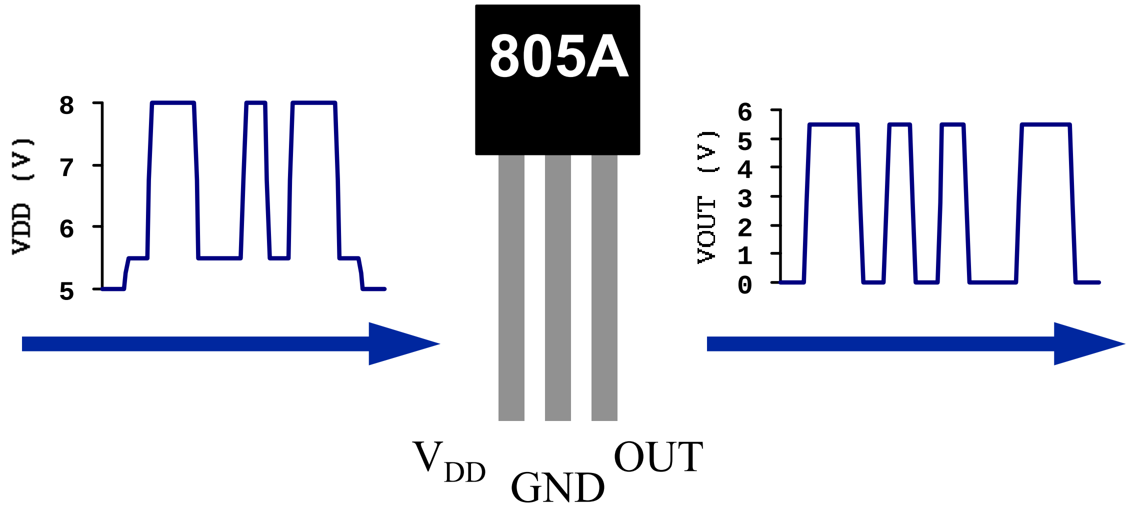
I. Application Notes

I.1 Functional Description

The HAL805 and the HAL815 are linear Hall effect ICs designed in CMOS technology. They can be used for angle and distance measurements if combined with a rotating or moving magnet. Because of their overall robustness, they are applicable in hostile automotive and industrial environments.

The Hall IC provides an output voltage proportional to the incident magnetic field and proportional to the supply voltage. Before the final locking of the IC, the output characteristic can be adjusted to the external mechanical and magnetic conditions by modifying internal EEPROM registers. During the calibration the Hall IC is addressed by modulating the supply voltage and it responds by modulating the output voltage.



Internal temperature and offset compensation circuitry enables operation over a wide temperature range with minimal changes in accuracy and offset stability. The circuitry also rejects shifts due to mechanical stress and long-term drifts.

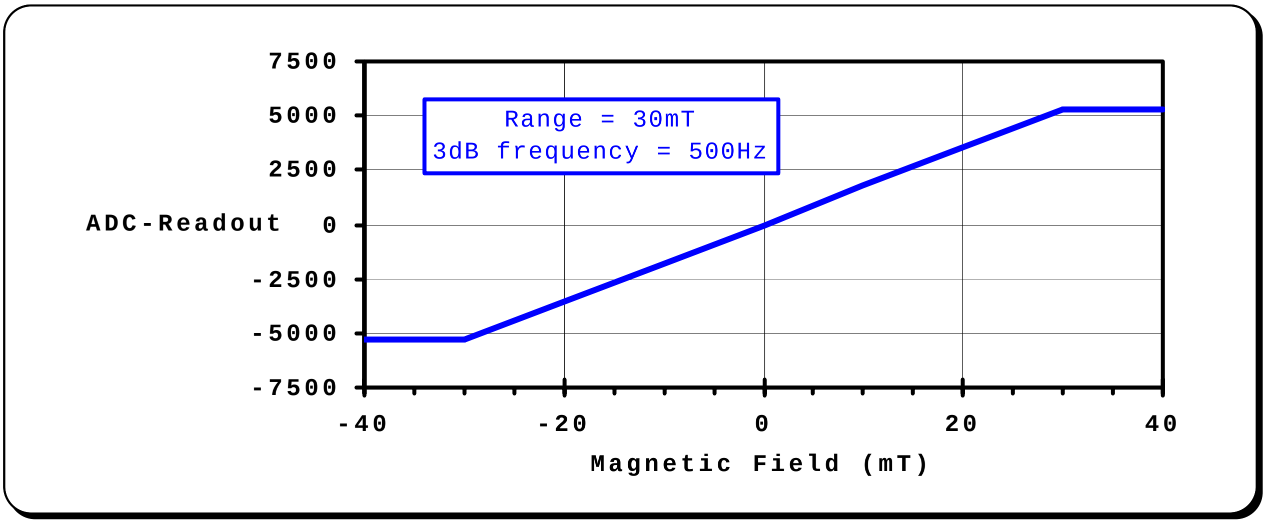
In addition, the sensor IC is equipped with devices for over-voltage protection and reverse voltage protection at the supply and output voltage.

I.2 Digital Signal Processing

An external magnetic field generates a Hall voltage perpendicular to the current driven through the Hall plates on the HAL805 or HAL815 chips. The amplified Hall voltage is converted to a 14 bit digital value. Depending on the programmable magnetic range of the Hall IC, the operating range of the AD conversion is between -30mT...+30mT or up to -150mT...150mT. The digital value after the AD converter is the basis for the further internal processing of the magnetic signal. There are digital functions for limiting and filtering the signal and for calculating the output characteristic. After the processing the digital signal is converted to an analog voltage and stabilized by a push-pull output transistor stage.

The residual offset of the AD conversion at zero magnetic field is measured and compensated at the factory.

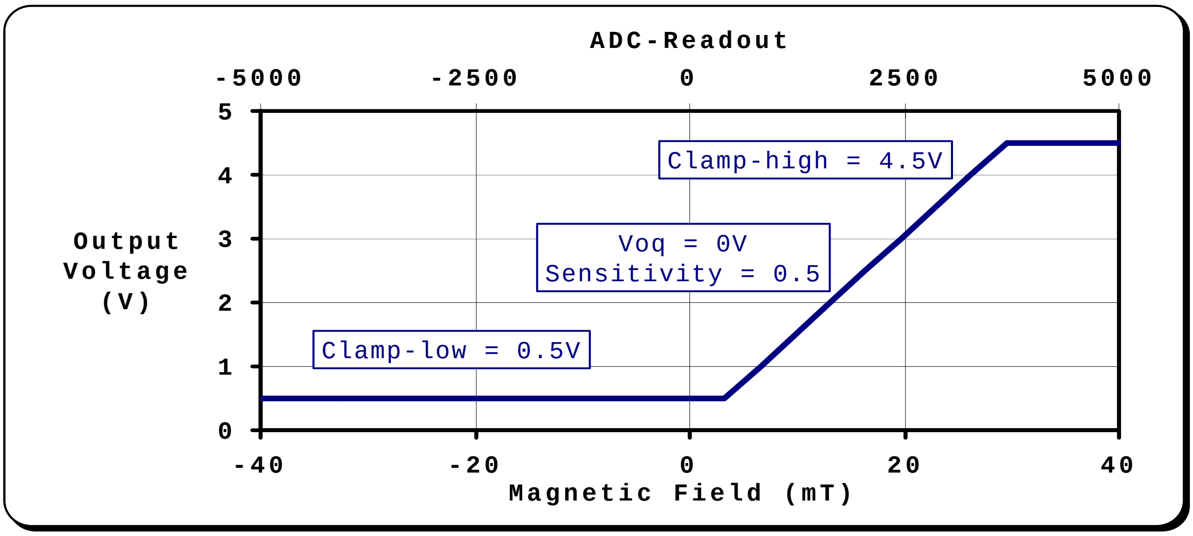
The next graph shows how the AD converter readout depends on the external magnetic field. The digital output can be read out from the Hall IC by reading out the ADC-Readout register. For the given example a magnetic range of 30mT and a low-pass filter frequency of 500Hz was selected. As you can see in the figure, the Hall IC is sensitive to positive and negative magnetic fields. Please remark that positive magnetic fields accord to a magnetic north pole on the branded side of the IC package.



I.3 Adjustment of the Output Characteristic

The output characteristic is determined by four parameters: The parameter Clamp-low specifies the lower clamp voltage of the output curve. Specifying Clamp-high can change the upper clamp voltage. The output voltage at zero magnetic field or more precisely at zero ADC-Readout is adjustable by the parameter Voq (quiescent output voltage). The parameter Sensitivity corresponds to the increase of the output voltage with magnetic field. A Sensitivity of 1 is equivalent to a voltage increase of 5V at an increase of 2048 of the AD converter output.

An example of how the magnetic signal can be transformed to an analog output voltage is given in the following graph:



There is a simple formula that relates the analog output voltage to the AD converter readout (ADC-Readout):

Vout = Voq + ADC-Readout * Sensitivity * 5V / 2048 (in case of a 5V supply)

For the programming of the Hall IC in the application we recommend to proceed as follows:

1. Step - Programming of the parameters, which need not to be adjusted individually:
Clamp-low, Clamp-high
Filter Frequency (we recommend 500Hz for maximum resolution)
TC Register
TCSQ Register (with the appropriate temperature compensation of your system)
In addition the Magnetic Range has to be programmed with a suitable value.

2. Step - Get the ADC-Readout value in the first calibration point
Please move the sensor module into the first calibration point. Get the ADC-Readout in this position (ADC-Readout1).

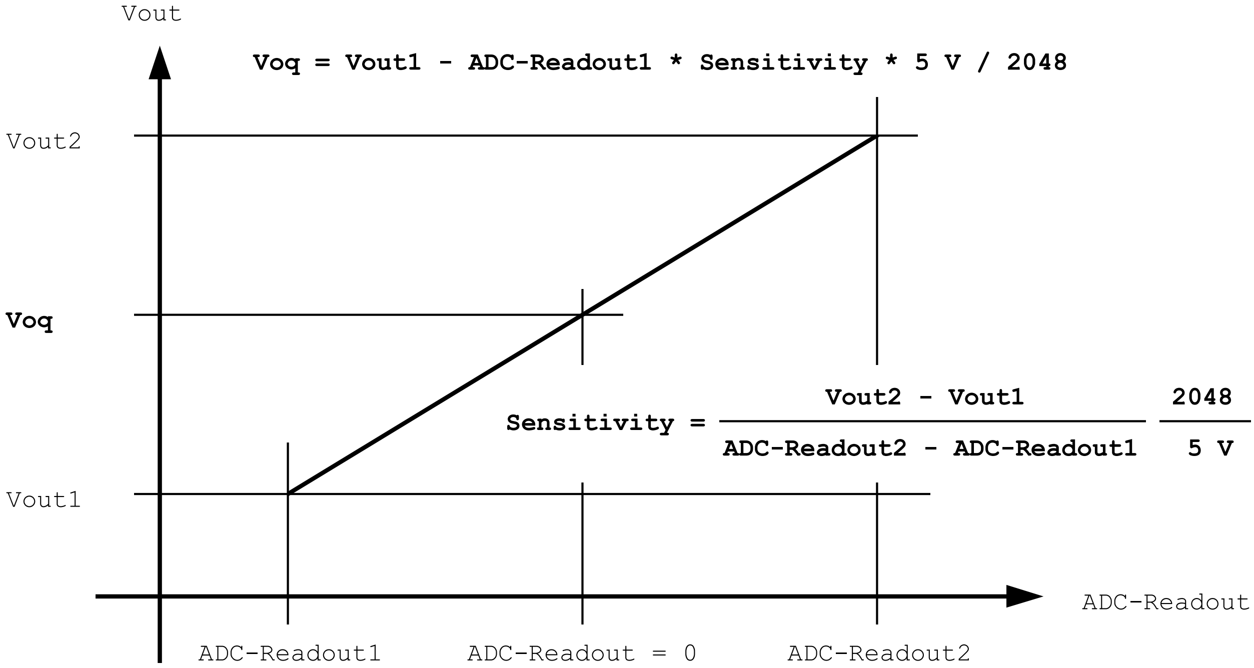
3. Step - Get the ADC-Readout value in the second calibration point
Please move the sensor module into the second calibration point. Get the ADC-Readout in this position (ADC-Readout2).

4. Step - Calculation and Programming of the SENSITIVITY and VOQ registers
Using the ADC-Readout values from the above calibration points (ADC-Readout1 and ADC-Readout2) Sensitivity and Voq can be adjusted so that the Hall IC will deliver a specific voltage (Vout1 and Vout2) in position 1 and 2:

Sensitivity = (Vout1 - Vout2)/(ADC-Readout1 - ADC-Readout2) * 2048 / 5 V

Voq = Vout1 - ADC-Readout1 * Sensitivity * 5 V / 2048

A graphical representation of the magnetic signal in the two calibration points and the calculation of Sensitivity and Voq is given here:



I.4 Maximum ADC-Readout

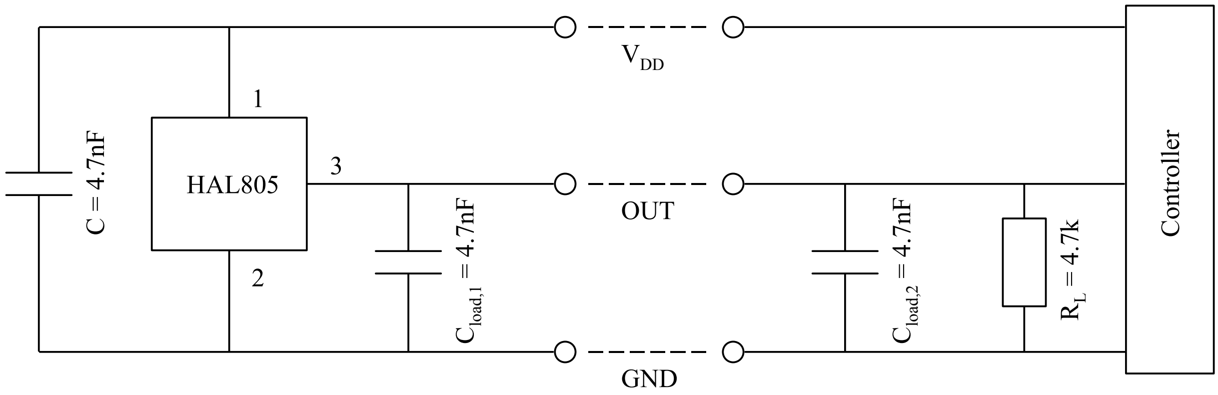
The saturation of the AD-conversion depends, for sure, on the programming of the magnetic range register. The maximum value of the ADC-Readout, however, depends on the programming of the 3dB-frequency register. The maximum ADC-Readout values are given in the following table:

3dB frequency	Maximum ADC-Readout
80	4040
160	2020
500	5350
1000	2680
2000	1520

The maximum values are obtained for magnetic north polarity. The corresponding minimum values are obtained at magnetic south polarity. Some care has to be taken that the maximum and minimum ADC-Readout values are not exceeded during the calibration and operation of the sensor.

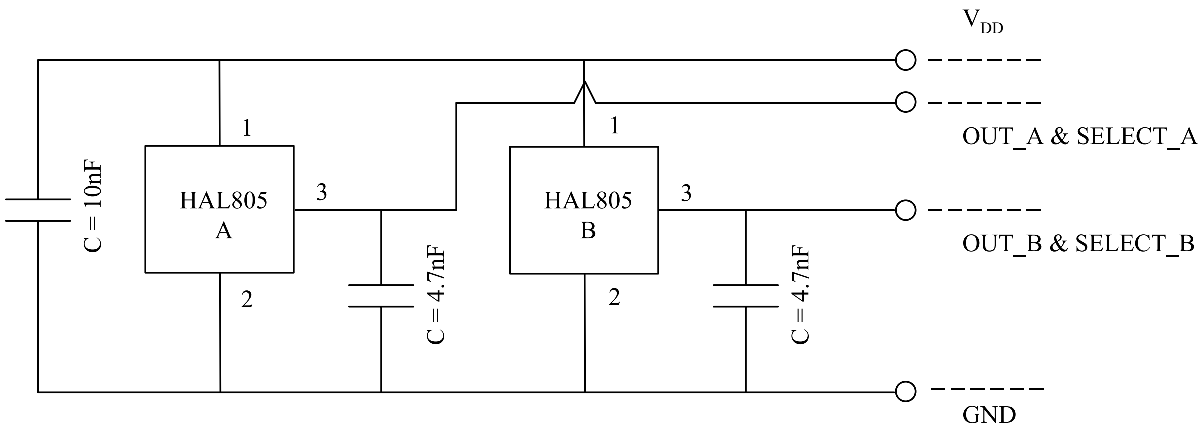
I.5 Electrical Circuit

For external EMI protection of the HAL805 and HAL815, it is recommended to add each a ceramic 4.7nF capacitor between ground and the supply voltage respectively the output voltage pin. In addition, the input of the controller unit should be pulled-down with a 4.7kOhm resistor and a ceramic 4.7nF capacitor.



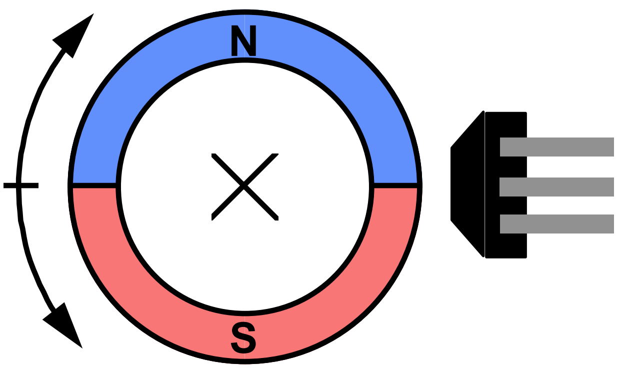
I.6 Use of two HAL805 or HAL815 in parallel

Four different HAL805 or HAL815 which are plugged in parallel to the same supply and ground line can be programmed individually. In order to select the IC which shall be programmed, all Hall IC's are inactivated by an inactivation command on the common supply line. Then the appropriate IC is activated by an activation pulse on its output. Only the activated sensor will react to all following read, write and program commands. If the next IC has to be programmed, an inactivation command is sent again and the next IC can be selected. The pin connection of the six-pin plug on the board which has to be used to connect the four sensor IC's is given in chapter II.4. It is possible to program more than four sensors in parallel if the programmer board is changed accordingly. Please contact us for more information.
The picture below shows an example circuitry for two sensors. The next two sensors can be connected to the same VDD and GND line with the same external capacitors.



I.7 Magnetic Circuit for Angular Sensors

For angular ranges of up to about -40°...+40° a diametrically magnetized ring can be used. Approximately, there is a linear dependence of the magnetic field on the mechanical angle close to the pole changes. A possible arrangement of sensor and magnet ring is shown in the following graph:



Please contact us, if you are interested in magnetic circuits with a wider linearity range.

II. HAL8x5 Application Board

The HAL8x5 Application Board Version 5.x is used for the communication between a PC and up to four different HAL805 or HAL815 IC’s. The Application Board has to be connected with the serial port of the PC (COM1:, COM2:, COM3: or COM4:) and has to be supplied with minimum +18 V DC (sockets for +18V and GND are present). Please ensure that the polarity of the voltage supply for the board is correct. The Hall IC’s can be inserted in the three-pin sockets or the Hall IC’s in the customers’ application can be connected via the two six-pin sockets P2 and P3. Up to four different HAL805 or HAL815 plugged in parallel to the same supply line can be addressed with the HAL80x Application Boards. The pin connection of the sockets P2/P3 is given in section II.4.

hardware:

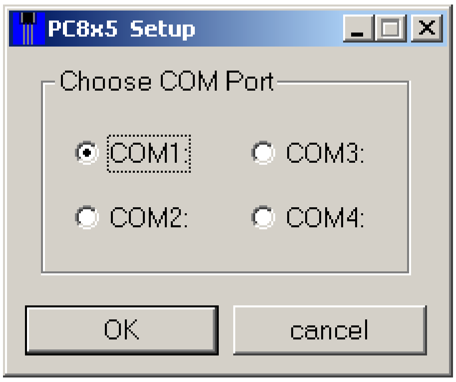
PC	<---> RS232	Application Board Version 5.x	<---> three-pin and six-pin sockets	HAL805 or HAL815

software:

PC8x5.EXE Vers. 6.00 (shipped on setup CD)	<--->	FIRMWARE Vers. 1.20 (stored in the flash memory of the Application Board)	<--->	HAL805 or HAL815

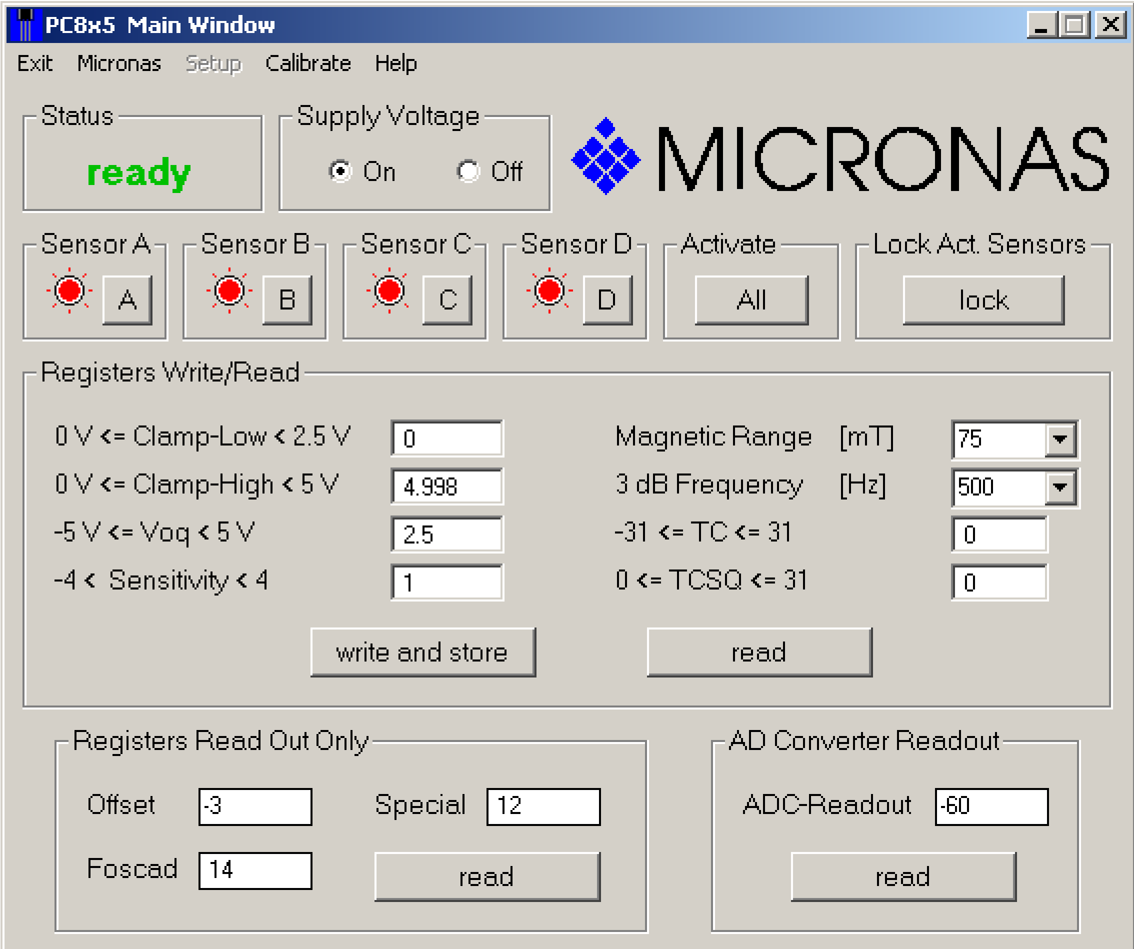
II.1 PC8x5.EXE Program

On the installation CD there is the setup folder WIN32BIT for the 32 bit operating systems WINDOWS 95, 98, 2000, NT and ME. In the setup folder is a sub-directory CDINST for the installation from CD. After the installation of the PC8x5 program there should be a PC8x5 item in the programs menu of WINDOWS 95, 98, 2000, NT and ME.
After starting the program, the main window of PC8x5 will open. If the Application Board is not plugged to COM1: (default port) you can select the appropriate port using the Setup menu:



After selecting the COM port, the Setup window is closed by hitting the return key or by clicking on the ‘OK’ button. Please remark, that it is necessary to use a programmer board firmware of version 1.20 or later. Please contact your supplier for the most recent firmware version.

In the PC8x5 main window all entries are disabled until you switch on the supply voltage of the HAL805 or HAL815 IC. This is done by pressing the ‘On’ button within the ‘Supply Voltage’ field. During the transmission of the On command to the Application Board the board status is busy. (Please ensure that the Application Board is connected to the PC and to the +18 V DC source). After switching on the Supply Voltage the NORM LED on the Application Board should light (besides the READY LED which ignites after supplying the Application Board).



If four HAL805 or HAL815 IC’s are connected in parallel to the programmer board, you have to choose the sensor which you want to address by hitting the ‘Sensor A’, ‘Sensor B’, ‘Sensor C’ or the ‘Sensor D’ button. The other sensors are then deactivated. The active sensor is indicated by a red light beside the corresponding button A, B, C or D.

The following registers can be changed: The lower clamp voltage (CLAMP-LOW) is variable between 0V and 2.5V. The upper clamp voltage (CLAMP-HIGH) can be changed between 0V and 5V. The output quiescent voltage is adjustable by the register VOQ. Values between -5V and 5V are possible. The SENSITIVITY register corresponds to the increase of the output voltage with magnetic field. For this register values between -4 and 4 are valid. A Sensitivity of 1 is equivalent to a voltage increase of 5V at an increase of the AD converter output of 2048. The full magnetic range of the Hall sensor can be selected from 8 different ranges. The magnetic ranges are between -30mT...+30mT, -40mT...+40mT, -60mT...60mT, -75mT...+75mT, -80mT...80mT, -90mT...+90mT, -100mT...100mT and -150mT...150mT. Changing the Magnetic Range entry does the selection. In addition, the 3dB frequency of an internal low pass filter can be chosen to be 80Hz, 160Hz, 500Hz, 1000Hz or 2000Hz. The temperature compensation of the Hall IC can be fit to different magnetic materials. The adaptation is done by programming the TC (Temperature Coefficient) and the TCSQ register (Quadratic Temperature Coefficient). TC can be changed between -31 and 31, TCSQ between 0 and 31.

When you have entered your choice into the entries of the main window, you have to press the ‘write and store’ button in order to store permanently the values in the EEPROM cells of the Hall IC. Thereby the magnetic response of the sensor will change as specified.

The registers ADC-READOUT (AD Converter Readout), OFFSET (AD Converter Offset), FOSCAD (Oscillator Frequency Adjustment), and SPECIAL (for special purposes) are read only. The values can be read by pressing the corresponding ‘read’ button.

If you don’t want to change the response of the IC any more, you may press the ‘lock’ button. Then all registers will be locked and the sensor will no more respond to any supply voltage modulation. Please remind, that only the activated sensor will be locked. In order to lock all connected sensors, all sensors have to be activated by the ‘All’ button. Then the lock command can be sent to all Ics.

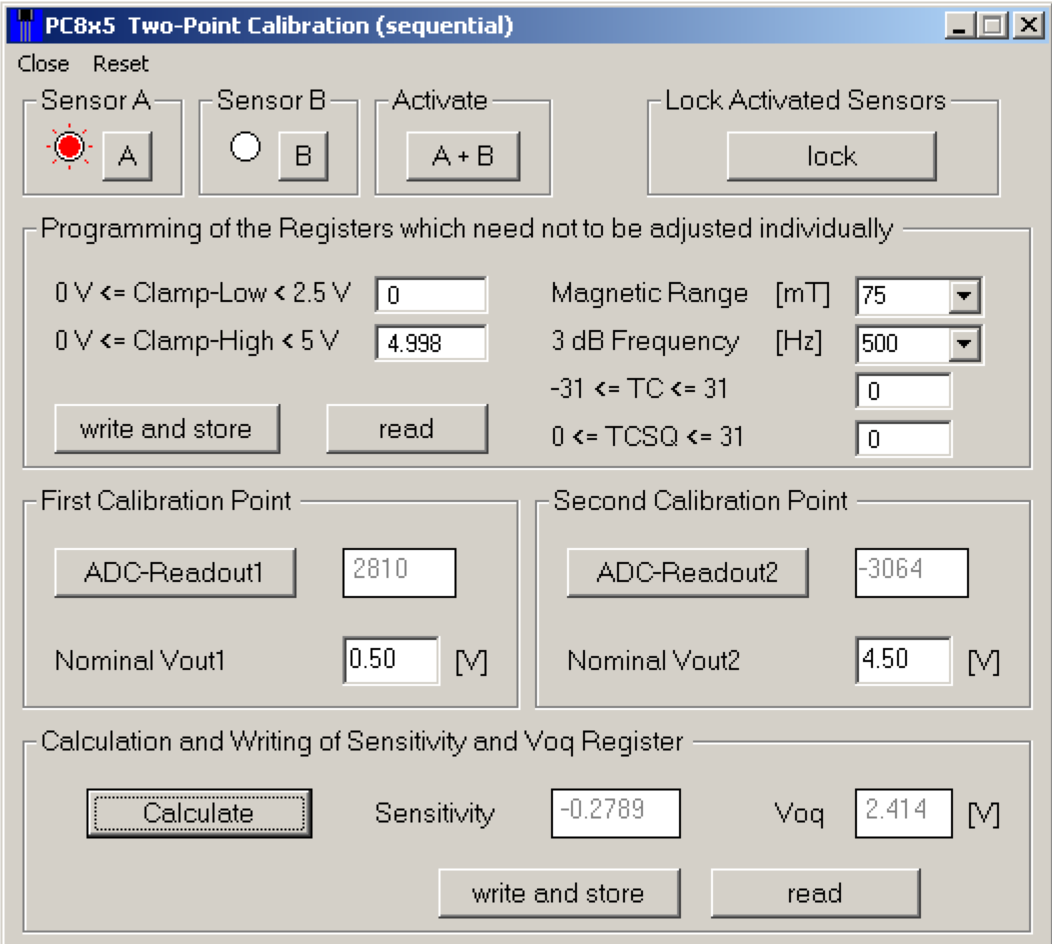
For the calibration of the Hall IC’s in the customer application the Calibrate menu has to be activated from the main window of PC8x5. There are different menu options for sequential and parallel two- and three-point calibration.

If the ‘sequential 2-Point’ option is activated, the stepwise two-point calibration which is described in section I.3 can be done. If more sensors are connected in parallel to the programmer board, the sensors have to be adjusted sequentially. The software is adapted for two sensors only. For that purpose, the Hall IC that you want to calibrate at first has to be activated by hitting the ‘A’ respectively the ‘B’ button. After the calibration of the first sensor, the second sensor has to be selected and the calibration sequence has to be repeated.

The two-point calibration of two sensors can also be done in parallel. The selection of the sensor A and B is then done automatically. In order to start the parallel two-point calibration, the ‘parallel 2-Point’ menu option has to be activated.

Special three point calibration procedures are also available. However, please remark that it is only possible to adjust Sensitivity and Voq. The third calibration point is mathematically not necessary. It is used for a more precise determination of the sensor programming in order to match the nominal output voltage at an intermediate position.

Sequential two-point calibration



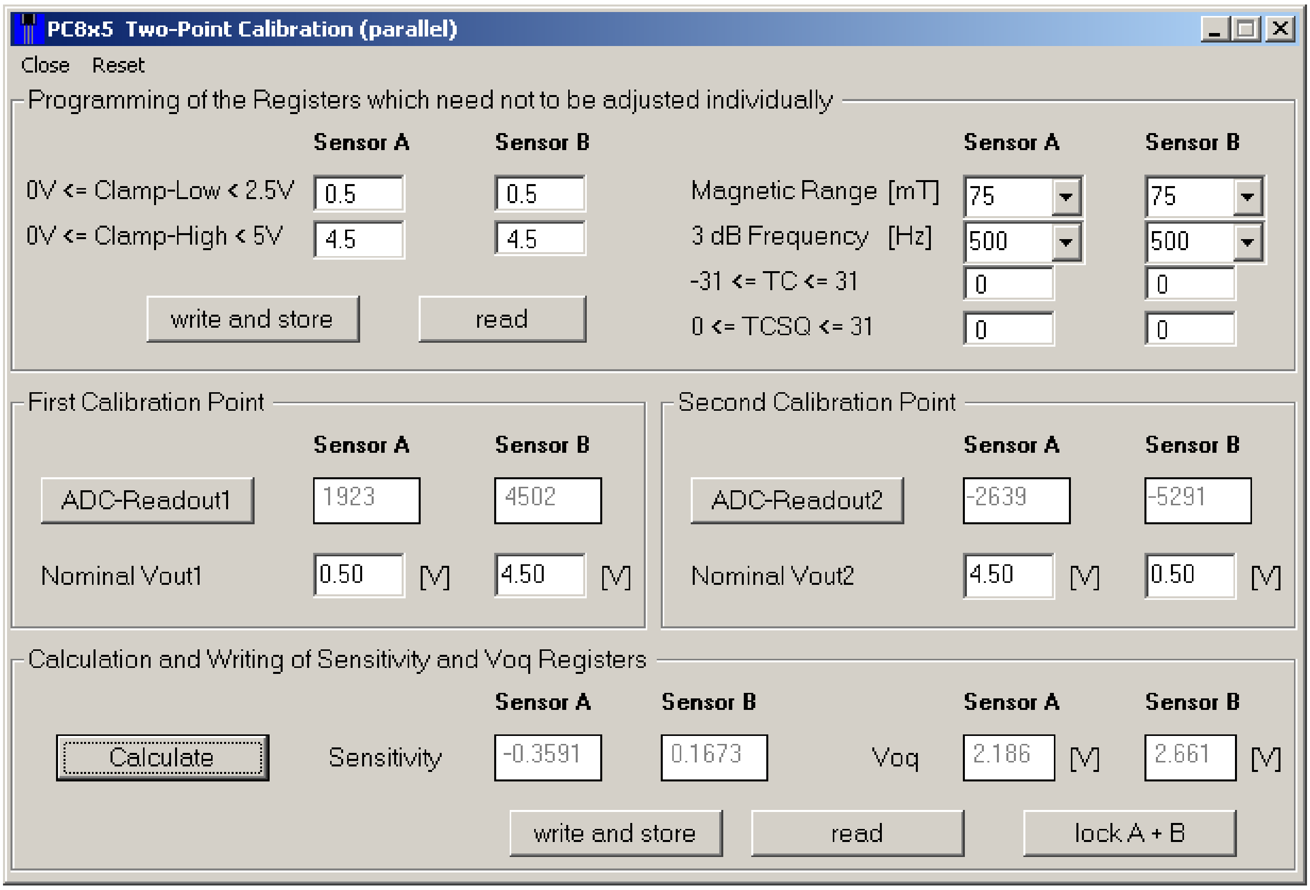
In the first step, the registers which need not to be adjusted individually have to be written. After these given parameters have been set, the sensor module has to be moved into the first calibration point. (This is done for example for an angle sensor module by mechanically turning the module into a defined angle and in case of a current sensor by applying a defined current). By pressing the 'Read ADC-Readout1' button, the ADC-Readout register of the activated sensor is read out and the result is shown beside the button. The nominal output voltage of the Hall IC in the first point has to be entered into the corresponding entry. Then the sensor module has to be moved into the second calibration point and the ADC-Readout register must be read out by pressing 'Read ADC-Readout2'. Please enter the nominal output in point 2 in the corresponding entry, too.

After the definition of point 1 and 2, the appropriate Sensitivity and Voq can be calculated by pressing the 'Calculate' button. The results of the calculation will be shown if they are within the valid range of the registers. By pressing the 'write and store' button the sensor will be calibrated.

After the calibration of the first sensor, the second sensor has to be selected and the calibration sequence has to be repeated.

After the calibration, the sensors can be locked. The programming can not be changed any more after the locking command. Pressing the 'lock' button does the locking. If two Hall IC's are plugged in parallel, both sensors should be activated via the 'A + B' button before locking the assembly.

Parallel two-point calibration

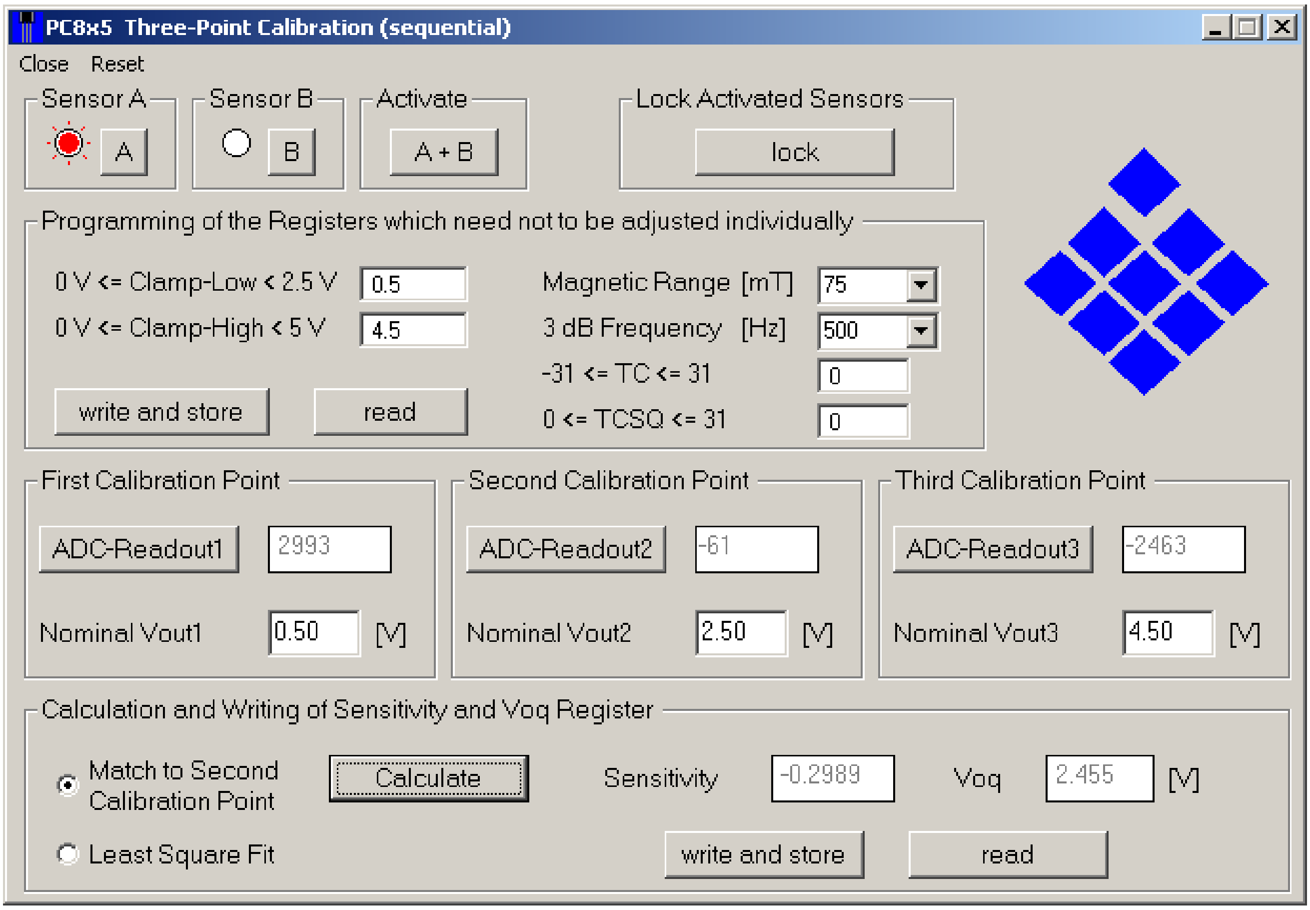


The registers which need not to be adjusted individually have to be written at first. Please remark that the settings for sensor A and sensor B can be different. After the sensor module is moved into the first calibration point the 'Read ADC-Readout1' button has to be hit. The ADC-Readout register of both sensors is read out and the results are shown beside the button. The nominal output voltages of sensor A and B in the first point have to be entered into the corresponding entries. Then the sensor module has to be moved into the second calibration point and the ADC-Readout registers must be read out by pressing 'Read ADC-Readout2'. Please enter the nominal outputs in point 2 in the corresponding entries, too.

After the definition of point 1 and 2, the appropriate Sensitivity and Voq can be calculated by pressing the 'Calculate' button. The results of the calculation will be shown if they are within the valid range of the registers. By pressing the 'write and store' button both sensors will be calibrated.

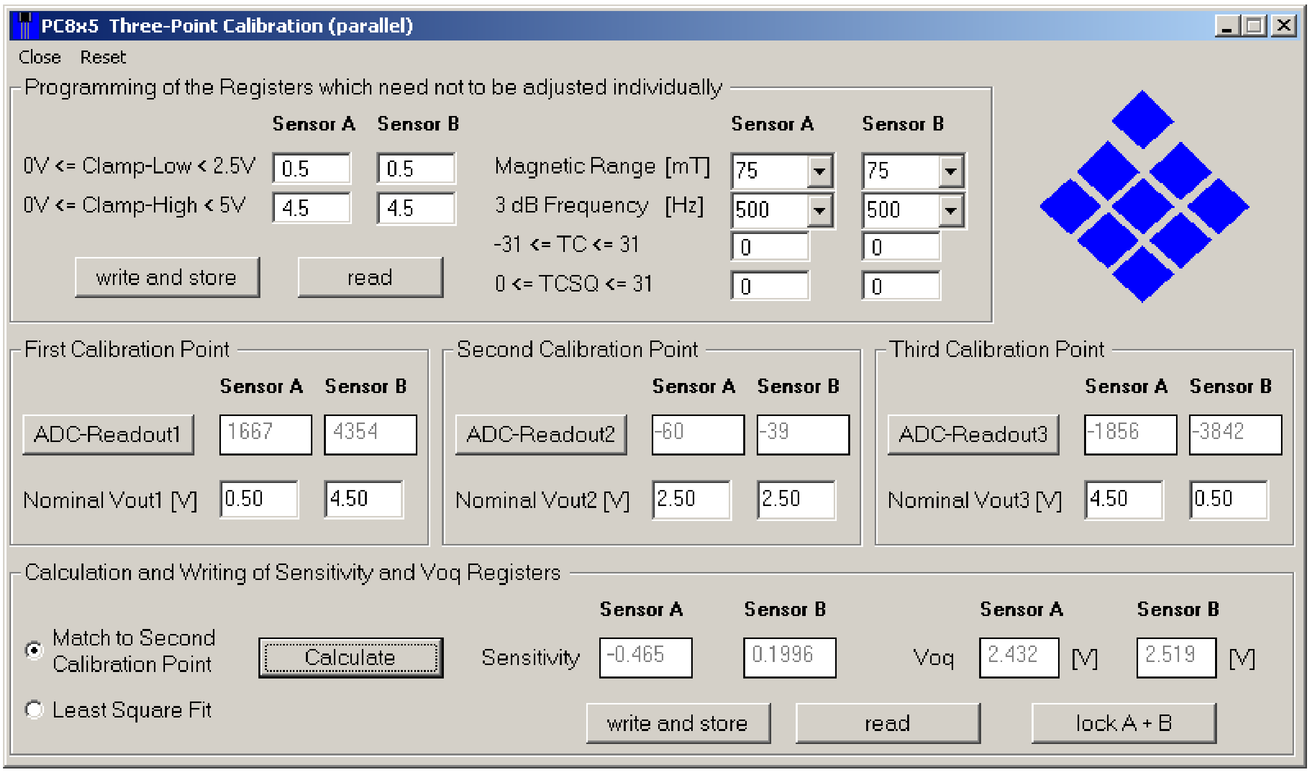
After the calibration, the sensors can be locked. The programming can not be changed any more after the locking command. Pressing the 'lock A + B' button does the locking of both sensors.

Sequential three-point calibration



Please remark that the accuracy of the sensor will be highest in those positions where the calibration has been done. In some applications the accuracy should be highest at some intermediate position. For such applications, the three-point calibration procedure is recommended. There the ADC-Readout is determined in three calibration points. The Sensitivity is calculated by a least square fit to all three measurements. In order to determine the Voq programming, two options are available: The Voq can be calculated in order to match the nominal output voltage at the second calibration point or by a least square fit to all three calibration points. If the first option is selected, the output voltage in the second calibration point will be closest to the nominal value.

Parallel three-point calibration

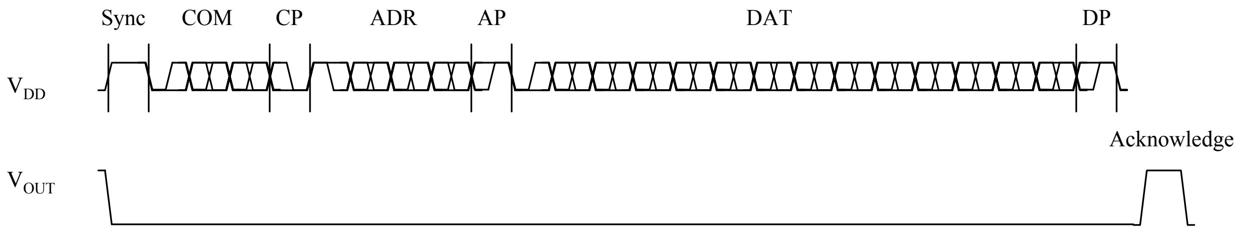


The PC8x5-Software also supports a parallel three-point calibration, which is similar to the sequential three point calibration. It is just the activation of the sensors, that is done automatically.

Please note that the register settings for Sensor A and Sensor B can be set differently, if suitable for the customer application.

II.2 HAL805 and HAL815 Protocoll Definition

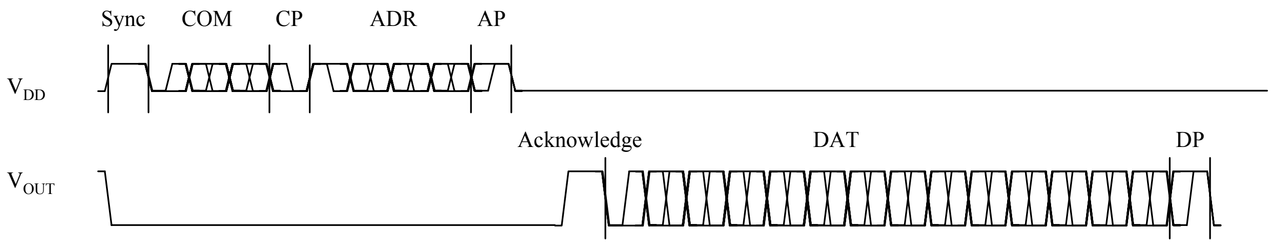
Write command - Serial protocoll to and from Hall IC:



For the communication with the Application Board, the command, the address, the data and the parity bits are combined and coded as hexadecimal numbers:

```
Bit   |24|23|22|21|20|19|18|17|16|15|14..13|12..09|08..05|04..01|00|
      |  |        |  |           |  |                           |  |
      | S|command | c|  address  | a|           data            | d|
      | y| 3 bit  | -|   4 bit   | -|          14 bit           | -|
      | n|        |pa|           |pa|                           |pa|
      | c|        |ri|           |ri|                           |ri|
      |  |        |ty|           |ty|                           |ty|
         \      / \/ \         / \/ \                         / \/
          COM     CP    ADR      AP  DAT4   DAT3   DAT2   DAT1  DP
```

Read command - Serial protocoll to and from Hall IC:



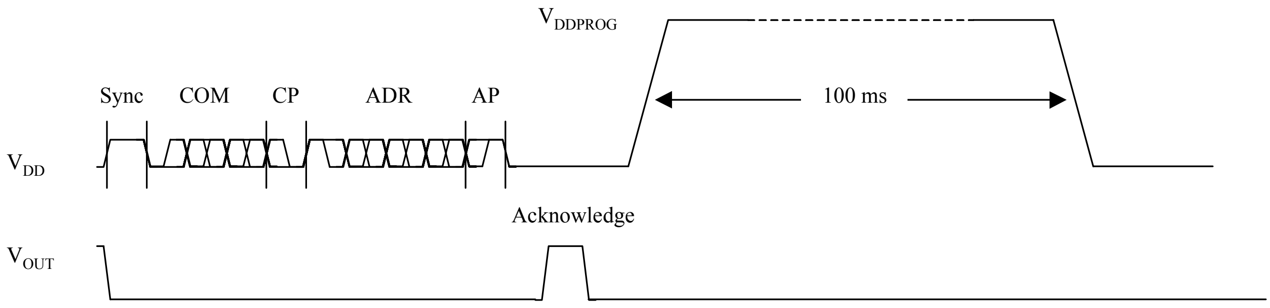
For the communication with the Application Board, the command, the address, and the parity bits are combined and coded as hexadecimal numbers:

```
Bit   |09|08|07|06|05|04|03|02|01|00|
      |  |        |  |           |  |
      | S|command | c|  address  | a|
      | y| 3 bit  | -|   4 bit   | -|
      | n|        |pa|           |pa|
      | c|        |ri|           |ri|
      |  |        |ty|           |ty|
         \      / \/ \         / \/
          COM     CP    ADR      AP
```

The response from the Hall IC is coded into the DAT characters.

```
Bit                                 |14..13|12..09|08..05|04..01|00|
                                    |                           |  |
                                    |           data            | d|
                                    |          14 bit           | -|
                                    |                           |pa|
                                    |                           |ri|
                                    |                           |ty|
                                     \                         / \/
                                      DAT4   DAT3   DAT2   DAT1  DP
```

Programm, erase and lock commands - Serial protocoll to and from Hall IC:



For the communication with the Application Board, the command, the address, and the parity bits are combined and coded as hexadecimal numbers:

```
Bit  |09|08|07|06|05|04|03|02|01|00|
     |  |        |  |           |  |
     | S|command | c|  address  | a|
     | y| 3 bit  | -|   4 bit   | -|
     | n|        |pa|           |pa|
     | c|        |ri|           |ri|
     |  |        |ty|           |ty|
         \      / \/ \         / \/
           COM     CP    ADR     AP
```

Possible values of the characters are:

command (COM):	2..7	(CHAR ”2”..”7”)
address (ADR):	1..9, A..F	(CHAR ”1”..”9”, ”A”..”F”)
data (DAT4):	0..3	(CHAR ”0”..”3”)
data (DAT3,DAT2,DAT1):	0..F	(CHAR ”1”..”9”, ”A”..”F”)
parity bit (CP,AP,DP):	0, 1	(CHAR ”0”,”1”)
status (STATUS):	0, 1	(CHAR ”0”,”1”)

Evaluation of the parity bit (CP,AP,DP)

For the command and address bits the generation of the parity bit is as follows:
The parity bit is 1, if the number of zeros within the binary number is uneven.
The parity bit is 0, if the number of zeros is even. COM has 3 digits and ADR 4 digits

For the data bits the generation of the parity bit is as follows:
The parity bit is 1, if the number of zeros within the binary number is even. The parity bit is 0, if the number of zeros is uneven. DAT has 14 digits.

Commands:

name	COM	explanation
READ	2	read a register
WRITE	3	write a register
PROM	4	program all registers
ERASE	5	erase all registers
LOCKIM	6	lock Micronas-lockable registers (switch to slow mode)
LOCK	7	lock the whole device (switch to analog mode)

"ERASE" means the permanent storing of the 0 bits of the data which was written into a register. "PROM" means the permanent storing of the 1 bits of the data. Locking is only possible for a lock register (LOCKR and LOCKIR). After a locking command the corresponding lock bit is set and all locked registers are no longer changeable.

Registers:

// registers programmable by customer (customer may read, write and program)

name	ADR	explanation
CLAMP-LOW	1	lower clamp voltage
CLAMP-HIGH	2	upper clamp voltage
VOQ	3	output voltage at zero magnetic field (quiescent output voltage)
SENSITIVITY	4	increase of output voltage with magnetic field (magnetic sensitivity)
MODE	5	magnetic sensitivity range, LPF-frequency
LOCKR	6	customer lock
TC	11 (B)	linear temperature coefficient adjustment
TCSQ	12 (C)	quadratic temperature coefficient adjustment

// registers programmable by Micronas only (customer may read)

name	ADR	explanation
OFFSET	8	ADC offset
FOSCAD	9	oscillator frequency adjustment
SPECIAL	13 (D)	SPECIAL register
LOCKIR	14 (E)	Micronas lock

// read only

name	ADR	explanation
ADC-READOUT	7	digital readout of A/D Converter value

// write only

name	ADR	explanation
DEACTIVATE	15 (F)	deactivate register

Format Description:

v: valid bit
*: don't care

ADR	name	#bits	format	bit 13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	CLAMP-LOW	10	write-format	*	*	*	*	v	v	v	v	v	v	v	v	v	v
			read-format	v	v	v	v	v	v	v	v	v	v	*	*	*	*
2	CLAMP-HIGH	11	write-format	*	*	*	v	v	v	v	v	v	v	v	v	v	v
			read-format	v	v	v	v	v	v	v	v	v	v	v	*	*	*
3	VOQ	11	write-format	*	*	*	v	v	v	v	v	v	v	v	v	v	v
			read-format	v	v	v	v	v	v	v	v	v	v	v	*	*	*
4	SENSITIVITY	14	write-format	v	v	v	v	v	v	v	v	v	v	v	v	v	v
			read-format	v	v	v	v	v	v	v	v	v	v	v	v	v	v
5	MODE	6	write-format	*	*	*	*	*	*	*	*	v	v	v	v	v	v
			read-format	v	v	v	v	v	v	*	*	*	*	*	*	*	*
7	ADC-READOUT	14	read-format	v	v	v	v	v	v	v	v	v	v	v	v	v	v
8	OFFSET	5	write-format	*	*	*	*	*	*	*	*	*	v	v	v	v	v
			read-format	v	v	v	v	v	*	*	*	*	*	*	*	*	*
9	FOSCAD	5	write-format	*	*	*	*	*	*	*	*	*	v	v	v	v	v
			read-format	v	v	v	v	v	*	*	*	*	*	*	*	*	*
B	TC	6	write-format	*	*	*	*	*	*	*	*	v	v	v	v	v	v
			read-format	v	v	v	v	v	v	*	*	*	*	*	*	*	*
C	TCSQ	5	write-format	*	*	*	*	*	*	*	*	*	v	v	v	v	v
			read-format	v	v	v	v	v	*	*	*	*	*	*	*	*	*
D	SPECIAL	8	write-format	*	*	*	*	*	*	v	v	v	v	v	v	v	v
			read-format	v	v	v	v	v	v	v	v	*	*	*	*	*	*
F	DEACTIVATE	12	write-format	*	*	1	0	0	0	0	0	0	0	1	1	1	1

Register Documentation

```
ADR name        #bits     range        (at 5 V Vdd)         value     (at 5 V Vdd)
                                                          of  lsb

 1  CLAMP-LOW:   10   0 ... 0.5*Vdd   (0 ... 2.5 V)   0.5*Vdd / 1024  (2.44 mV)
(binary number)


 2  CLAMP-HIGH:  11     0 ... Vdd      (0 ... 5 V)      Vdd / 2048    (2.44 mV)
(binary number)


 3  VOQ:         11   -Vdd ... Vdd    (-5 V .. 5 V)   2*Vdd / 2048    (4.89 mV)
(two-complementary number)


 4  SENSITIVITY: 14     -4 ... 4                        1/2048
(signed fixed      at a Sensitivity of 1.0 an increase of the ADCR value of 2048
 point number)     corresponds to an increase of the output voltage of Vdd


 5  MODE:         6    MODE[5:3] | low pass freq. | MODE[2:0] | magnetic range
(binary number)       =========================================================
                           000    |       80 Hz    |    000    |    -/+  30 mT
                           001    |      160 Hz    |    001    |    -/+  75 mT
                           010    |      500 Hz    |    010    |    -/+  90 mT
                           011    |     1000 Hz    |    011    |    -/+ 150 mT
                           100    |     2000 Hz    |    100    |    -/+  40 mT
                           101    |     5000 Hz    |    101    |    -/+  60 mT
                           110    |    10000 Hz    |    110    |    -/+  80 mT
                           111    |    15000 Hz    |    111    |    -/+ 100 mT


 7  ADC-READOUT: 14   -8192 ... 8191
(two-complementary number)


 8  OFFSET:       5    -16 ... 15
(two-complementary number)


 9  FOSCAD:       5     0 ... 31
(binary)


 B  TC:           6   -31 ... 31
(signed binary)


 C  TCSQ:         5     0 ... 31
(binary)


 D  SPECIAL:      8     0 ... 255
```

Temperature Compensation

Micronas provides a software ‘TC_CALC.EXE’ which helps to optimize the temperature compensation using a three step procedure:

1. The user programs initial TC and TCSQ parameters which match the temperature coefficient of the magnet best according to the table in the data sheet.
2. The sensitivity over temperature of the assembly has to be measured.
3. The software then calculates improved settings for TC and TCSQ according to the measured data and the initial TC and TCSQ.

For details, please refer to the documentation delivered together with ‘TC_CALC.EXE’.

For more information about the various temperature compensation possibilities, please contact your supplier.

Number Formats

Binary number:
The most significant bit is given as first, the least significant bit as last digit.
Example: 101001 represents 41 decimal.

Signed binary number:
The first digit represents the sign of the following binary number (1 for negative, 0 for positive sign).

```
Example: 0101001 represents +41 decimal
         1101001 represents -41 decimal
```

Two-complementary number:
The first digit of positive numbers is 0, the rest of the number is a binary number. Negative numbers start with 1. In order to calculate the absolute value of the number, you have to calculate the complement of the remaining digits and to add 1.

```
Example: 0101001 represents +41 decimal
         1010111 represents -41 decimal
```

Signed fixed point number (only for SENSITIVITY):
The first digit represents the sign (1 for negative, 0 for positive sign). The following numbers represent a fixed point number in the binary system.

```
    bit
    13    12    11    10    9    8    7    6    5    4    3    2    1    0
    sign  2^1   2^0   2^-1 ............................................ 2^-11
Example: 00101000000000 represents 1.25 decimal
         11011000000000 represents -2.75 decimal
```

II.3 Communication PC <---> Application Board

Each transmission to the Application Board has to start with the STX character and one of the following instructions:

instruction	meaning	explanation
n	VDD_ON	Switch on supply voltage of Hall IC
o	VDD_OFF	Switch off supply voltage of Hall IC
t	STATUS	Transmit STATUS and DAT to PC
s	SLOWMODE	Transmission to and from Hall IC in slow mode
f	FASTMODE	Transmission to and from Hall IC in fast mode
z	SETSLOWBIT	Set bittime for slow mode (default is 162 eq. 3.4ms)
d	SETFASTBIT	Set bittime for fast mode (default is 24 eq. 26µs)
v	VERSION	Ask for firmware version. Next STATUS command gives version no. (for example 0v350 for V3.50)
r	READ	Send the following COM|CP|ADR|AP to Hall IC and check for data
q	READ_S	Executes READ and STATUS command
w	WRITE	Send COM|CP|ADR|AP|DAT4|DAT3|DAT2|DAT1|DP to Hall IC and check for acknowledge
e	WRITE_S	Executes WRITE and STATUS command
u	SETPROTIME	Set duration for programming/erasing/locking pulses The duration in one milliseconds is the ascii value of the following character
p	PROGRAM	Send COM|CP|ADR|AP to Hall IC and check for Acknowledge pulse. After Acknowledge, a programming/ erasing/locking pulse is generated. It is possible to possible to measure and check the pulse voltage.
m	PROGRAM_S	Executes PROGRAM and STATUS command
h[nt]	SELECT	Generate select pulse on the output of sensor n. The duration in microseconds is the ascii value of parameter “t”
j[p]	SENSOR type	Selection of sensor type(1 = HAL8x5, 810, 1000)

Each instruction string has to be terminated with ETX.

The recommended baud rate is 9600.

The command syntax is as follows (each statement corresponds to one character)

PC ---> Application Board:

```
STX|n|ETX
STX|o|ETX
STX|t|ETX
STX|s|ETX
STX|f|ETX
STX|z|SLOWBITTIME|ETX
STX|d|FASTBITTIME|ETX
STX|v|ETX
STX|r|COM|CP|ADR|AP|ETX
STX|q|COM|CP|ADR|AP|ETX
STX|w|COM|CP|ADR|AP|DAT4|DAT3|DAT2|DAT1|DP|ETX
STX|e|COM|CP|ADR|AP|DAT4|DAT3|DAT2|DAT1|DP|ETX
STX|u|PROGRAMTIME|ETX
STX|p|COM|CP|ADR|AP|ETX
STX|m|COM|CP|ADR|AP|ETX
STX|h|n|SELECTATIME|ETX
STX|j|1|ETX
```

After the STATUS, READ_S, WRITE_S, and PROGRAM_S instructions, the Application Board sends the STATUS and the DAT characters to the PC:

```
PC ---> Application Board
      STX|t|ETX
      STX|q|COM|CP|ADR|AP|ETX
      STX|e|COM|CP|ADR|AP|DAT4|DAT3|DAT2|DAT1|DP|ETX
      STX|m|COM|CP|ADR|AP|ETX

Application Board ---> PC
      STX|STATUS|DAT4|DAT3|DAT2|DAT1|DP|ETX
```

Each character consists of

- 1 start bit
- 8 data bit
- 1 parity bit even
- 1 stop bit

Examples:

```
      STX s ETX                     (blanks are only given for clarity)
      STX f ETX
      STX z chr$(85) ETX
      STX d chr$(27) ETX
      STX r 2 0 2 1 ETX
      STX q 2 0 2 1 ETX
      STX w 3 1 2 1 0 0 0 A 1 ETX
      STX e 3 1 2 1 0 0 0 A 1 ETX
      STX u chr$(100) ETX
      STX p 5 1 2 1 ETX
      STX p 4 0 2 1 ETX
      STX m 5 1 2 1 ETX
      STX m 4 0 2 1 ETX
      STX h 1 chr$(50) ETX
```

In order to program the HAL805 or the HAL815 it is necessary to reduce the default bittime of the Application Board to about 1.6ms (SLOWBITTIME = chr$(85)). This is done by sending the SETSLOWBIT command:

```
STX z chr$(85) ETX
```

If you want to change the content of any register (except the lock registers) you have to write the desired value into the register at first. For example, if you want to change the sensitivity of the device you have to write into register no. 4

```
STX e 3 1 4 1 0 8 0 0 0 ETX   (please regard that the blanks are only given
                               for clarity)
```

If you want to permanently store the value, you have to send an erasing and a programming command afterwards.

```
STX u chr$(100) ETX    Set duration of erasing and programming pulse to 100ms.
STX m 5 1 1 1 ETX      (please omit the blanks when you write on the rs232 port)
STX m 4 0 1 1 ETX
```

The address within the erasing and programming command is not important. Erasing and programming acts on all registers in parallel.

If you want to change all registers of the Hall IC, you can send all writing commands one after each other and send one erasing and programming command at the end. Again, the erasing and programming command acts on all registers (except the locking registers, for sure).

In order to read out the content of a register the READ or READ_S commands can be used. The command to read out the VOQ register is for example:

STX q 2 0 3 0 ETX

Please remark, that a register has to be written and stored before it can be read out correctly.

In order to deactivate a HAL805 or a HAL815, you have to write $80f into the DEACTIVATE register:

STX w 3 1 f 0 0 8 0 f 0 ETX

Please remark that the sensor will not answer with an acknowledge pulse after writing into the DEACTIVATE register. The error LED on the application board will ignite and the STATUS character will be ‘1’.

To activate the Hall IC again, a 5V pulse has to be applied on the output of the IC. The application board generates this pulse after the a and b command. In addition a dummy command has to be sent, because the first command after the activation will be ignored from the Hall IC.

For the activation of Hall IC A, the command sequence may be:

STX h 1 chr$(50) ETX
STX q 2 0 2 1 ETX

If the Hall IC B has to be activated the command sequence may be as follows:

STX h 2 chr$(50) ETX
STX q 2 0 2 1 ETX

If the Hall IC C has to be activated the command sequence may be as follows:

STX h 3 chr$(50) ETX
STX q 2 0 2 1 ETX

If the Hall IC D has to be activated the command sequence may be as follows:

STX h 4 chr$(50) ETX
STX q 2 0 2 1 ETX

In order to lock the Hall IC, the LOCK command has to be applied to the customer lock register LOCKR:

STX u chr$(100) ETX	Set duration of locking pulse to 100ms.
STX m 7 0 6 0 ETX	(please omit the blanks when you write on the rs232 port)

or

STX u chr$(100) ETX	Set duration of locking pulse to 100ms.
STX p 7 0 6 0 ETX	(please omit the blanks when you write on the rs232 port)

The application boards version 5.x have an on board A/D converter which allows in combination with the firmware V3.50 to check for the programming/erasing/locking voltage. If the STATUS and DAT characters are read after a PROGRAM command (for example by sending a PROGRAM_S instruction), it is possible to evaluate if the Hall IC has acknowledged the command and if the pulse voltage was within specification:

In case the Hall IC did not acknowledge the PROGRAM command, STATUS is set to 1 and DAT is set to 0 0 0 0.

In case the Hall IC did acknowledge the PROGRAM command but the pulse voltage was out of specification (12.4 V to 12.6 V), STATUS is set to 1 and the DAT characters reflect the pulse voltage. The voltage can be calculated as

Pulse voltage = DAT (in hexadecimal coding) / 4095 * 6 * 2.485 V

If DAT is 0 D 0 A, the pulse voltage was measured as 12.15 V.

In case the Hall IC did acknowledge the PROGRAM command and the pulse voltage was within specification, STATUS is set to 0 and the DAT characters reflect the pulse voltage, too.

If DAT is 0 D 6 9, the pulse voltage was measured as 12.50 V.

II.4 Pin connections

Sixpin Socket To and From HAL80X

HAL8XX APPLICATION BOARD VERSION 5.x

```
               ---------------       (top view)
    HAL80X    | 1   3   5   |
 INTERFACE    |   2   4   6 |  P2/P3
               ---------------
```

Pin 1, 2 Sensor Input (Vdd of Sensor A and B (C and D))
Pin 3, 4 Sensor GND (GND of Sensor A and B (C and D))
Pin 5 Sensor A Output (Vout of Sensor A/C)
Pin 6 Sensor B Output (Vout of Sensor B/D)

The male plug (Amp 215083) to connect to the socket can be ordered from Bürklin with order no. 58F462.

III. Documentation History

2.4l 04/14/99 Dr. R. Gampp
First version of the HAL805 Application Notes based on the Application Notes of the HAL800, Version 2.3k.

2.4m 07/08/99 Dr. R. Gampp
Second version of the HAL805 Application Notes. Inclusion of detailed serial protocol to and from HAL805. Inclusion of TC and TCSQ table.

2.51n 09/21/99 Dr. R. Gampp
Third version of the HAL805 Application Notes. Adaptions to redesign HACB-01-07, new programmer board firmware V2.51, and PC805 Software V4.10.

2.51o 09/30/99 Dr. R. Gampp
Fourth version. TC table deleted.

2.51p 10/21/99 Dr. R. Gampp
Fifth version. Adapations to PC805 Software V4.20. Specification of SLOWBITTIME and write/store/read sequence for redesigned HAL805.

2.52q 08/23/00 Dr. R. Gampp
Adaptions to PC805 Software V4.25 and Application Board Version 3.0.

2.60r 01/18/01 Dr. R. Gampp
Adaptions to PC8x5 Software V4.60 and Application Board Version 4.0.

2.60s 06/25/01 M. Schönstein
Adaptions to PX8x5 Software V5.20 and Application Board Version 4.1.

3.50t 06/26/02 Dr. R. Gampp
Adaptions to firmware version 3.50, PC8x5 Software V5.50 and programming pulse voltage adjustment to 12.5V.

1.20u 03/21/03 J. Schubert
Adaption to programmer board version 5.1

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