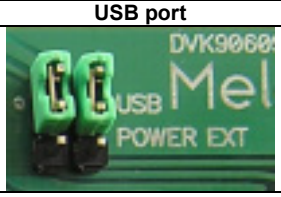


Pic. 2. Main board block diagram.

The board's schematic is shown in the section **Schematic**.

Type of power supply source:

1. USB port;
2. Additional power supply (range from 4.75V up to 5.25V).

Power supply source	
USB port	**Additional power supply**
	

Bandwidth:

The EVB90609 is designed to allow customers to quickly configure bandwidth of the MLX90609. Customers can quickly experiment with the value of the bandwidth.

Procedure to change the bandwidth: you have to disconnect the bandwidth jumper with a Filter label. After that you must put a capacitor into the collet socket.

Settings bandwidth	
Capacitor 82nF	Additional capacitor
	

Bandwidth calculation: BW = 1/(2*π*R*C), Hz.

π = 3.1415926; R = 200 kOm; C – value of capacitor capacity.

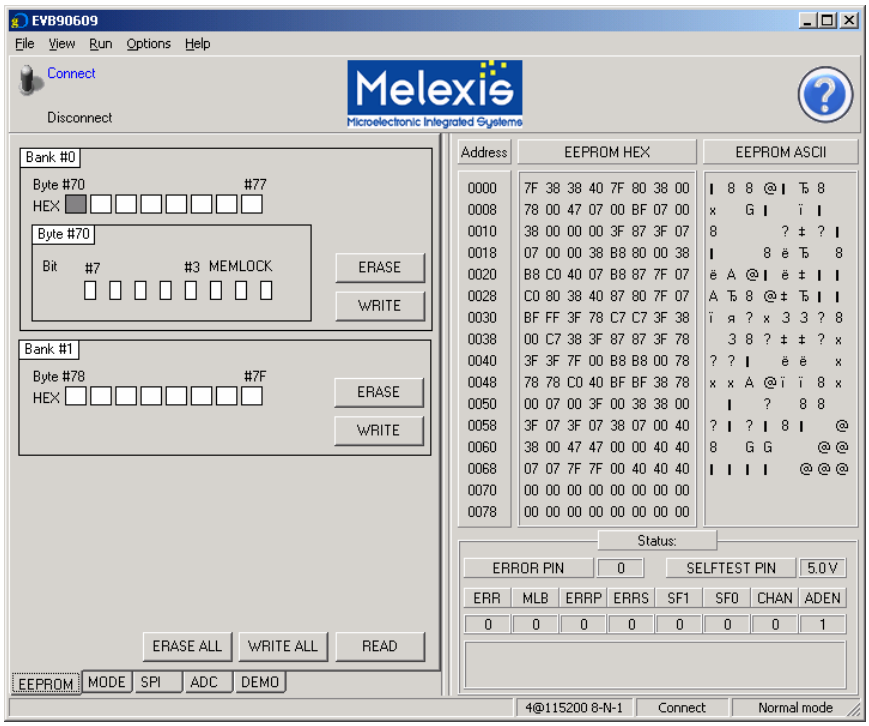
For example:

π = 3.1415926; R = 200 kOm, C = 82nF.

BW = 1/(2*π*200000*82E-09) = 9.7 Hz.

3 Software

The picture below shows the main window of the EVB90609 software. This software uses its own protocol (see **EVB90609 Protocol**) for the connection with the main board and controls the MLX90609 via SPI and/or SELFTEST pin. This software supports all modes of operation of the MLX90609 (analog, digital and mixed mode) and has an additional function: the demo mode.



Pic. 3. The main window of the EVB90609 software.

4 System requirements

The minimum requirements (not guarantied by Melexis):

1. IBM PC (or 100-percent compatible) machine with 16 Mb RAM;
2. SVGA Video Adapter;
3. Hard Disk Drive (3 Mb free space; with driver and documentation);
4. USB Port;
5. Mouse or Pointing Device;
6. Microsoft Windows 95/98/NT/2000/XP.

The recommended requirements:

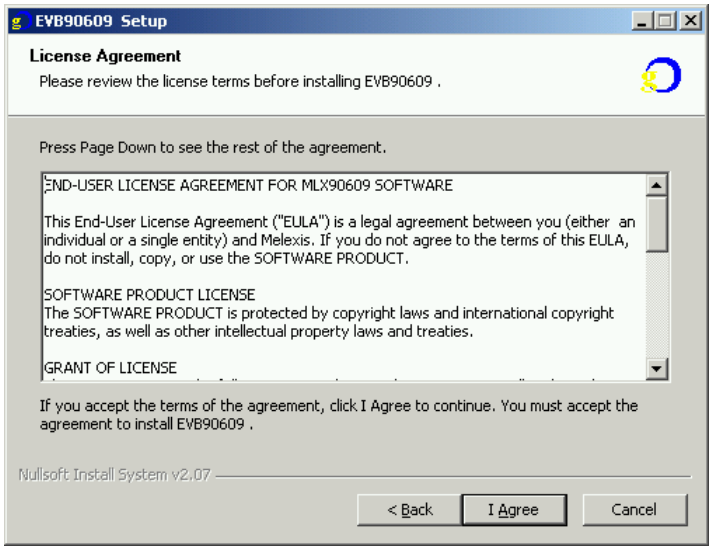
1. IBM PC (or 100-percent compatible) machine 1 GHz with 512 MB RAM;
2. SVGA Video Adapter (Screen resolution 1024 by 768 pixels; Color quality: Highest (32 bits));
3. Hard Disk Drive (3 Mb free space; with driver and documentation);
4. USB Port;
5. Mouse or Pointing Device;
6. Microsoft Windows XP.

5 Installation EVB90609 software

Run SetupEVB90609.exe and wait some seconds until you see the following window

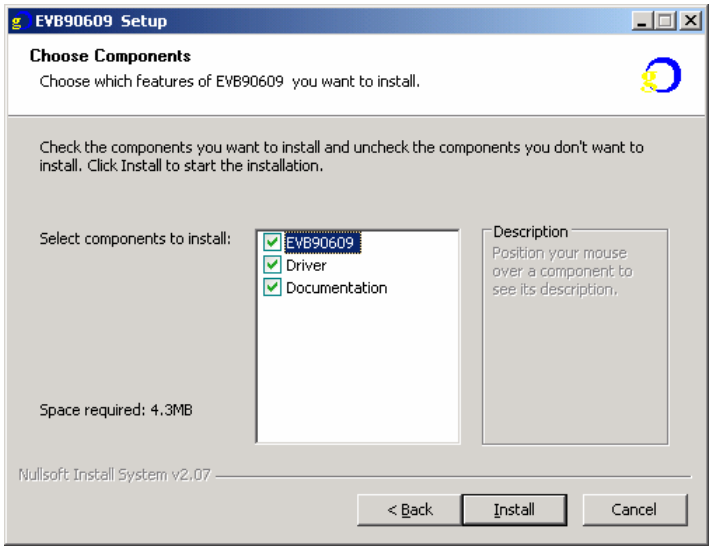
Pic. 4. Installation, Step 1.

Next step - License window. If you are agree you must select “I agree”.



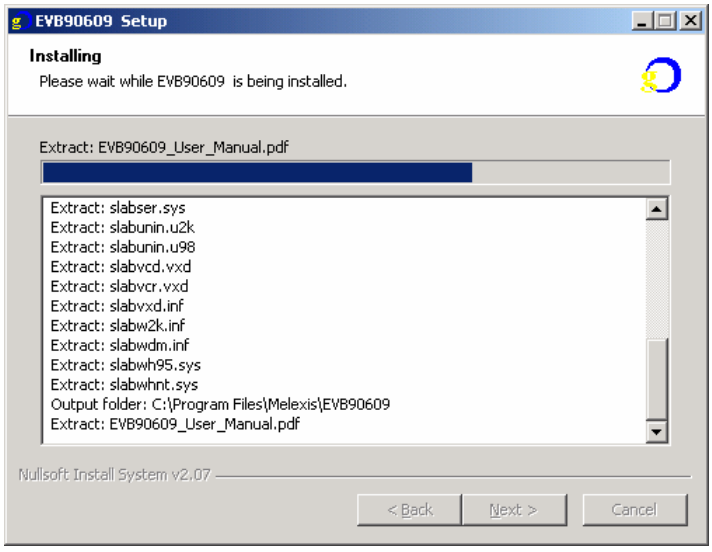
Pic. 5. Installation, Step 2.

After you see the window with the installation components, choose the necessary options.



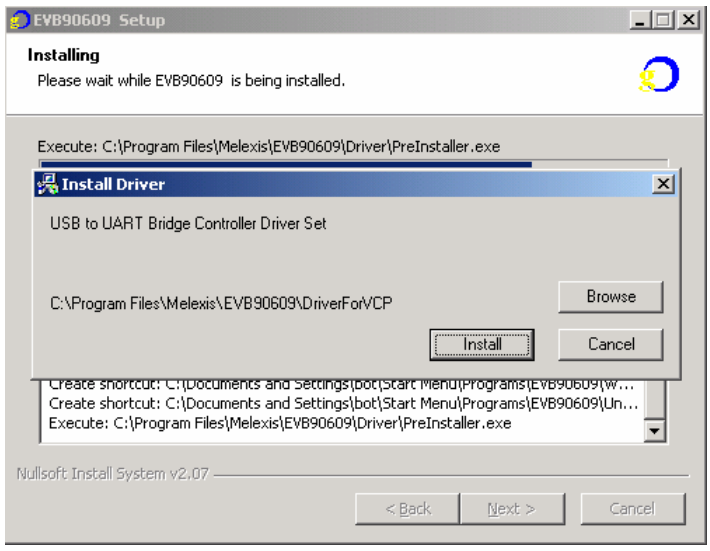
Pic. 6. Installation, Step 3.

Then, detailed information on installing process will be shown.



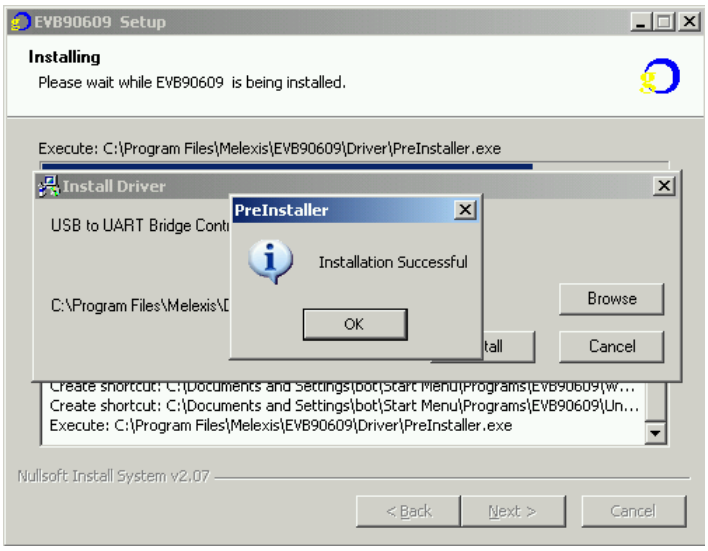
Pic. 7. Installation, Step 4.

The picture below informs about the VCP driver installation.



Pic. 8. Installation, Step 5.

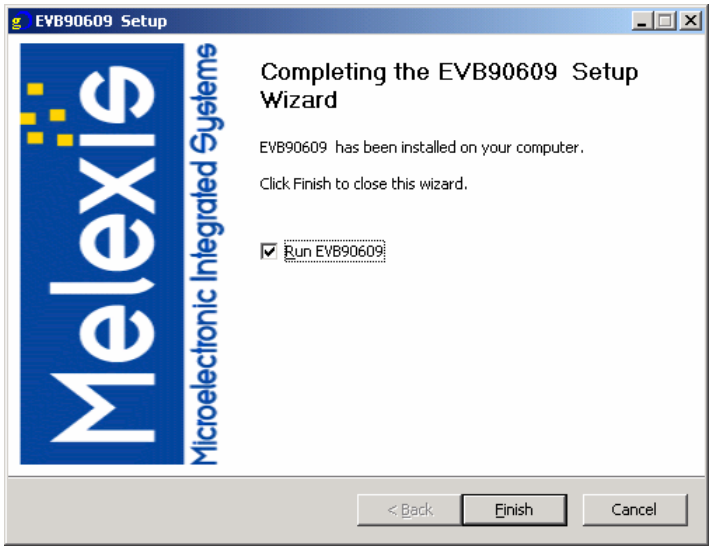
The picture below will appear if the installation was successful.



Pic. 9. Installation, Step 6.

After the driver's installation, plug-in the main board and wait until Windows finds a new hardware.

After this you can run the EVB90609 software.



Pic. 10. Installation, Step 7.

6 Technical Support

If you experience any problems with the module, Evaluation board or Software tools please contact technical support. Specialized support can be reached through your local sales representative.

7 Contents

7.1 Contents

7.2 Menu Commands

7.3 File Menu

The File menu offers the following commands:

Open	Load internal EEPROM dump with the contents of selected file. (Only User's area).
Save As…	Stores the contents of the EEPROM dump (all modes) and Text format file, Excel format file, CSD Data file (OrCAD), Bitmap format file, JPEG format file (Demo mode).
Print	Prints the graph of angular rate or/and temperature (Demo mode).
Exit	Exits the EVB90609 software.

7.4 View Menu

The View menu offers the following commands:

Tool bar	Shows/hides Tool bar.
Status bar	Shows/hides Status bar.
Always on Top	Sets/resets always on top mode.
EEPROM	Shows EEPROM page.
MODE	Shows MODE page.
SPI	Shows SPI page.
ADC	Shows ADC page.
DEMO	Shows DEMO page.

7.5 Run Menu

The Run menu offers the following commands:

Connect/Disconnect	Connects/Disconnects to the EVB90609.

7.6 Options Menu

The Options menu offers the following commands:

Communication	Displays dialog window. Sets communication channel.
Demo	Displays dialog window. Sets demo mode (graph, angular rate fitting).

7.7 Help Menu

The Help menu offers the following commands:

Content	Displays the Help Contents.
About…	Displays the version number and Copyright information of the EVB90609 software.

8 Main Window

This is the main window application and it features the following settings:

8.1 Application menu

Complete list of the EVB90609 menu commands see **Menu commands**.

8.2 Application's toolbar

The toolbar duplicates some of the commonly used menu commands:

Click	To execute
	Connection/disconnection to the main board
	The content help

8.3 Multifunctional status bar

The EVB90609 status bar is divided into 4 areas. The first area is used to display application messages, 3 extra areas are provided for user convenience. The meaning of each extra area follows:

- **Configuration of VCP** – displays the configuration of virtual communication port (number of port, bits per second, data bits, parity, stop bits);
- **Status of connection** – displays the status of connection (connect\disconnect);
- **Mode of the chip** – displays chip operating mode.

Note: closing the main window will close the application and the communication port .

8.4 Pages

The main window has 5 pages:

Pic. 11. Main window pages.

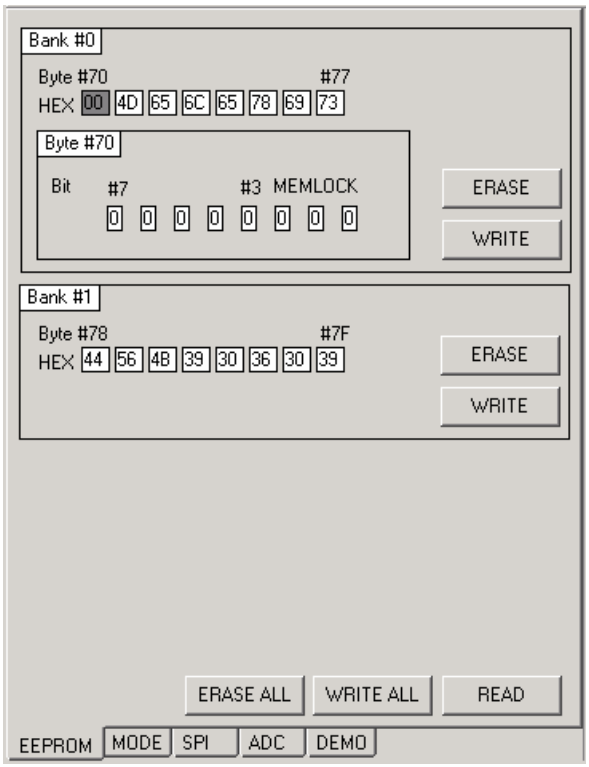
9 Pages on main window

Pages are divided into the following sections:

- EEPROM;
- MODE;
- SPI;
- ADC;
- DEMO.

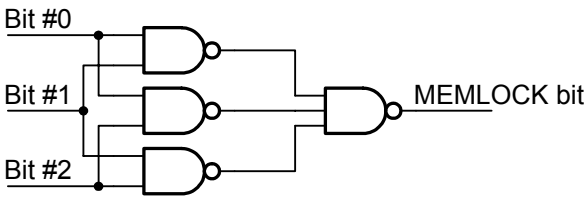
9.1 EEPROM Page

The EEPROM page looks like



Pic. 12. EEPROM Page.

This page is divided in 2 banks: User's space is available for recording, erasing and changing contents. These banks have the following characteristics: each is of 8 bytes; the addressing is ranged from 0x70 to 0x7F. Zero bank has its specific byte 0x70, in which 3 minor changes are the so called bits MEMLOCK. These bits forbid any further modification of the EEPROM User's space, they are bit-by-bit voting and work like shown in the logical circuitry below:



Pic. 13. Bit-by-bit violation.

This page provides the below functionalities:

1. Recording to EEPROM (recording only to bank 0, recording only to bank 1, and recording to both banks). For convenience, the recording fields are located in the same sequence as in dump of memory; the space for byte #70 was specially eliminated. This byte contains 3 bit-by-bit voting bits.

Warning! Setting at least 2 bits to "1" disables any further modification of the User's memory EEPROM. **This setting comes into effect only after switching off the supply.** If you have disabled the User's memory space by accident and then need to reset the User's memory EEPROM, please contact Melexis.

The data input to the fields of recording is done in hex format, which is equivalent to ASCII format. For example, digits '0' – 0x30; '9' – 0x39, and letters 'A' – 0x41 and 'a' – 0x61. Digits input have to be done without prefix.

For example, input of line "Melexis". We need to input the following hex digits: 4D, 65, 6C, 65, 78, 69 and 73.

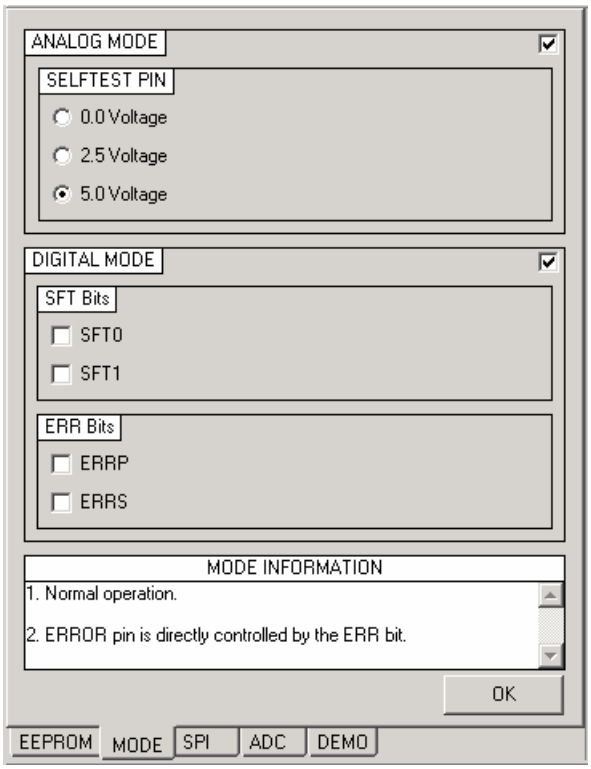
2. EEPROM erasing. You can erase the EEPROM as separate banks, as well as the whole User's space. For this you can use the button Erase in the applicable areas, or the button Erase all.

3. EEPROM reading. After pressing the button Read, the program will read the data from the User's space. The technical data can not be modified by the User. The technical data is read only when the software is connected to the EVB90609.

After each EEPROM data manipulation, a verification of the recorded (rerecorded, deleted) data takes place by a repeated reading of the EEPROM User's space.

9.2 MODE Page

The MODE page looks like



Pic. 14. Mode Page.

This page is divided into 3 areas:

- Analogue mode;
- Digital mode;
- Explanations to the User.

The MODE INFORMATION field will be changed every time the User modifies the page, but the modifications will only be activated after the OK button is pressed.

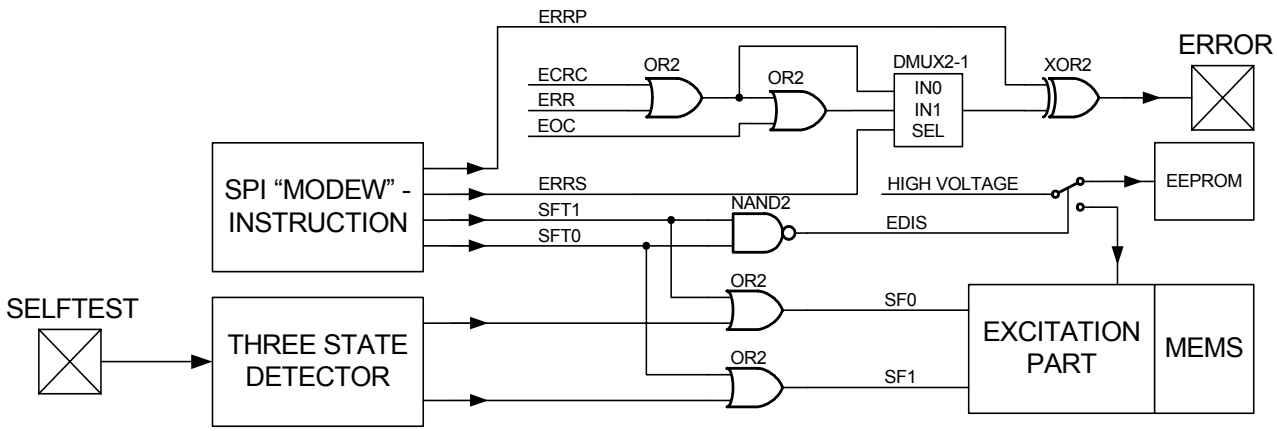
This page allows the User to change the operation mode of the chip (for analog or digital mode, etc.):

1. normal conditions;
2. self-testing conditions:
   a. constant positive angular rate emulation
   b. constant negative angular rate emulation
3. EEPROM conditions;
4. modification of data output view on the pin ERROR.

The table of conditions and simplified circuitry is shown below:

Table 1. Operation mode choice of the MLX90609.

SPI		SELFTEST pin	SF[1:0]	EEDIS	MODE name
SFT1	SFT0				
0	0	5.0 Volt, Out Code: 00	00	1	Normal mode
0	1		01	1	SELFTEST mode, emulation of the POSITIVE angular rate
1	0		10	1	SELFTEST mode, emulation of the NEGATIVE angular rate
1	1		11	0	EEPROM mode with INTERNAL charge pump
0	0	2.5 Volt, Out Code: 10	10	1	SELFTEST mode, emulation of the NEGATIVE angular rate.
0	1		11	1	Not used combination
1	0		10	1	SELFTEST mode, emulation of the NEGATIVE angular rate
1	1		11	0	EEPROM mode with INTERNAL charge pump
0	0	0.0 Volt, Out Code: 01	01	1	SELFTEST mode, emulation of the POSITIVE angular rate
0	1		01	1	SELFTEST mode, emulation of the POSITIVE angular rate
1	0		11	1	Not used combination
1	1		11	0	EEPROM mode with INTERNAL charge pump



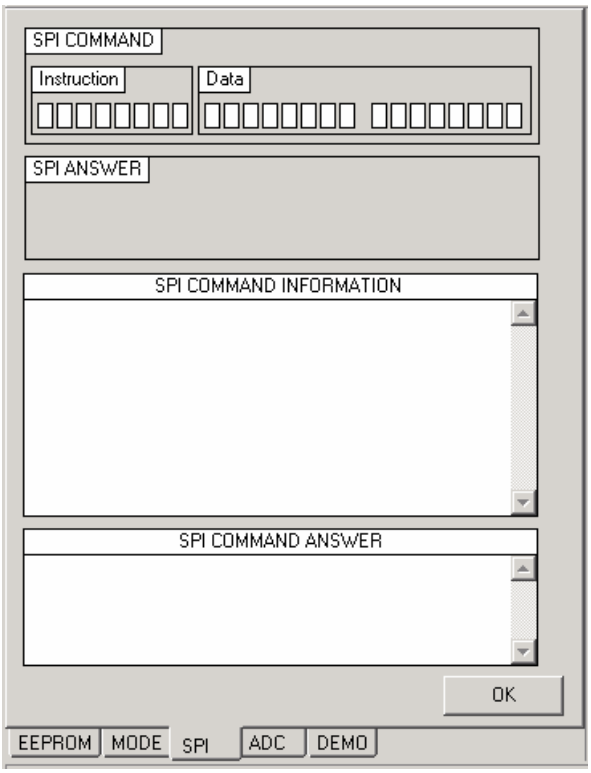
Pic. 15. Simplified schematic of ERROR and SELFTEST circuit.

REMARKS:

1. The table and the figures above were composed to explain all possible sub-modes related to the SELFTEST pin and SFT-bits.
2. Bits SFT [1:0] is cleared after power-up.
3. STATUS OF THE CHIP explains the value of the internal bits (without taking state of the SELFTEST pin), the ERROR pin and the value of the SELFTEST pin. Field MODE INFORMATION displays comments with taking into account the state of the SELFTEST pin.
4. Each modification will display into the Status of the chip.

9.3 SPI Page

The SPI page looks like



Pic. 16. SPI Page.

On this page the User has the possibility to work with a low-level SPI instruction. Please find a more detailed description of the SPI instructions in the section SPI instruction. (see **SPI protocol**).

This page is divided into 4 fields:

The 1st field represents the SPI instruction (8 bits) and data (16 bits).

The 2nd field represents the answer for an earlier sent SPI instruction (the detailed description of the SPI instruction answers can be found in the section **SPI protocol**).

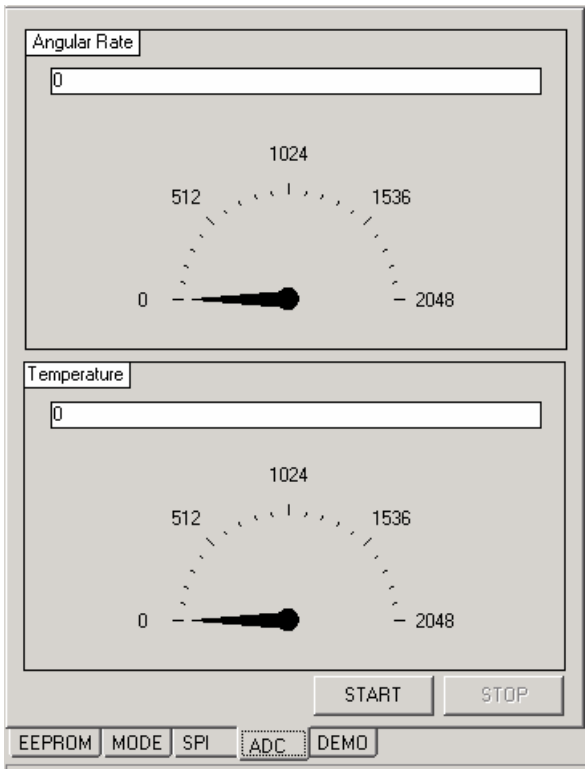
The 3rd and 4th fields are information areas. The 3rd field explains specified SPI instruction, and the 4th gives a detailed description of the answer to a sent SPI instruction.

REMARKS:

1. SPI COMMAND INFORMATION explains the specified SPI instruction by taking state of the SELFTEST pin (the value of the supply is displayed into parenthesis).
2. Each modification will be displayed in the Status of the chip.

9.4 ADC Page

The ADC page looks like



Pic. 17. ADC Page.

Two analog pointer indicators are located on this page. The upper indicator displays the dynamics of the angular rate. The lower indicator shows the dynamics of temperature-sensitive element. The values range from 0 up to 2048 (this range is determined by the bit capacity of the used ADC, 11 bits).

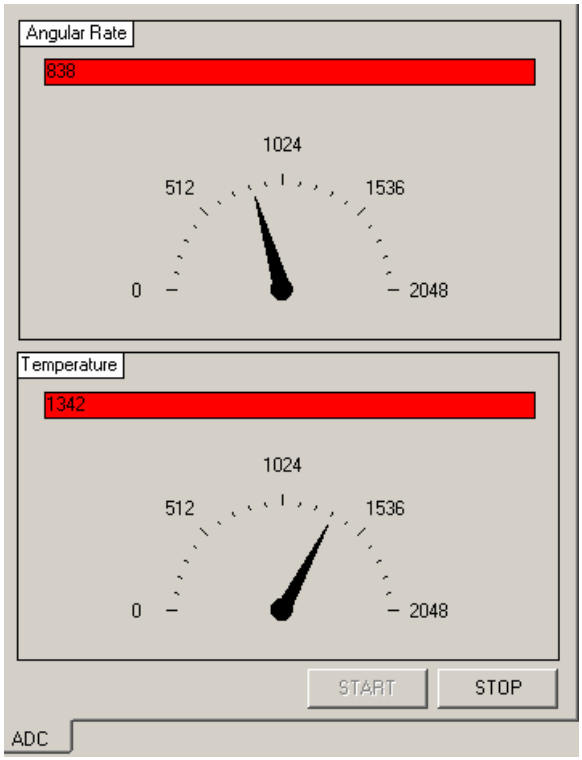
At this page the batch controlling of the chip through the SPI Instruction is used, i.e. alternate interrogation of current angular rate and temperature.

To start the performance of batch controlling press the button START, to finish the performance of command's chains press the button STOP.

During the process of command's chain, the modification of inner chip registers will be reflected in the Status of the chip. For example, the modification of CHAN register at switching of channels of source signal pickup is 0 – angular rate, 1 – temperature.

If, for some reason, the register ERR equals 1, that conforms to condition when picked up signals are not authentic, this condition will be displayed for the User in two fields: in the

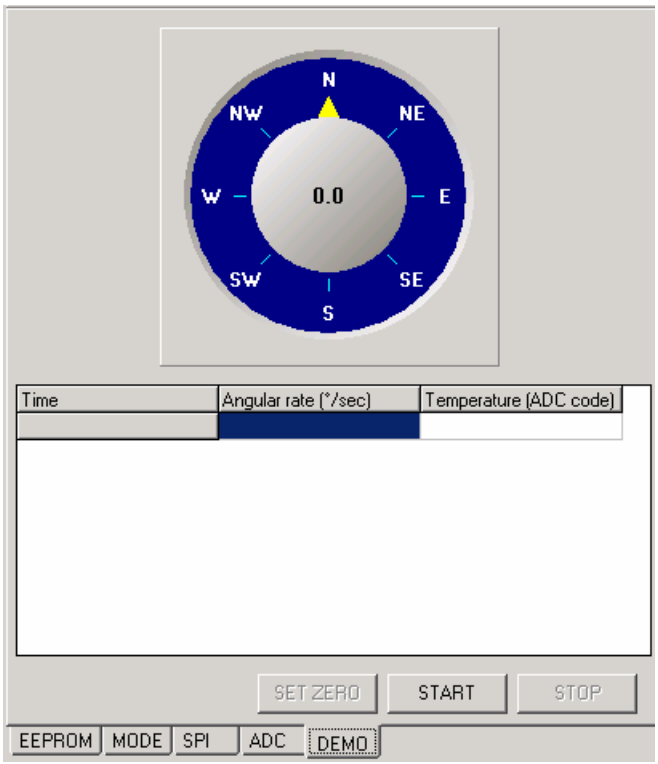
chip Status and by changing the color of the index indicator to red (for the value of the angular rate and/or temperature).



Pic. 18. ADC Page (anomalous data).

9.5 DEMO Page

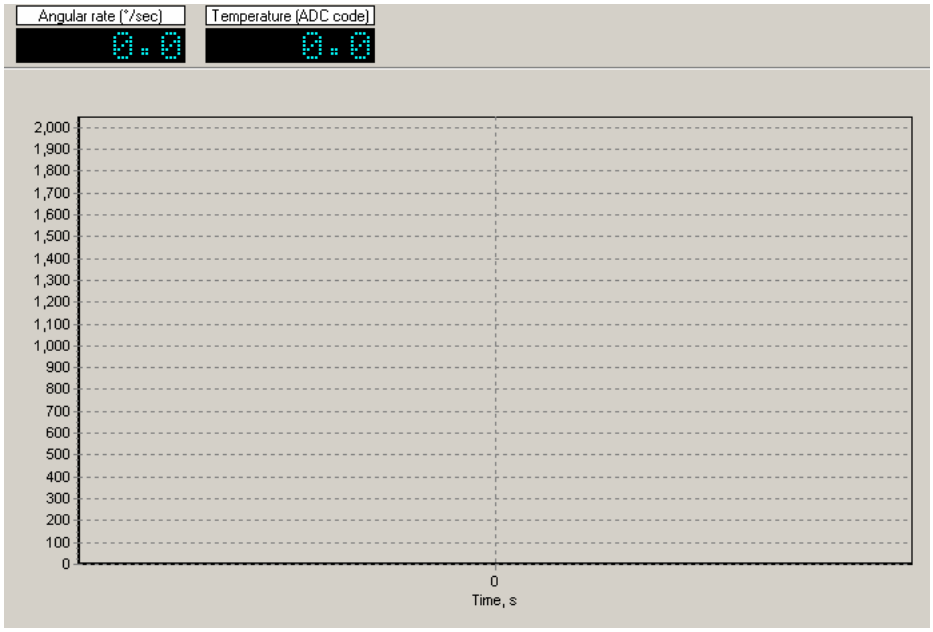
The DEMO page looks like



Pic. 19. DEMO Page.

This page contains 3 fields: a page like an analog compass indicator, an analog thermometer indicator and a table of read values (the table contains the data about the measurement time intervals, the values of the angular rate and temperature). The temperature value can be shown in different units (see **Dialog box – Demo Options**): ADC code, Celsius, Fahrenheit and Kelvin degree.

While opening this page, the content of the EEPROM and the Status of the chip will be hidden. The chart of angular rate modification and/or temperature will be shown instead. Two digital indicators showing the current angular rate and temperature are located over the chart.



Pic. 20. Chart.

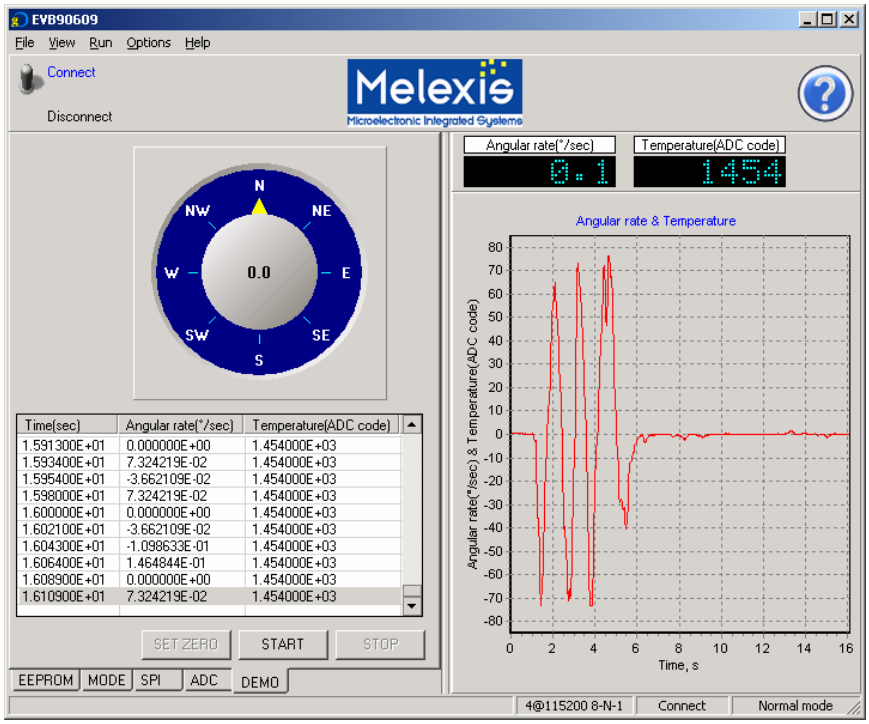
The settings of the data displayed on the chart are available via text menu **Options-Demo** or after pressing the buttons **Ctrl+D** in dialog box Demo options.

9.6 Run in DEMO MODE

To run the program in DEMO MODE press the button START. During an interchanging between the main board and the software, the coming data will be shown on the indicators, on the chart and in the table. While data communicating other pages will be unavailable, as well as modifications of chip modes.

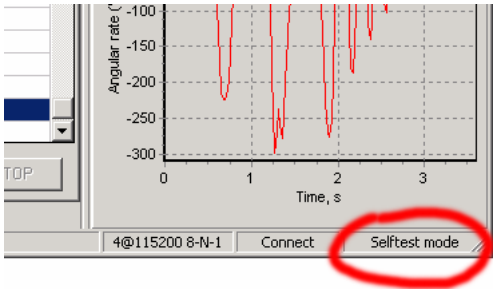
To specify or install the zero value of the angular rate press the SET ZERO button.

To stop the DEMO MODE press the STOP button, as a result other pages will be available, and the process of data interchange will be over.



Pic. 21. Demo mode operation.

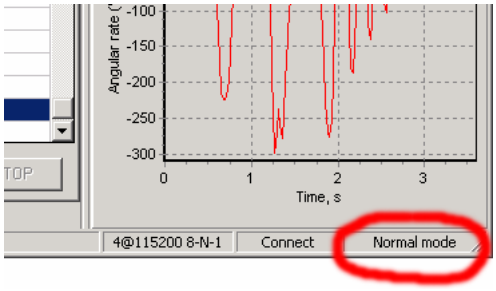
WARNING: After SELFTEST MODE setting, the chip condition will not change, when proceeding to DEMO MODE.



Pic. 22. Status – Selftest mode.

That is why, after the DEMO MODE starts, the angular rate will be observed, while PCB is stationary. It will take place because SELFTEST MODE is the mode of emulation of the angular rate availability.

WARNING: Be vigilant about the mode in which you work!



Pic. 23. Status – Normal mode.

10 Dialog windows

The EVB90609 software has the following dialog boxes:

- Open;
- Save As;
- Print preview;
- Communication options;
- Demo options;
- Others.

10.1 Dialog box - Open

This standard dialog box of file opening can be reached through the text menu **File-Open** or the buttons **Ctrl+O**.

This dialog box allows opening files in HEX format. These files are the dump of the chip EEPROM chip that were saved before by this program (see **Dialog box Save as…**). Following the file opening, the fields of inputting will be filled with EEPROM byte over the range of 0x70 up to 0x7F by the file data. Further these data could be written to the EEPROM of a new chip.

10.2 Dialog box - Save As…

This standard dialog box of file saving can be reached through text menu **File-Save as…** or buttons **Ctrl+S**.

This dialog box allows to store the contents dump of the EEPROM chip in HEX format file (see **Intel Hex file format**) (all modes) and Text format file, Excel format file, CSD format file – OrCAD (see **CSD format file**), Bitmap format file, JPEG format file (Demo mode).

All contents of EEPROM are stored in HEX mode in address space from 0x0000 to 0x007F. This mode is described in section Intel HEX file format (see **Intel HEX file format**).

You can store the received data of the angular rate, temperature and time intervals in DEMO MODE as well. The data can be in the following modes:

- Text format file. Delimiter is space. For example:

  Date:<*space*><current date>
  Time:<*space*><current time>

  Time(sec)<*space*>Angular_rate(°/sec)<*space*>Temperature(ADC_code)
  0.000000E+00<*space*>6.200000E+01<*space*>1.311000E+03
  3.250000E-01<*space*>6.200000E+01<*space*>1.311000E+03
  3.500000E-01<*space*>4.000000E+00<*space*>1.310000E+03

- Excel format file. It's text file with delimiter of tab. For example:

  Date:<*tab*><current date>
  Time:<*tab*><current time>

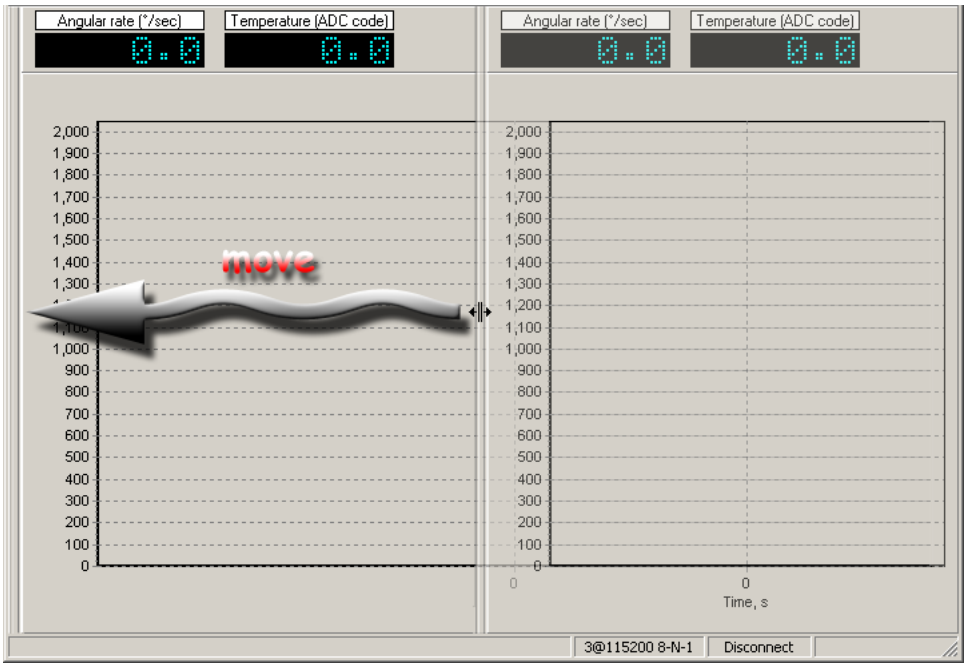
  Time(sec)<*tab*>Angular_rate(°/sec)<*tab*>Temperature(ADC_code)
  0.000000E+00<*tab*>6.200000E+01<*tab*>1.311000E+03
  3.250000E-01<*tab*>6.200000E+01<*tab*>1.311000E+03

- CSD format file. More detail information look at section of **CSD format file**. Example:

```
#H
SOURCE='PSPICE' VERSION='PSpice 9.2 (Mar 2000)'
TITLE='* Measurement *'
SUBTITLE='Angular rate'
TIME='<current time>' DATE='<current date>' TEMPERATURE='var'
ANALYSIS='Transient Analysis' SERIALNO='61414'
ALLVALUES='NO' COMPLEXVALUES='NO' NODES='2'
SWEEPVAR='Time' SWEEPMODE='VAR_STEP'
XBEGIN='0.000000E+00' XEND='1.804000E+00'
FORMAT='0 VOLTSorAMPS;EFLOAT : NODEorBRANCH;NODE  '
DGTLDATA='NO'
#N
'Angular_rate(°/sec)' 'Temperature(ADC_code)'
#C 0.000000E+00 2
6.200000E+01:1 1.311000E+03:2
#C 3.250000E-01 2
6.200000E+01:1 1.311000E+03:2
#C 3.500000E-01 2
4.000000E+00:1 1.310000E+03:2
#C 1.804000E+00 2
0.000000E+00:1 1.311000E+03:2
#;
```

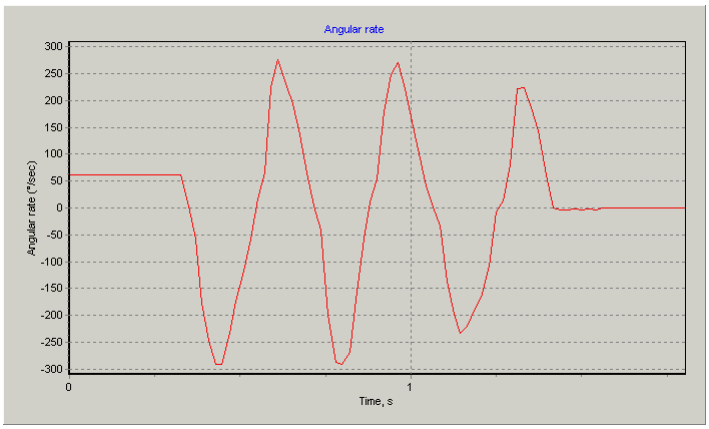
- Bitmap format file. This file format is the MS-Windows standard format. It holds truecolor images. Note there is also an OS/2-BMP format. All values stored in the BMP file are in the Intel format, sometimes also called the little endian format because of the byte order that an Intel processor uses internally to store values.

The saved file will store the shown info in the chart of main window. The bigger is the chart the better will be the quality of the graphics file. That is why it is recommended to take the splitter by mouse and drag it to the leftmost position.



Pic. 24. Moving splitter.

Example:



Pic. 25. Best view of chart.

- JPEG format file (Joint Photographic Experts Group) format file is a commonly used standard method of lossy compression for photographic images. The file format which employs this compression is commonly also called JPEG; the most common file

extensions for this format are .jpeg, .jfif, .jpg. JPG or JPE although is the most common on all platforms.

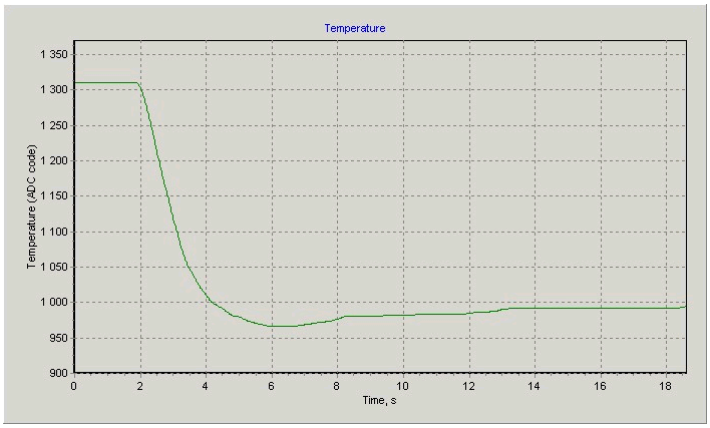
The recommendations regarding the image quality improvement is the same as for bitmap format files.

The JPEG settings are at default:

- Save compression quality = 90%;
- Progressive encoding = true.

These settings allow getting the best indices ratio file size/image quality.

Example:



Pic. 26. Temperature chart.

10.3 Dialog box- Print preview

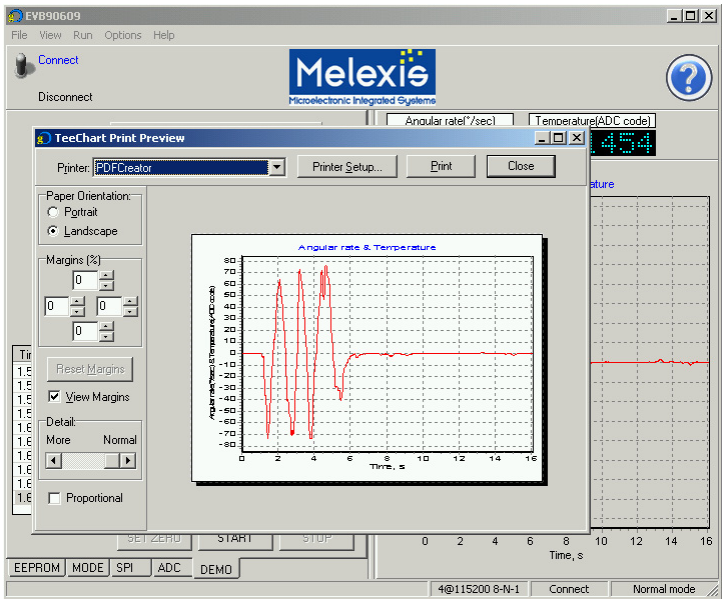
This dialog box of printing can be reached through text menu **File-Print-Preview** or buttons **Ctrl+P**.

This dialog box allows printing only chart (the chart that is shown in the right part of the main window – DEMO MODE). To get the image of the best quality move the splitter on the main window to the leftmost position. After that, call the dialog window by one of possible ways.

This dialog box is a combination of the following spaces:

- Printer setup (Printer, Printer setup and others);
- Page orientation (portrait, landscape);
- Margins(% values, reset margins, view margin);
- Detail (from normal up to more);
- Proportional option (default uncheck).

To increase grid's refining on the chart move the slider **Details** to the position **More**.



Pic. 27. Print preview.

If required to make a PDF file of an existing chart it is recommended to use the program PDFCreator. PDFCreator is a freeware software. It easily creates a PDF of the EVB90609 program. For more information and file download, enter

http://sourceforge.net/projects/pdfcreator/.

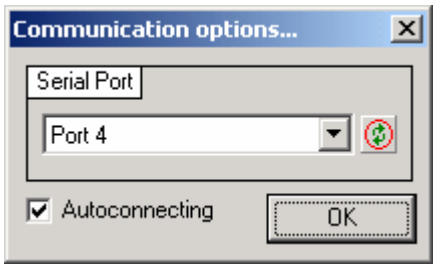
10.4 Dialog box - Communication options...

This is a dialog box of the communication path settings between the EVB90609 software and the EVB90609 PCB and it is called through the text menu **File-Options-Communication** or by the buttons **Ctrl+C**.

This dialog box is called automatically during the first start and later on when it is required to modify the communication port to the EVB90609 PCB. If it is required to modify the communication port to the EVB90609 the procedure of disconnecting has to be done, i.e. choose the text menu **Port-Disconnect** or press **F5**, or switch the tumbler to the position **Disconnect**.

Pic. 28. Setting switch in position disconnect.

The dialog box looks like:



Pic. 29. Dialog box – Communication options.

The dialog box contains the following parts:

Dependent list in which the available ports are shown.


The button of ports' lists update. This button is essential as the EVB90609 PCB is a plug-and-play device working through USB port, and as a result the operating system needs some time to reveal and register the device in the system. And it happens sometimes that there are no necessary VCP in the list.

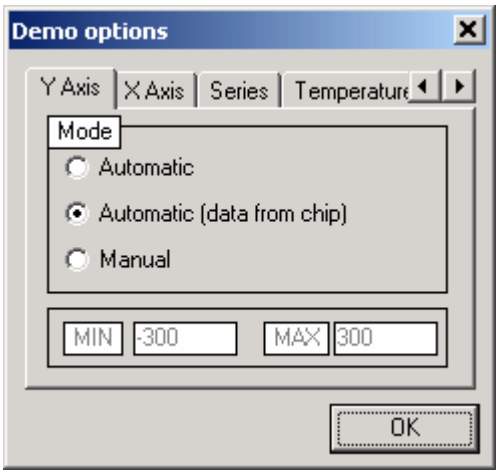
Checkbox that points the program to connect automatically to the EVB9069 PCB.

REMARK: The settings of the data are to be performed only after pressing the OK button.

10.5 Dialog box - Demo options

This dialog box of the demo mode settings can be reached through the text menu **File-Options-Demo** or by the buttons **Ctrl+D**.

This window looks like:



Pic. 30. Demo options – main view.

This dialog box has 5 pages:

- Axis X;
- Axis Y;
- Series;
- Temperature;
- Other.

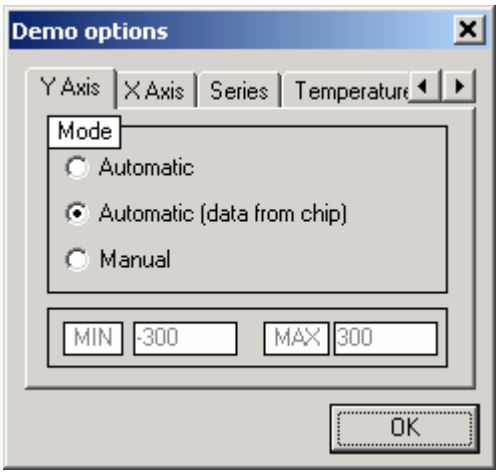
10.5.1 Page Axis Y

There are settings of data display on Axis Y at this page. There are 3 operation modes:

Automatic, automatically scaling at axis Y (from minimum up to maximum value);

Automatic (data from chip), range is read out from the EEPROM of the chip (range equals from (-range-10) up to (range+10));

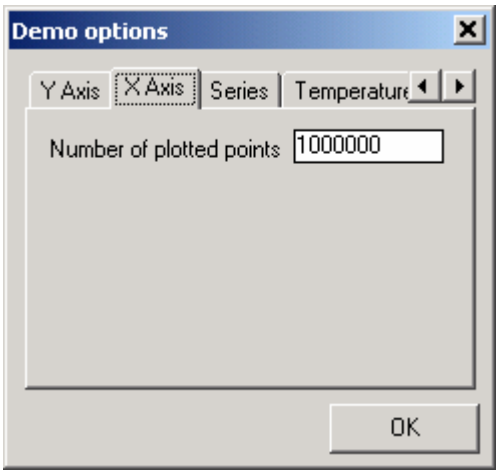
Manual, manual control – settings appointed to the User. For example, a range from 1000 up to 1400.



Pic. 31. Demo options – Y Axis Page.

10.5.2 Page Axis X

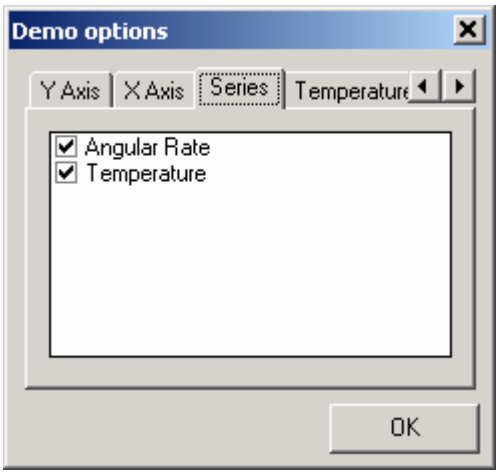
On this page the User sets the quantity of the displayed data on axis X in a range from 10 up to 9999999.



Pic. 32. Demo options – X Axis Page.

10.5.3 Page Series

On this page the User sets the quantity of the displayed series (data for displayed on the chart). Setting (cleaning) of a tick makes seen (invisible) to a series on the chart.



Pic. 33. Demo options – Series Page.

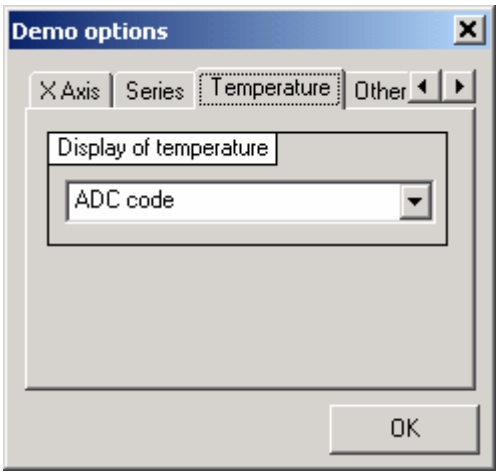
10.5.4 Page Temperature

The following variants are possible:

- ADC code;
- Celsius degrees;
- Fahrenheit degrees;
- Calvin degrees.

Display of the temperature data in terms of the ADC code is established by default.

The quantity of probable variants of data shown depends on the chip type.



Pic. 34. Demo options – Temperature Page.

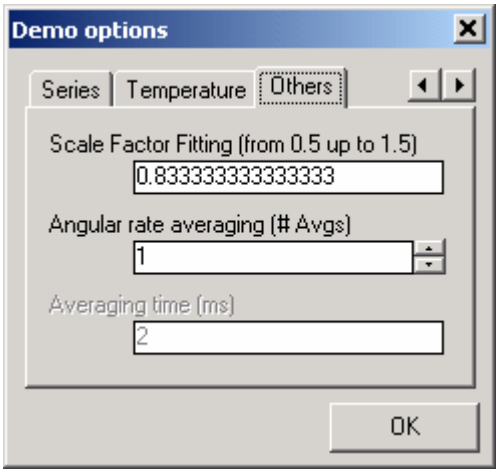
10.5.5 Page Others

At this page there is a setting of scale size factor fitting and value of angular rate data averaging.

For the specification of the directional indicator display ("compass"), it is necessary to enter the correction factor into the field Scale Factor Fitting.

Calculation procedure of the correction factor:

1. If the demo mode is running, stop it by pressing on the STOP button;
2. Install the value of the Scale Factor Fitting to “1”;
3. Turn a PCB on the valid 360 degrees;
4. Then, the value of the indicator "compass" is to be divided by 360; for example, if the value on the indicator is 300: 300/360 = 0.833333;
5. The obtained number has to be entered into a field of Scale Factor Fitting (look at Pic. 35.).



Pic. 35. Demo options – Others Page.

10.6 Dialog boxes – Others

Other dialog boxes are warning and error messages. These messages are shown during running of the application when there is not a typical situation originating on fault of the user or other programs (for example, an operational system).

For example, this message will appear when the user sets an incorrect data about the number of the port. The application will try to connect to the main board, but will not receive the answer in the set time interval. It will be a timeout error.

Pic. 36. Demo options – Others Pages.

11 SPI Protocol

The MLX90609 has a serial communication interface compatible with SPI. Likewise SPI the Serial Interface of the MLX90609 specifies four signals:

- serial clock (SCLK);
- master data output, slave data input (MOSI);
- master data input, slave data output (MISO); and
- slave select ($\overline{SS}$).

The MLX90609 always operates as a slave. Therefore only MISO pin is an output.

The MLX90609 is selected when the $\overline{SS}$ pin is low (see Fig. 37.). When $\overline{SS}$ pin is high, data will not be accepted via the MOSI pin. The serial output pin (MISO) will remain in a high impedance state. High level of $\overline{SS}$ forces the serial interface into the start state of data exchange.

Data is serially transmitted to the MLX90609 in 8 bit words (a command byte) and in 16 bit data words. Data is serially received from the MLX90609 in 16 bit words (an answer word). Most Significant Bit (MSB) is the first bit transmitted and received.

Transmission:

After the device is selected with $\overline{SS}$ going low, the command byte will be received by the MLX90609. On each rising edge of SCLK data from MOSI enter into an internal 8-bit shift register. The accepted command byte contains the op-code that defines the operations to be performed. Along with op-code this byte can also contain information such as EEPROM address or ADC mode (to be setup). One of the commands (see **Instruction of the data preparation (EED)**) also needs 16 bit data word transmission which should be shifted to the MLX90609 together with reception answer.

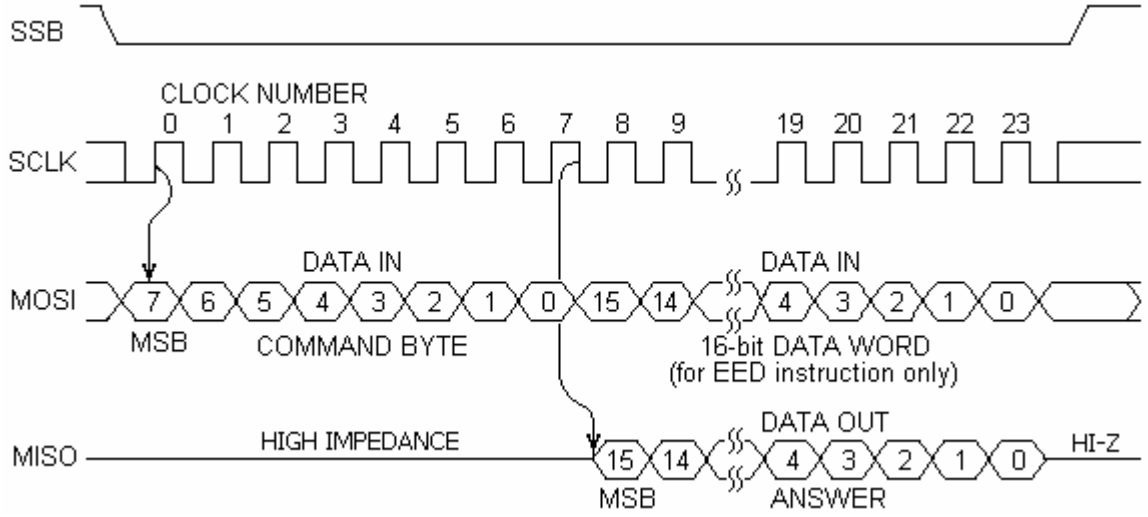
Reception:

After the 8th bit is received to the shift register, the command will be executed by the MLX90609. The format of the outgoing data is defined by the received command. All commands evoke an answer. A full communication cycle (transmitting a command and receiving the full answer) is finished after 24th clock of the SCLK. Communication can be terminated by putting $\overline{SS}$ high.

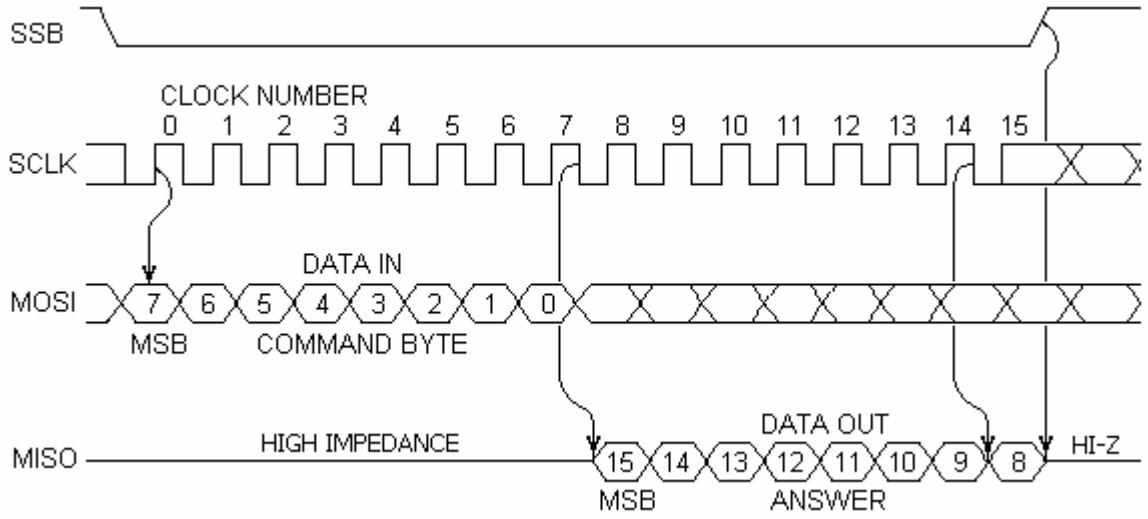
Some remarks:

- If an invalid op-code is received, it is rejected and the corresponding data is ignored. In this case a special refusal answer will be generated.
- It's recommended to use synchronization by $\overline{SS}$ after every data exchange to prevent a data distortion.
- If high level is applied to $\overline{SS}$ during a command byte transmission, the command will be ignored.

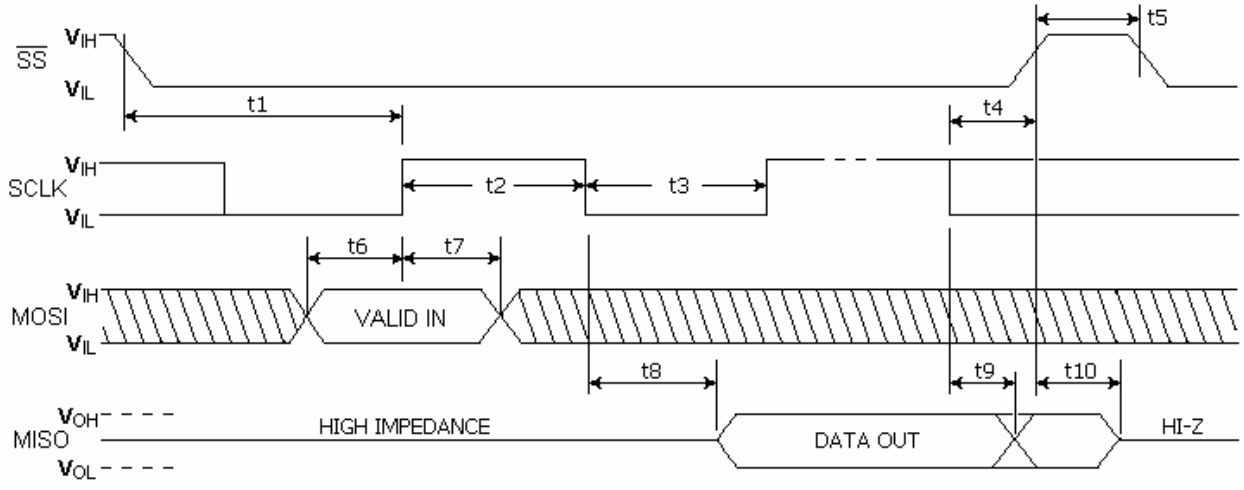
- If high level $\overline{SS}$ is applied during the answer reception, the answer will be truncated. This can be used to limit the reading of the answer to e.g. one byte only (see Fig. 38.).



Pic. 37. Serial Exchange Sequence (full answer reading).



Pic. 38. Serial Exchange Sequence (the reading of the higher half of the answer).



Pic. 39. Synchronous Data Timing.

Table 2. SPI Timing Characteristics (see Fig. 38).

Parameter	Limit	Units	Test Conditions/Comments
t1	Minimum 30	ns	$\overline{SS}$ to SCLK Rising Edge Setup Time
t2	Minimum 80	ns	SCLK High Duration
t3	Minimum 80	ns	SCLK Low Duration
t4	Minimum 0	ns	$\overline{SS}$ Hold Time
t5	Minimum 50	ns	$\overline{SS}$ High Duration
t6	Minimum 80	ns	Data In Setup Time
T7	Minimum 50	ns	Data In Hold Time
T8	Maximum 50	ns	Output Valid
T9	Minimum 0	ns	Output Hold Time
T10	Maximum 40	ns	Output Disable Time

MLX90609 commands and answers

The SPI commands are mainly used for 3 purposes:

- for the status poll

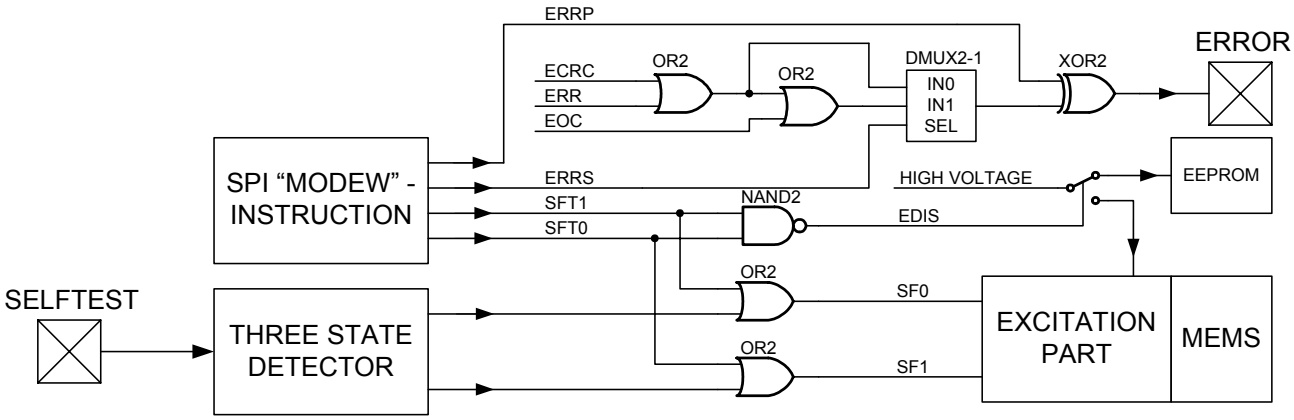
- for the EEPROM manipulation: reading the EEPROM contents or writing/erasing the customers banks
- for the internal ADC control: reading the 11 bit angular rate or temperature output.

Table 3 gives the description of each command and answer bit.

Table 3 It has to be named: e.g. "SPI bits description" or somehow else.

OPC	Unknown Operation Code. This bit is set when a received operation code was not recognized.
EOC	End of AD-conversion bit. EOC bit indicates an ADC state. EOC=0 : ADC in progress and can not be restarted. EOC=1 : AD-conversion has been completed and can be restarted. As a result, any attempt of the ADC starting will be rejected if EOC has a "0" state.
MLB	When this bit is set to "1", the EEPROM is not available anymore for writing or erasing.
EEB	EEPROM busy bit. Being set this bit informs that the EEPROM is in a busy state and that no operation (writing/erasing or reading) can be performed on it.
BUSY	This bit will be set after a reset and will be toggled to zero after all initialization procedures inside the MLX90609. While BUSY=1, only refusal answers will be sent.
EEDIS	EEDIS = (SFT1 NAND SFT0). This bit informs that the internal chip high voltage is being used to drive the MEMS and is not available for erasing or writing into the EEPROM.
Reserved	These bits are reserved and have an undefined state.
ECRC	CRC Error indicator. An incorrect result of the CRC calculation will set ECRC to "1". In this case, a refusal answer will always be generated and the ERROR pin will keep a high logical state. toggle to the selected error logical state (with the command bit ERRP).
EDRV, EPLL and ERR	EDRV and EPLL bits reflect the result of the Continuous Self Test which is used to monitor and detect permanent/temporary errors in the primary mode amplitude (EDRV) and frequency of oscillations (EPLL). After the status reading bits EDRV and EPLL will be cleared by hardware. To clear EDRV and EPLL bits it's possible also to apply zero pulse to the SELFTEST pin. ERR bit combines EDRV, EPLL and ECRC bits by OR logic.
BN	BN bit defines the number of the customer's bank of the EEPROM to be erased or written (see **EEE and EEW instructions**). This bit should be preloaded before any write/erase procedure by using EER instruction. BN = 0 means EEPROM bank 70H…77H BN = 1 means EEPROM bank 78H…7FH
ERRP, ERRS	These bits are set by the MODEW-instruction. The ERRS bit selects the source controlling the ERROR pin and the ERRP bit defines the polarity of the ERROR pin: ERRP=0, ERRS=0 : ERROR pin is controlled by the ERR and ECRC bits connected via an OR gate. ERROR = ERR or ECRC ERRP=0, ERRS=1 : ERROR pin is controlled by the ERR, ECRC and EOC bits. ERROR = (ERR or ECRC) or EOC ERRP=1, ERRS=0 : ERROR pin is controlled by the inverted result of (ERR or ECRC). ERRP=1, ERRS=1 : ERROR pin is controlled by the bit not ((ERR or ECRC) or EOC). The ERRP and ERRS bits are helpful for the fitting of the ERROR pin to the interruption input of the external microprocessor. After power-up bits ERRP and ERRS are cleared.
SF1, SF0	When the SELFTEST pin is in the high logical state, the bits SF1 and SF0 reflect the state of SFT1 and SFT0 respectively.
CHAN	The CHAN bit is used to select the input source for the ADC. CHAN=0: the angular rate channel. CHAN=1: the temperature sensor channel. This bit is set by the ADCC-instruction. After power-up bit CHAN is cleared.
ADEN	The ADEN bit selects the power management mode of the ADC: ADEN=0: ADC is switched to the sleep mode, no AD-conversion is allowed. ADEN=1: AD-conversion is allowed. This bit is set by the ADCC-instruction. After power-up bit ADEN is cleared.
ADCM1, ADCM0	These bits are used to choose an ADC operation mode: ADCM1=0, ADCM0=0: AD-conversion is initiated by the ADCC-instruction. The other combinations are reserved for future designs. If these bits are not cleared, CHAN and ADEN bits will be loaded but the ADC will not start and a refusal answer will be generated.

SFT1, SFT0	This couple of bits are used to select between Self-Test mode and EEPROM mode. SFT1=0, SFT0=0 : Normal operation (pin SELFTEST has high logical state) SFT1=0, SFT0=1 : Self-Test mode (positive angular rate emulation; pin SELFTEST has high logical state) SFT1=1, SFT0=0 : Self-Test mode (negative angular rate emulation; pin SELFTEST has high logical state) SFT1=1, SFT0=1 : EEPROM programming / erasing There are two ways to setup Self-Test mode for the MLX90609: by using the MODEW instruction or by managing SELFTEST pin. To prevent interference it's recommended to hold SELFTEST pin at the high logical state if the MODEW instruction is used. On the other hand bits SFT1 and SFT0 have to be cleared before using the SELFTEST pin to setup a Self-Test mode. After power-up bits SFT1 and SFT0 are cleared.



Pic. 40. Simplified schematic around pins ERROR and SELFTEST.

11.1 The refusal answer

Every command sent to the MLX90609 has an answer. If the MLX90609 is not able to accept the instruction a refusal answer will be transmitted out. This answer has a unique format which is shown in the table 4 below. The refusal answer is the only one that has a settled MSB. The other bits help to understand a possible reason for the command rejection. One can also on purpose force a refusal answer (for example by sending a command "11111111b") to read some of those bits.

Table 4. Refusal answer format.

Refusal answer															
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
1	OPC	EOC	MLB	EEB	BUSY	EEDIS	Reserved		ECRC	EPLL	EDRV	Reserved			

11.2 Instruction of the status reading (STATR)

Command							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
1	0	0	0	1	X	X	X

Table 5. Format of the STATR instruction.

Answer															
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	ERR	EOC	MLB	EEB	BN	Reserved		ERRP	ERRS	SF1	SF0	CHAN	ADEN	Reserved	

11.3 Control mode instruction (MODEW)

Table 6. Format of the MODEW instruction (The answer is the same as for the STATR instruction).

Command							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
1	0	1	0	ERRP	ERRS	SFT1	SFT0

11.4 Instruction of the ADC control (ADCC)

Table 7. Format of the ADCC instruction (The answer is the same as for the STATR instruction).

Command							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
1	0	0	1	CHAN	ADEN	ADCM1	ADCM0

11.5 Reading the EEPROM and the address setup (EER)

Command							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	A6	A5	A4	A3 / BN	A2	A1	A0

A6…A0	Address of the EEPROM cells to be read or to write/erase. For the read operation all of these bits are significant and result of the reading will be included into the answer. The second result of the operation is a loading of the BN bit. This bit has to be preloaded before each write/erase operation as it defines the number of the customer's EEPROM bank to be erased or written (see **EEE and EEW instructions**). It's also recommended to setup bits A2…A0 to zero before write/erase procedure. BN = 0 means EEPROM bank 70H…77H BN = 1 means EEPROM bank 78H…7FH After power-up the bits A6…A0 and BN are cleared.

Table 8. Format of the EER instruction.

Answer															
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	ERR	EOC	MLB	Reserved				DR7	DR6	DR5	DR4	DR3	DR2	DR1	DR0

DR7…DR0	The result of the EEPROM reading. Warning: At least 60 us delay should be guaranteed after the shifting of the command LSB and before the DR7 reading in order to read a correct EEPROM data.

11.6 Instruction of the data preparation (EED)

Command							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
1	0	0	0	0	1	AW1	AW0

Table 9: Format of the EED instruction (The answer is the same as for the STATR instruction).

AW1…AW0	A destination address of 16-bit data word in 64-bit data word to be written into the EEPROM. The 16-bit word should be shifted after instruction during the answer receiving.

11.7 Write instruction (EEW)

Table 10: Format of the EEW instruction (The answer is the same as for the STATR instruction).

Command							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
1	0	0	0	0	0	1	1

Note: BN bit defines the number of the customer's bank of the EEPROM to be written. If BN=0 the cells 70H…77H will be written, otherwise if BN=1 the cells 78H…7FH will be written. Bit BN should be specified previously by the EER-instruction as well as 64-bit data word should be specified by the EED-instruction.

11.8 Instruction of a write/erase cancel (EEC)

Table 11: Format of the EEC instruction (The answer is the same as for the STATR instruction).

Command							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
1	0	0	0	0	0	0	1

11.9 Instruction of the ADC reading (ADCR)

Command							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
1	0	0	0	0	0	0	0

Table 12: Format of the ADCR instruction

Answer															
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	ERR	EOC	MLB	AD10	AD9	AD8	AD7	AD6	AD5	AD4	AD3	AD2	AD1	AD0	0

AD10…AD0	A result of the AD-conversion. These bits are valid only when EOC bit is set.

11.10 Erasing the EEPROM contents

Notes:

The bit with leftmost position should be shifted first.

If MEMLOCK bit is activated the erase/write procedure will be impossible.

Step 1 (setup of the initial conditions)

SELFTEST pin should be free or pulled up and HVIN pin should be free (This condition will be not necessary for BA-version).

Internal booting procedure after power-up should be finalized (bit BUSY=0; see **Refusal answer**).

Previous erase/write procedure should be finalized (bit EEB=0; see **STATR instruction**).

Step 2 (EEPROM programming mode setup)

Use SPI to send MODEW instruction: 1 0 1 0 x x 1 1 x x x x x x x x x x x x x x x x

And check 15th bit of the answer (it should be zero): 0 x x x x x x x x x x x x x x x

If 15th bit isn't zero it's necessary to check the cause of the refusal answer.

Step 3 (setup of the bank number to be erased)

Use SPI to send EER instruction (check table 8): 0 x x x BN 0 0 0 x x x x x x x x x x x x x x x x

And check 15th bit of the answer (it should be zero): 0 x x x x x x x x x x x x x x x

If 15th bit isn't zero it's necessary to check the cause of the refusal answer.

BN bit defines the bank number to be erased:

Step 4 (setup of the erasing)

Use SPI to send EEE instruction: 1 0 0 0 0 0 1 0 x x x x x x x x x x x x x x x x

And check 15th bit of the answer (it should be zero): 0 x x x x x x x x x x x x x x x

If 15th bit isn't zero it's necessary to check the cause of the refusal answer.

Step 5 (finalize erasing procedure; see Finalizing the writing procedure)

11.11 Writing into the EEPROM:

Step 1 (setup of the initial conditions)

SELFTEST pin should be free or pulled up and HVIN pin should be free. (This condition will be not necessary for BA-version).

Internal booting procedure after power-up should be finalized (bit BUSY=0; see **Refusal answer**).

Previous erase/write procedure should be finalized (bit EEB=0; see **STATR instruction**).

Step 2 (EEPROM programming mode setup)

Use SPI to send MODEW instruction: 1 0 1 0 x x 1 1 x x x x x x x x x x x x x x x x

And check 15th bit of the answer (it should be zero): 0 x x x x x x x x x x x x x x x x

If 15th bit isn't zero it's necessary to check the cause of the refusal answer.

Step 3 (setup of the bank number to be written)

Use SPI to send EER instruction: 0 x x x BN 0 0 0 x x x x x x x x x x x x x x x x

And check 15th bit of the answer (it should be zero): 0 x x x x x x x x x x x x x x x x

If 15th bit isn't zero it's necessary to check the cause of the refusal answer.

BN bit defines the bank number to be written

Step 4 (64-bit data setup)

Use SPI to setup the data by using EED instruction and check 15th bit of each answer (they should be in zero state):

1 0 0 0 0 1 0 0 d15 d14 d13 d12 d11 d10 d09 d08 d07 d06 d05 d04 d03 d02 d01 d00

0 x x x x x x x x x x x x x x x x

1 0 0 0 0 1 0 1 d31 d30 d29 d28 d27 d26 d25 d24 d23 d22 d21 d20 d19 d18 d17 d16

0 x x x x x x x x x x x x x x x x

1 0 0 0 0 1 1 0 d47 d46 d45 d44 d43 d42 d41 d40 d39 d38 d37 d36 d35 d34 d33 d32

0 x x x x x x x x x x x x x x x x

1 0 0 0 0 1 1 1 d63 d62 d61 d60 d59 d58 d57 d56 d55 d54 d53 d52 d51 d50 d49 d48

0 x x x x x x x x x x x x x x x x

If 15th bits are not zeros it's necessary to check the cause.

Step 5 (setup of the writing)

Use SPI to send EEW instruction: 1 0 0 0 0 0 1 1 x x x x x x x x x x x x x x x x

And check 15th bit of the answer (it should be zero): 0 x x x x x x x x x x x x x x x x

If 15th bit isn't zero it's necessary to check the cause of the refusal answer.

Step 6 (finalize writing procedure; see Finalizing the writing procedure)

11.12 Finalizing the writing procedure

The MLX90609 has an internal timer which provides a write/erase monitoring. Nevertheless the timer just limits the write/erase duration in order to spare EEPROM's lifetime. This instruction (EEC) can be used to optimize the write/erase duration. It's recommended to cancel the write/erase cycle by using the EEC-instruction in order to provide 6 ms duration.

There are two possibilities to finalize write/erase procedure:

Finalizing by using EEC instruction:

Step 1 (delay)

Provide 4…15 ms delay (recommended value: 6ms).

Step 2 (cancel of the programming)

Use SPI to send EEC instruction: 1000 0001 xxxx xxxx xxxx xxxx

And check 15th bit of the answer (it should be zero): 0xxx xxxx xxxx xxxx

If 15th bit isn't zero it's necessary to check the cause of the refusal answer.

Finalizing by using polling:

Use SPI to send STATR instruction: 1000 1xxx xxxx x xxx xxxx xxxx

And check 15th bit of the answer (it should be zero): 0xxx EEB xxx xxxx xxxx

If 15th bit isn't zero it's necessary to check the cause of the refusal answer.

If EEB bit is one a programming is in progress. It's necessary to wait till EEB will be cleared by internal timer of the MLX90609.

Conversion time of the ADC: Typical value: 100 µs; Maximum value: 180 µs.

Reading the digital angular rate or temperature

Step 1 (put ADC to the active mode if it did not)

Use SPI to send ADCC instruction (see Instruction of the ADC control (ADCC)):

1 0 0 1 x 1 x x x x x x x x x x x x x x x x

And check 15th bit of the answer (it should be zero): 0 x x x x x x x x x x x x x x x

If 15th bit isn't zero it's necessary to check the cause of the refusal answer.

Use delay at least 200 us.

Step 2 (start)

Use SPI to send ADCC instruction: 1 0 0 1 CHAN 1 0 0 x x x x x x x x x x x x x x x x

And check 15th bit of the answer (it should be zero): 0 x x x x x x x x x x x x x x x

If 15th bit isn't zero it's necessary to check the cause of the refusal answer.

CHAN bit specifies the input source to be digitized by ADC.

CHAN=0 : An angular rate channel.

CHAN=1 : A temperature sensor channel.

Step 3 (polling and result obtaining)

Use SPI to send ADCR instruction (see **Instruction of the ADC reading (ADCR)**) and check 15th bit of the answer (it should be zero):

1 0 0 0 0 0 0 0 x x x x x x x x x x x x x x x x

0 ERR EOC x AD10 AD9 AD8 AD7 AD6 AD5 AD4 AD3 AD2 AD1 AD0 0

If 15th bit isn't zero it's necessary to check the cause of the refusal answer.

If ERR bit is set a value of the angular rate may be invalid.

If EOC bit is zero a result of conversion is not valid as ADC in progress. It's necessary to wait till EOC will be set.

If EOC bit is one an AD-conversion has been completed and a result of conversion (AD10…AD0) is valid.

Step 4 (put ADC to the sleep mode if it's necessary)

Use SPI to send ADCC instruction (see **Instruction of the ADC control (ADCC)**):

1 0 0 1 x 0 x x x x x x x x x x x x x x x x

And check 15th bit of the answer (it should be zero): 0 x x x x x x x x x x x x x x x

If 15th bit isn't zero it's necessary to check the cause of the refusal answer.

12 EVB90609 Protocol

The EVB90609 evaluation board acts as an interface between a MLX90609 module and a PC. It allows to perform all basic read/write operations with the module's internal registers or EEPROM. It also allows reading ADC codes of the output signals (angular rate and/or temperature) and of the demo mode (angular rate, temperature and time periods).

The microcontroller (U5) C8051F331 (Silicon Laboratories) is used to convert the PC application software commands to the module's SPI commands and to return the module's replies back to the PC software. The microcontroller uses its built-in UART port for communication with the PC and SPI for communication with the MLX90609.

The USB to UART conversion is accomplished by the CP2102 (Silicon Laboratories) IC (U9). The USB port is the VCP for the EVB90609 software. The EVB is accessed as a standard RS-232 device, while the physical media is the USB interface.

The corresponding Virtual Communication Port Drivers provided by Silicon Laboratories Chip (available for most of the existing operating systems) must be previously installed (see **Installation EVB90609**).

The data written in the internal EEPROM is used to customize the USB VID, PID, Serial Number, Product Description String and Power Descriptor value of the CP2102. This data during the USB link establishment and it is not used by the EVB's microcontroller.

The settings of the PC virtual serial RS-232 port must be the following:

- Baud rate: 115200;
- Data bits: 8;
- Parity: None;
- Stop bit: 1;
- Flow control: None.

12.1 Timeouts

1. The virtual communication port has the following timeouts:
    - Read Interval Timeout = 0 milliseconds;
    - Read Total Timeout Multiplier = 0 milliseconds;
    - Read Total Timeout Constant = 200 milliseconds;
    - Write Total Timeout Multiplier = 0 milliseconds;
    - Write Total Timeout Constant = 200 milliseconds.

2. The timeout of the answer is equal to 100 milliseconds (the first byte of the answer);
3. The timeout of the answer is a symbol equal to 10 milliseconds (an intersymbolical time interval).

12.2 Commands

All the commands supplied from the PC to the EVB are text (ASCII) statements starting with the colon symbol (:) and ending with a carriage return symbol (CR).

All the answers are text (ASCII) statements starting with a line feed symbol (LF) and ending with a carriage return symbol (CR).

The commands syntax are the following: <:> **command** <CR>
The answers syntax are the following: <LF> **answer** <CR>

All data in the commands have a hexadecimal representation of bytes. For example, the byte <CMD> in A command is equal 00001111_{bin} the hexadecimal format is written as $0F_{hex}$, i.e. in the command it will be written as two bytes 0 (ASCII, 0x30) and F (ASCII, 0x46).

This protocol has following commands:

1. A command;
2. B command;
3. C command;
4. D command;
5. W command;
6. Z command.

12.2.1 A Command

Category

Mode setting command.

Syntax

:A <*CMD*><*N*><*CS*><CR>

Description

Controls the following modes:

- IC MLX90609 analogue mode setting (modification of value power supply on SELFTEST pin);
- Setting of LED function mode;
- Resetting of supply voltage disconnection mode;
- Setting of transfer to Demo mode bit.

<CMD> – Byte of A command data.

<CR> – A carriage return symbol.

Table 13 CMD bit (A Command).

#	Name	Description
0	ST0	Setting analog mode of MLX90609 (see **Table 14 ST bits**)
1	ST1	
2	L0	Setting of LED modes (see **Table 15 L bits**)
3	L1	
4	R	Bit of supply voltage flag: 1 – Reset of a flag supply voltage switch off 0 – Not used
5	X	Not used
6	X	
7	DEMO	Setting of demo mode

Table 14 ST bits.

ST1	ST0	Description
0	0	0 Voltage (SELFTEST mode – the positive angular rate)
0	1	2.5 Voltage (SELFTEST mode – the negative angular rate)
1	0	2.5 Voltage (SELFTEST mode – the negative angular rate)

1	1	5 Voltage (Normal mode)

Table 15 L bits.

L1	L0	Description
0	0	Switch off
0	1	Short flashes
1	0	Short fading
1	1	Light continuously

<N> – The global counter of commands. Has its value ranging from 0 up to 255, after 255 changes to 0. It can be used for data loss verification and for escaping second command setting.

<CS> – Checksum. See **Checksum**.

Example

Next command example: reset of a flag supply voltage switch off, setting of normal mode for MLX90609 (SELFTEST pin = 5 Voltage) and setting the mode of continuous LED light. This command has <N> = 0 because it is first command.

Usually this command is first command after connecting with main board and after switch off.

:A1F00E1<CR>

<CMD> – 1F; <N> – 0; <CS> – E1.

Answer of A command

Syntax

<LF>A<STAT><CS><CR>

Description

<LF> – A line feed symbol.

<STAT> – Status byte. See **Answer of the STAT**.

<CS> – Checksum. See **Checksum**.

<CR> – A carriage return symbol.

Example

After power de-energization the command of normal functioning of MLX90609 mode and constant LED light command (A0FF1) is to be sent to microcontroller. In reply to A command the following response will appear:

Reply: <LF>A1FE1<CR>

<STAT> – 1F; <CS> – E1.

Attention! After each power de-energization it is required to make re-initialization with bit R reset (see A Command), because data loss, MLX90609 chip destroy, incorrectness of further data are possible.

12.2.2 B Command

Category

Status getting command.

Syntax

:B<CR>

Description

<CR> – A carriage return symbol.

This command does not have any parameters. It is intended for prompt status information receipt, inner microcontroller registers (see **STAT**).

Answer of B command

Syntax

<LF>B<STAT><CS><CR>

Description

<LF> – A line feed symbol.

<STAT> – Status byte. See **Answer of the STAT**.

<CS> – Checksum. See **Checksum**.

<CR> – A carriage return symbol.

Example

In this example MLX90609 chip works in normal mode, LED is switched on constantly. Bit E equals 1 (see **STAT and Datasheet MLX90609 (ERROR Pin)**).

Reply: <LF>B2FD1<CR>

<STAT> – 2F; <CS> – D1.

12.2.3 C Command

Category

Command of SPI commands transfer.

Syntax

:C<CMDSPI><DH><DL><N><CS><CR>

Description

<CMDSPI> – SPI command.

<DH> – High byte of data word.

<DL> – Low byte of data word.

<N> – The global counter of commands. Has its value ranging from 0 to 255, after 255 changes to 0. It can be used for data loss verification and for escaping second command setting.

<CS> – Checksum (see **Checksum**).

<CR> – A carriage return symbol.

This command transfers data to microcontroller for their further modification to SPI commands. These commands are meant for functioning control of MLX90609 in digital and mixed modes (see **SPI commands and Datasheet MLX90609**).

Answer of command C

Syntax

<LF>C<ANS1><ANS0><STAT><CS><CR>

Description

<LF> – A line feed symbol.

<ANS1> – High byte of SPI answer;

<ANS0> – Low byte of SPI answer;

<STAT> – Status byte. See **Answer of the STAT**.

<CS> – Checksum. See **Checksum**.

<CR> – A carriage return symbol.

Example

In this example MLX90609 chip works in normal mode. EER command with 0x78 parameter is sent via SPI (reading byte from EEPROM to the address 0x78, bank #1), this command on the counter will be 12 then the sent command to the microcontroller will be following view :C78AAAA1222<CR> (number of the command has been selected accidentally).

Reply for example may be next: <LF>C00450FAC<CR>

<ANS1> – 00; <ANS0> – 45; <STAT> – 0F; <CS> – AC. This answer means following, cell 0x78 (bank #1) contains byte 0x45 (ASCII code, E). The value of byte <STAT> look at **STAT**.

12.2.4 D Command

Category

The command of data acquisition in a demo mode.

Syntax

:D<CR>

Description

<CR> – A carriage return symbol.

This command does not have any parameters. It is intended for prompt demo data receipt (angular rate, temperature, angle and interval time).

Answer of D command

Syntax

<LF>D<TIME><ANGLE><AR><TEMP><STAT><CS><CR>

Description

<LF> – A line feed symbol.

<TIME> – Value of interval time. This parameter has WORD size and has milliseconds dimension.

<ANGLE> – Value of angle divided 1000. This parameter has WORD size and has degree dimension.

<AR> – Value of angular rate. This parameter has WORD size.

<TEMP> – Value of temperature. This parameter has WORD size.

<STAT> – Status byte. See **Answer of the STAT**.

<CS> – Checksum. See **Checksum**.

<CR> – A carriage return symbol.

Example

For example, reply may be next <LF>D083C0AAC0704730BC8B5<CR>

<TIME> = 0x083C; <ANGLE> = 0x0AAC; <AR> = 0x0704; <TEMP> = 0x730B; <STAT> = 0xC8; <CS> = 0xB5.

Interval time equals (0x083C+(N*65536))/1000;

Angle equals 0x0AAC*1000 (seconds);

Angular rate equals (0x0704*Sensitivity Range)/2048), Sensitivity range may be equal 300 (see **Datasheet MLX90609**).

12.2.5 W Commands

Category

Some setting commands.

Syntax

:W<PARAM><VALUE><N><CS><CR>

Description

<PARAM> – Number of parameter.

Table 16. Number of parameter.

PARAM	Description
0	Number of averaging
1	Scale factor fitting

<VALUE> – Value of parameter. This parameter has WORD size.

<N> – The global counter of commands. Has its value ranging from 0 to 255, after 255 changes to 0. It can be used for data loss verification and for escaping second command setting.

<CS> – Checksum (see **Checksum**).

<CR> – A carriage return symbol.

Answer of command W

Syntax

<LF>W<STAT><CS><CR>

Description

<LF> – A line feed symbol.

<STAT> – Status byte. See **Answer of the STAT**.

<CS> – Checksum. See **Checksum**.

<CR> – A carriage return symbol.

Example

In this example MLX90609 chip works in normal mode, LED is switched on constantly. Bit E equals 1 (see **STAT and Datasheet MLX90609(ERROR Pin)**).

Reply: <LF>W2FD1<CR>

<STAT> – 2F; <CS> – D1.

12.2.6 Z Command

Category

Zero setting command.

Syntax

:Z<CR>

Description

<CR> – A carriage return symbol.

This command does not have any parameters. Current value of ADC will be equal to 0 degree per second of angular rate.

Answer of command W

Syntax

<LF>Z<STAT><CS><CR>

Description

<LF> – A line feed symbol.

<STAT> – Status byte. See **Answer of the STAT**.

<CS> – Checksum. See **Checksum**.

<CR> – A carriage return symbol.

Example

In this example MLX90609 chip works in normal mode, LED is switched on constantly. Reply: <LF>Z0FF1<CR>

<STAT> – 0F; <CS> – F1.

12.2.7 Answer of the STAT

Values of this byte signaled about a state of functional modes main board and MLX90609.

Description

Table 17 Description of STAT bite.

#	Name	Description
0	DEMO BIT	This of bit is installed in 1 in demo mode
1	ACCEPT BIT	This bit is installed in 1 when demo mode will ready to work.
2	E	Status ERROR pin
3	R	Flag of power de-energization
4	L1	Setting of LED modes (see **Table 15 L bits**)
5	L0	
6	ST1	Setting analog mode of MLX90609 (see **Table 14 ST bits**)
7	ST0	

12.3 Checksum

The aim of a checksum is to detect errors. This detection technique enables the receiver of a message transmitted through a noisy (error-introducing) channel to determine whether the message has been corrupted or not. To do this, the transmitter constructs a value (called a checksum) that is a function of the message, and appends it to the message. The receiver can then use the same function to calculate the checksum of the received message and compare it with the appended checksum to see if the message was correctly received.

Description

Here's a simple algorithm, written in a pseudo-high-level and C++ language. Calculating a checksum is just adding together all the bytes in the command, getting the low byte, inverting it and adding 1. After that, the checksum will be appended to the command.

<CS> = (invert (LowByte($\Sigma byte_i$)))+1

Example

C command – C669F2FCC (checksum = CC)

Pseudo-high level code:

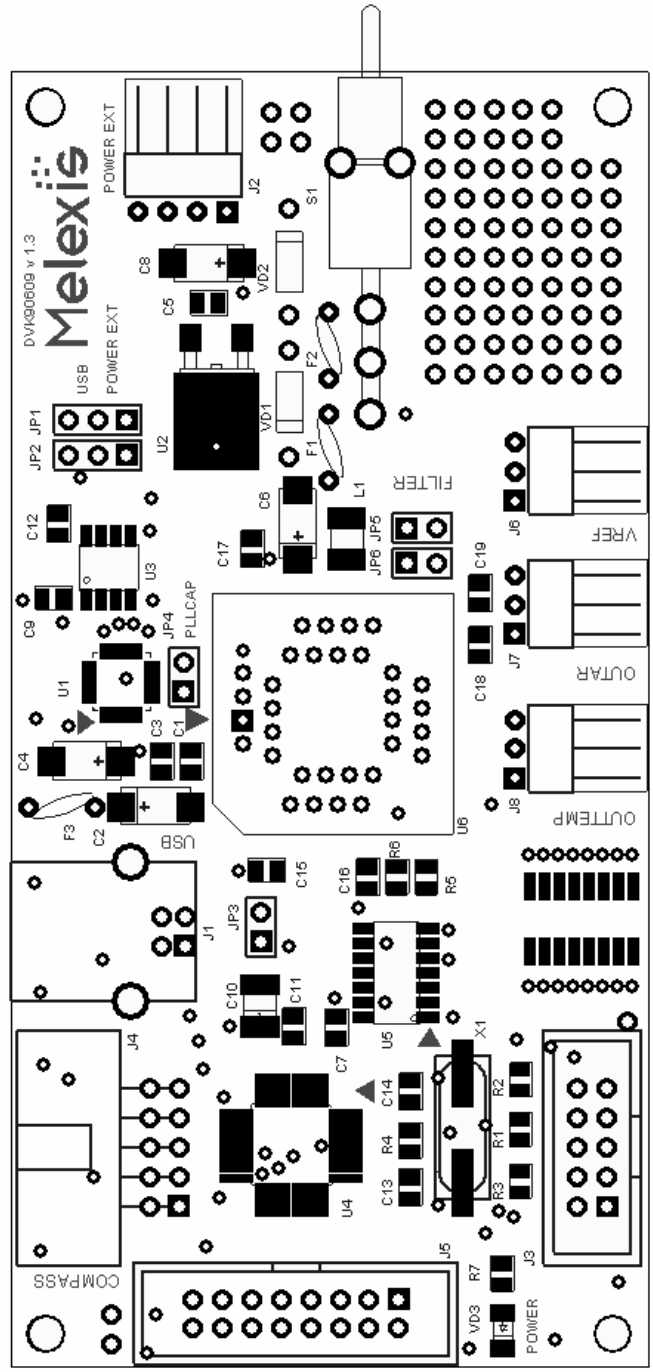
1. 0x66+0x9F+0x2F = 0x0134
2. LowByte(0x0134) = 0x34
3. Invert(0x34) = 0xCB
4. 0xCB + 0x01 = CC

And how result we have <CS> = 0xCC.

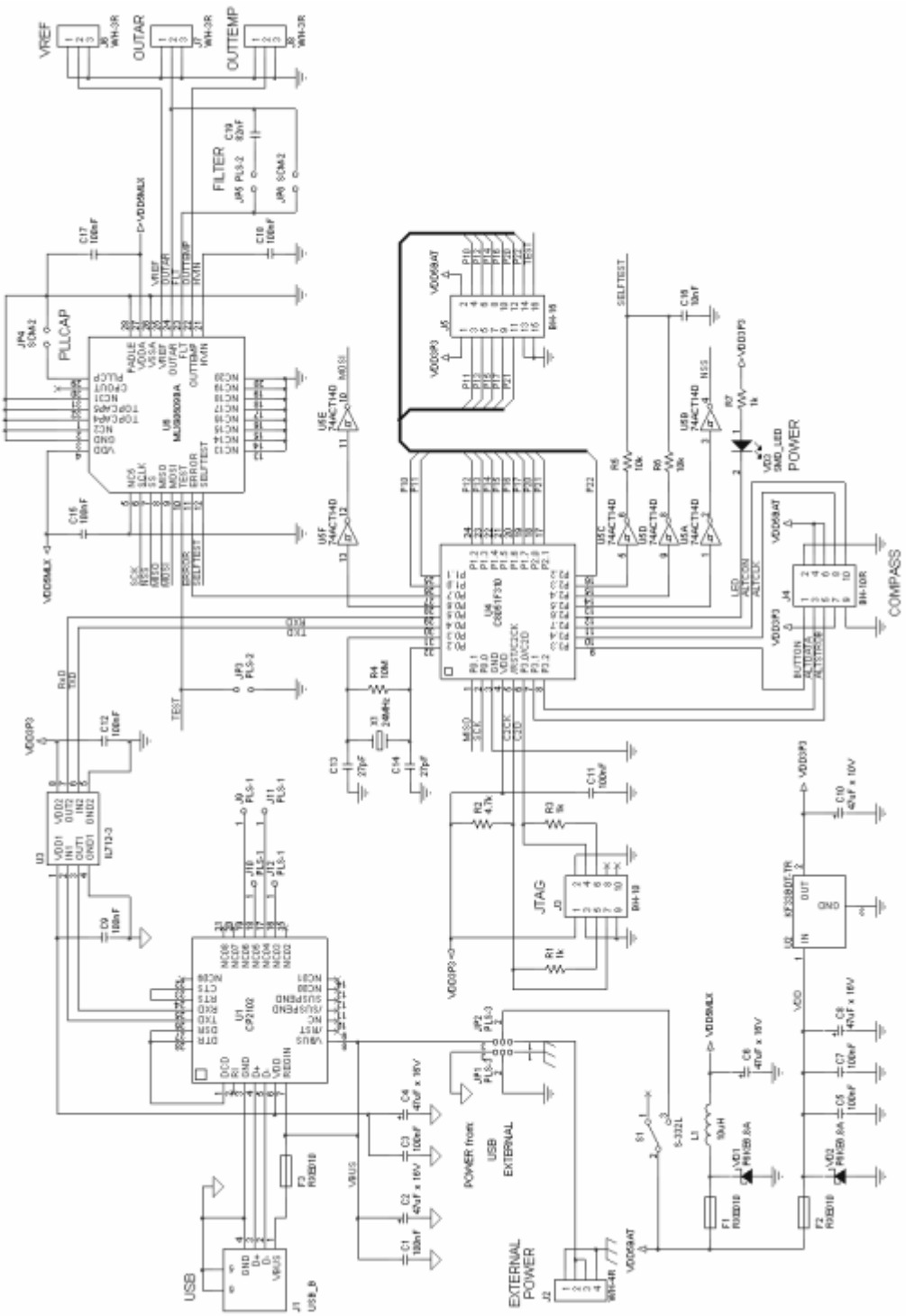
C++ code:

```
BYTE CS=~(0x66+0x9F+0x2F)+0x01;
```

13 Schematic



Pic. 41. The external view of the EVB90609 Evaluation Board.



Pic. 42. The EVB90609 evaluation board schematic.

14 Intel hex file format

This Information applies to:

- C166 All Versions
- C251 All Versions
- C51 All Versions

The Intel HEX file is an ASCII text file with lines of text that follow the Intel HEX file format. Each line in an Intel HEX file contains one HEX record. These records are made up of hexadecimal numbers that represent machine language code and/or constant data. Intel HEX files are often used to transfer the program and data that would be stored in a ROM or EPROM. Most EPROM programmers or emulators can use Intel HEX files.

14.1 Record Format

An Intel HEX file is composed of any number of HEX records. Each record is made up of five fields that are arranged in the following format:

:llaaaatt[dd...]cc

Each group of letters corresponds to a different field, and each letter represents a single hexadecimal digit. Each field is composed of at least two hexadecimal digits-which make up a byte-as described below:

: is the colon that starts every Intel HEX record.

ll is the record-length field that represents the number of data bytes (dd) in the record.

aaaa is the address field that represents the starting address for subsequent data in the record.

tt is the field that represents the HEX record type, which may be one of the following:

00 - data record

01 - end-of-file record

02 - extended segment address record

04 - extended linear address record

dd is a data field that represents one byte of data. A record may have multiple data bytes. The number of data bytes in the record must match the number specified by the ll field.

cc is the checksum field that represents the checksum of the record. The checksum is calculated by summing the values of all hexadecimal digit pairs in the record modulo 256 and taking the two's complement.

14.2 Data Records

The Intel HEX file is made up of any number of data records that are terminated with a carriage return and a linefeed. Data records appear as follows:

:10246200464C5549442050524F46494C4500464C33

```
:10246200464C5549442050524F46494C4500464C33
|||||||||||                                 CC->Checksum
|||||||||DD->Data
|||||||TT->Record Type
|||AAAA->Address
|LL->Record Length
:->Colon
```

This record is decoded as follows:

where:

10 is the number of data bytes in the record.

2462 is the address where the data are to be located in memory.

00 is the record type 00 (a data record).

464C...464C is the data.

33 is the checksum of the record.

14.3 Extended Linear Address Records (HEX386)

Extended linear address records are also known as 32-bit address records and HEX386 records. These records contain the upper 16 bits (bits 16-31) of the data address. The extended linear address record always has two data bytes and appears as follows:

:02000004FFFFFC

where:

02 is the number of data bytes in the record.

0000 is the address field. For the extended linear address record, this field is always 0000.

04 is the record type 04 (an extended linear address record).

FFFF is the upper 16 bits of the address.

FC is the checksum of the record and is calculated as 01h + NOT(02h + 00h + 00h + 04h + FFh + FFh).

When an extended linear address record is read, the extended linear address stored in the data field is saved and is applied to subsequent records read from the Intel HEX file. The linear address remains effective until changed by another extended address record.

The absolute-memory address of a data record is obtained by adding the address field in the record to the shifted address data from the extended linear address record. The following example illustrates this process..

Address from the data record's address field	2462
Extended linear address record data field	FFFF
Absolute-memory address	FFFF2462

14.4 Extended Segment Address Records (HEX86)

Extended segment address records-also known as HEX86 records-contain bits 4-19 of the data address segment. The extended segment address record always has two data bytes and appears as follows:

:020000021200EA

where:

02 is the number of data bytes in the record.

0000 is the address field. For the extended segment address record, this field is always 0000.

02 is the record type 02 (an extended segment address record).

1200 is the segment of the address.

EA is the checksum of the record and is calculated as 01h + NOT(02h + 00h + 00h + 02h + 12h + 00h).

When an extended segment address record is read, the extended segment address stored in the data field is saved and is applied to subsequent records read from the Intel HEX file. The segment address remains effective until changed by another extended address record.

The absolute-memory address of a data record is obtained by adding the address field in the record to the shifted-address data from the extended segment address record. The following example illustrates this process.

Address from the data record's address field	2462
Extended segment address record data field	1200
Absolute-memory address	00014462

14.5 End-of-File (EOF) Records

An Intel HEX file must end with an end-of-file (EOF) record. This record must have the value 01 in the record type field. An EOF record always appears as follows:

:00000001FF

where:

00 is the number of data bytes in the record.

0000 is the address where the data are to be located in memory. The address in end-of-file records is meaningless and is ignored. An address of 0000h is typical.

01 is the record type 01 (an end-of-file record).

FF is the checksum of the record and is calculated as 01h + NOT(00h + 00h + 00h + 01h).

14.6 Example Intel HEX File

Following is an example of a complete Intel HEX file:

```
:0800000047003F4000FF0038FB
:080008000038383F00BF003F43
:0800100038383807 38B8073F03
:0800180007000038388 00038B1
:0800200000003807 38BF00079B
:0800280000003800 38803F079A
:080030003F3F3F3838803838AB
:080038008080B8803880800050
:08004000388000B880B8B80058
:080048008000B80038B8B83898
:0800500040784040 78784000
:0800580078407840 40407840F8
:0800600004040000 040400098
:0800680078404707 07474000FC
:08007000004D656C 65786973B1
:0800780045564239 3036303 99B
:00000001FF
```

15 CSD format file

The Common Simulation Data File (CSDF) format has been proposed as a standard format for results from simulation programs. The CSDF is in a generic manner so that any computer link can handle the file transfer and any computer platform can process the data. The default file name extension for a CSDF file is .CSD.

16 Disclaimer

Devices sold by Melexis are covered by the warranty and patent indemnification provisions appearing in the Terms of Sale. Melexis makes no warranty, express, statutory, implied, or by description regarding the information set forth herein or regarding the freedom of the described devices from patent infringement. Melexis reserves the right to change specifications and pricing at any time and without notice. Therefore, prior to designing this product into a system, it is necessary to check with Melexis for current information. This product is intended for use in normal commercial applications. Applications requiring extended temperature range, unusual environmental requirements, or high reliability applications, such as military, medical life-support or life-sustaining equipment are specifically not recommended without additional processing by Melexis for each application.

The information furnished by Melexis is believed to be correct and accurate. However, Melexis shall not be liable to recipient or any third party for any damages, including but not limited to personal injury, property damage, loss of profits, loss of use, interruption of business or indirect, incidental or consequential damages, of any kind, in connection with or arising out of the furnishing, performance or use of the technical data herein. No obligation or liability to recipient or any third party shall arise or flow out of Melexis' rendering of technical or other services.

Certified ISO/ TS 16949, ISO 14001

For the latest version of this document, visit our website at:

www.melexis.com

For additional information contact Melexis Direct:

Europe and Japan:	All other locations:
Phone: +32 13 67 04 95	Phone: +1 603 223 2362
E-mail: sales_europe@melexis.com	E-mail: sales_usa@melexis.com