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MICRONAS

Hardware
Documentation

Data Sheet

HAL® 83x

Robust Multi-Purpose Programmable Linear Hall-Effect Sensor Family

Edition March 21, 2018
DSH000169_003EN

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Contents

Contents

Robust Multi-Purpose Programmable Linear Hall-Effect Sensor Family

Release Note:	**Revision bars indicate significant changes to the previous edition.**

1. Introduction

The HAL83x is a family of programmable linear Hall sensors from TDK-Micronas. This robust multipurpose sensors can replace the HAL 805, HAL 815, HAL 825, and HAL810. HAL 83x offers better quality, extended functionality and performance compared to the first generation devices. This family consists of two members: the HAL830 and the HAL835. HAL835 is the device with the full feature set and maximum performance compared with the HAL830.

The HAL83x is an universal magnetic field sensor with linear output based on the Hall effect. The IC can be used for angle or distance measurements when combined with a rotating or moving magnet. The major characteristics like magnetic field range, sensitivity, output quiescent voltage (output voltage at B = 0 mT), and output voltage range are programmable in a non-volatile memory. The sensor has a ratiometric output characteristic, which means that the output voltage is proportional to the magnetic flux and the supply voltage. It is possible to program several devices connected to the same supply and ground line.

The HAL83x features a temperature-compensated Hall plate with spinning-current offset compensation, an A/D converter, digital signal processing, a D/A converter with output driver, an EEPROM memory with redundancy and lock function for the calibration data, an EEPROM for customer serial number, a serial interface for programming the EEPROM, and protection devices at all pins.

The HAL83x is programmable by modulating the supply voltage. No additional programming pin is needed. The easy programmability allows a 2-point calibration by adjusting the output voltage directly to the input signal (like mechanical angle, distance, or current). Individual adjustment of each sensor during the customer's manufacturing process is possible. With this calibration procedure, the tolerances of the sensor, the magnet, and the mechanical positioning can be compensated in the final assembly.

In addition, the temperature compensation of the Hall IC can be fit to common magnetic materials by programming first and second order temperature coefficients of the Hall sensor sensitivity. This enables operation over the full temperature range with high accuracy.

The calculation of the individual sensor characteristics and the programming of the EEPROM memory can easily be done with a PC and the application kit from TDK-Micronas.

The sensor is designed for hostile industrial and automotive applications and operates with typically 5 V supply voltage in the ambient temperature range from –40 °C up to 160 °C. The HAL83x is available in the very small leaded package TO92UT-1/-2 and is AECQ 100 qualified.

1.1. Applications

Due to the sensor's versatile programming characteristics and low temperature drift, the HAL 83x is the optimal system solution for applications such as:

– Pedal, turbo-charger, throttle and EGR systems

– Distance measurements

1.2. General Features

– high-precision linear Hall-effect sensor family with 12 bit ratiometric analog output and digital signal processing

– multiple programmable magnetic characteristics in a non-volatile memory (EEPROM) with redundancy and lock function

– operates from T_J = –40 °C up to 170 °C

– operates from 4.5 V up to 5.5 V supply voltage in specification and functions up to 8.5 V

– operates with static magnetic fields and dynamic magnetic fields up to 2 kHz

– programmable magnetic field range from ±30 mT up to ±150 mT

– open-circuit (ground and supply line break detection) with 5 kΩ pull-up and pull-down resistor, overvoltage and undervoltage detection

– for programming an individual sensor within several sensors in parallel to the same supply voltage, a selection can be done via the output pin

– temperature characteristics are programmable for matching common magnetic materials

– programmable clamping function

– programming via modulation of the supply voltage

– overvoltage and reverse-voltage protection at all pins

– magnetic characteristics extremely robust against mechanical stress

– short-circuit protected push-pull output

– EMC and ESD optimized design

1.2.1. Device-specific features of HAL835

– very low offset (±0.2 %V_{SUP}) and sensitivity (±1 %) drift over temperature

– selectable PWM output with 11 bit resolution and 8 ms period

– 14 bit multiplex analog output

– ±15 mT magnetic range

2. Ordering Information

A Micronas device is available in a variety of delivery forms. They are distinguished by a specific ordering code:

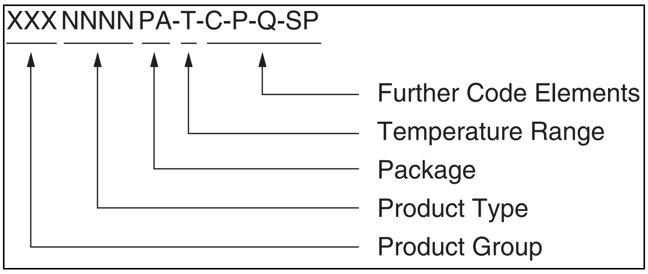


Fig. 2–1: Ordering Code Principle

For a detailed information, please refer to the brochure:
"Micronas Sensors and Controllers: Ordering Codes, Packaging, Handling".

2.1. Device-Specific Ordering Codes

The HAL 83x is available in the following package and temperature variants.

Table 2–1: Available packages

Package Code (PA)	Package Type
UT	TO92UT-1/2

Table 2–2: Available temperature ranges

Temperature Code (T)	Temperature Range
A	T_J = –40 °C to 170 °C

The relationship between ambient temperature (T_A) and junction temperature (T_J) is explained in Section 5.4. on page 42.

For available variants for Configuration (C), Packaging (P), Quantity (Q), and Special Procedure (SP) please contact TDK-Micronas.

Table 2–3: Available ordering codes and corresponding package marking

Available Ordering Codes	Package Marking
HAL830UT-A-[C-P-Q-SP]	830A
HAL835UT-A-[C-P-Q-SP]	835A

3. Functional Description

3.1. General Function

The HAL 83x is a programmable linear Hall-Effect sensor which provides an output signal proportional to the magnetic flux through the Hall plate and proportional to the supply voltage (ratiometric behavior) as long as the analog output mode is selected. When the PWM output mode is selected, the PWM signal is not ratiometric to the supply voltage (for HAL 835 only).

The external magnetic field component perpendicular to the branded side of the package generates a Hall voltage. The Hall IC is sensitive to magnetic north and south polarity. This voltage is converted to a digital value, processed in the Digital Signal Processing Unit (DSP) according to the settings of the EEPROM registers and converted to an output signal. The function and the parameters for the DSP are explained in Section 3.2. on page 11.

The setting of the LOCK register disables the programming of the EEPROM memory for all time. It also disables the reading of the memory. This register cannot be reset.

As long as the LOCK register is not set, the output characteristic can be adjusted by programming the EEPROM registers. The IC is addressed by modulating the supply voltage (see Fig. 3–1). In the supply voltage range from 4.5 V up to 5.5 V, the sensor generates an normal output signal. After detecting a command, the sensor reads or writes the memory and answers with a digital signal on the output pin (see also application note “HAL 8xy, HAL 100x Programmer Board”). The output switches from analog to digital during the communication. Several sensors in parallel to the same supply and ground line can be programmed individually. The selection of each sensor is done via its output pin.

For HAL 835 the digital output for generation of the BiPhase-M programming protocol is also used to generate the PWM output signal.

The open-circuit detection function provides a defined output voltage for the analog output if the V_{SUP} or GND line are broken. Internal temperature compensation circuitry and spinning-current offset compensation enable operation over the full temperature range with minimal changes in accuracy and high offset stability. The circuitry also reduces offset shifts due to mechanical stress from the package. The non-volatile memory consists of redundant and non-redundant EEPROM cells. The non-redundant EEPROM cells are only used to store production information for tracking inside the sensor. In addition, the sensor IC is equipped with devices for overvoltage and reverse-voltage protection at all pins.

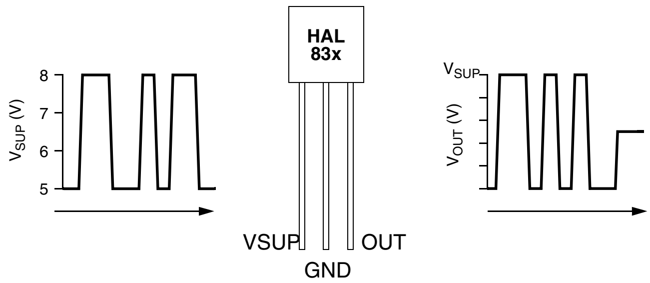


Fig. 3–1: Programming with V_{SUP} modulation

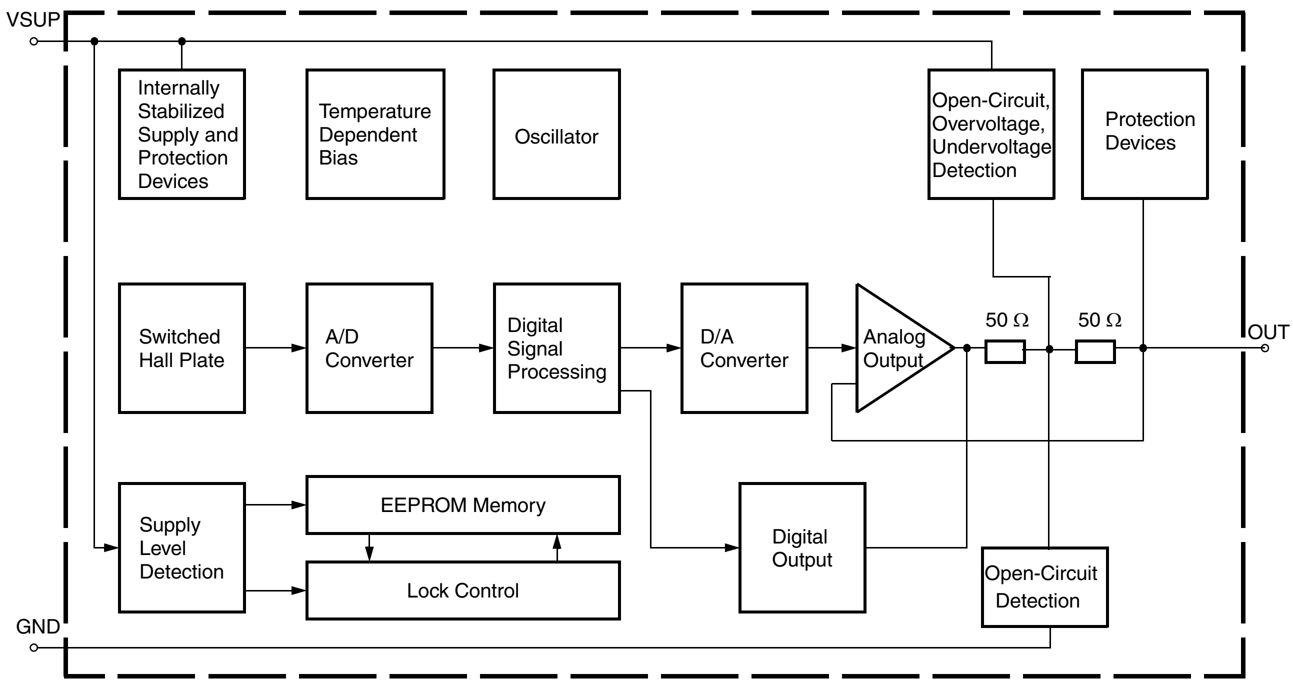


Fig. 3–2: HAL 83x block diagram

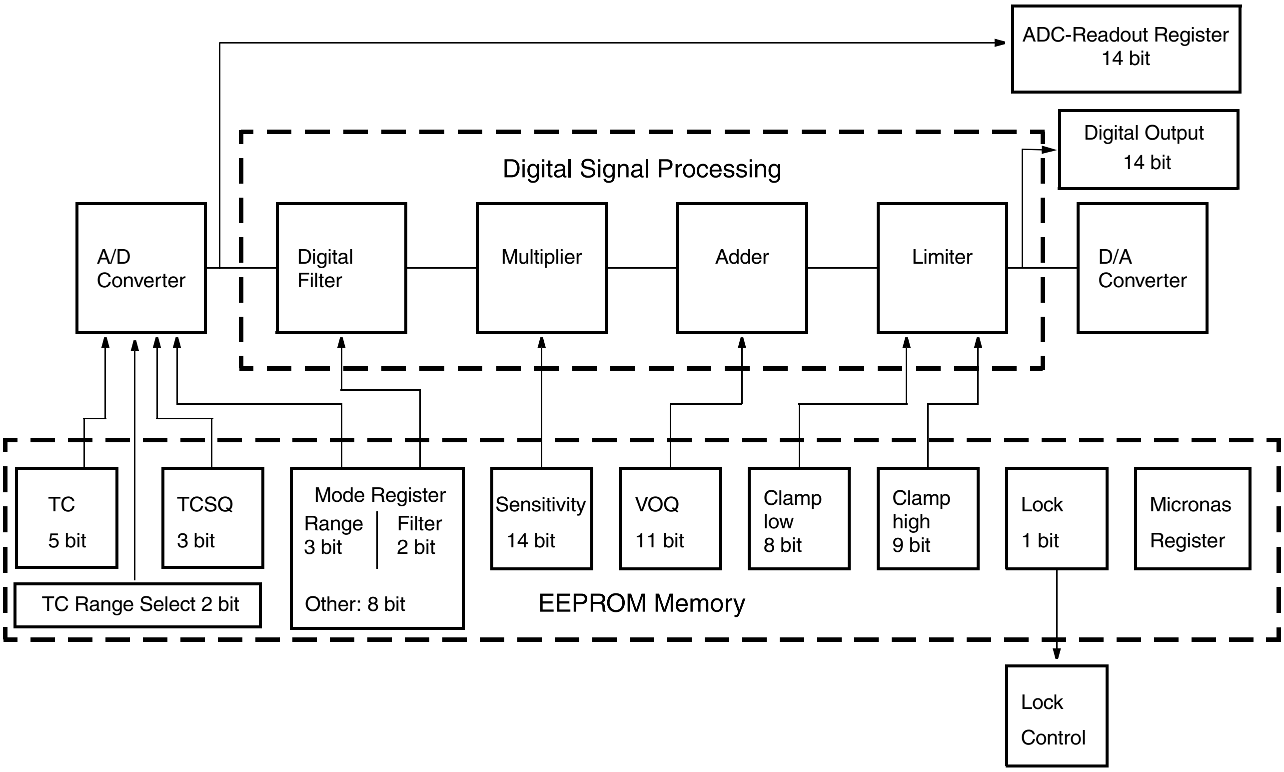


Fig. 3–3: Details of EEPROM Registers and Digital Signal Processing

3.2. A/D Converter

The ADC used in HAL83x sensor has a "Sigma-Delta" architecture. It delivers an over-sampled multi-bit stream with high-frequency shaped quantization noise. Low-pass filtering performs an averaging of the signal by accumulation. With longer accumulation the resolution of the data converter increases.
The accumulation takes place in the decimating filter, the low-pass filter, and the external RC-filter.

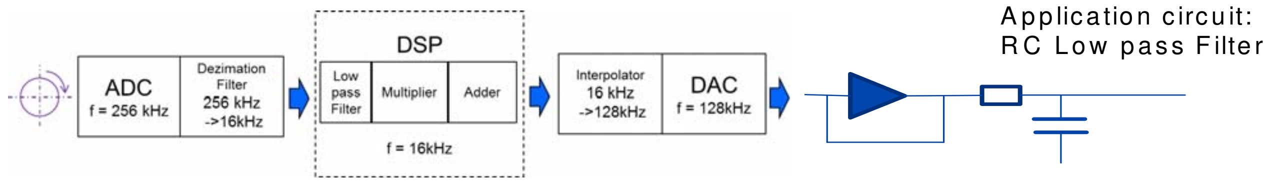


Fig. 3–4: Signal path

Example of a Sigma-Delta-ADC (simplified illustration)

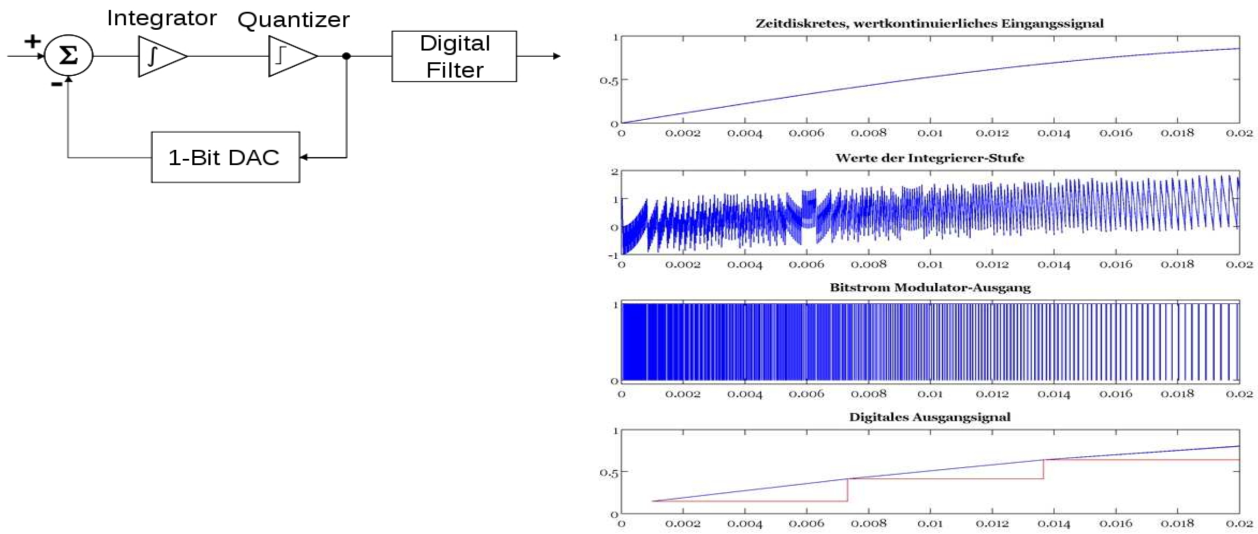


Fig. 3–5: Sigma-Delta-ADC

A: Input Signal
B: Integrated value
C: High frequency data stream (modulated)

After filtering (D), the signal is reconstructed: the lower the cutoff frequency of this filter the higher is the resolution.

The A/D readout of the sensor is a snapshot of the explained data stream.

3.3. Digital Signal Processing and EEPROM

The DSP performs signal conditioning and allows adaption of the sensor to the customer application. The parameters for the DSP are stored in the EEPROM registers. The details are shown in Fig. 3–3.

Terminology:

SENSITIVITY: name of the register or register value

Sensitivity: name of the parameter

The EEPROM registers consist of four groups:

Group 1 contains the registers for the adaptation of the sensor to the magnetic system: MODE for selecting the magnetic field range and filter frequency, TC, TCSQ and TC-Range for the temperature characteristics of the magnetic sensitivity.

Group 2 contains the registers for defining the output characteristics: SENSITIVITY, VOQ, CLAMP-LOW (MIN-OUT), CLAMP-HIGH (MAX-OUT) and OUTPUT MODE. The output characteristic of the sensor is defined by these parameters.

– The parameter V_{OQ} (Output Quiescent Voltage) corresponds to the output signal at B = 0 mT.

– The parameter Sensitivity defines the magnetic sensitivity:

$$\text{Sensitivity} = \frac{\Delta V_{OUT}}{\Delta B}$$

– The output voltage can be calculated as:

$$V_{OUT} = \text{Sensitivity} \times B + V_{OQ}$$

The output voltage range can be clamped by setting the registers CLAMP-LOW and CLAMP-HIGH in order to enable failure detection (such as short-circuits to V_{SUP} or GND and open connections).

Group 3 contains the general purpose register GP. The GP Register can be used to store customer information, like a serial number after manufacturing. TDK-Micronas will use this GP REGISTER to store informations like, Lot number, wafer number, x and y position of the die on the wafer, etc. This information can be read by the customer and stored in its own data base or it can stay in the sensor as is.

Group 4 contains the Micronas registers and LOCK for the locking of all registers. The MICRONAS registers are programmed and locked during production. These registers are used for oscillator frequency trimming, A/D converter offset compensation, and several other special settings.

An external magnetic field generates a Hall voltage on the Hall plate. The ADC converts the amplified positive or negative Hall voltage (operates with magnetic north and south poles at the branded side of the package) to a digital value. This value can be read by the A/D-READOUT register to ensure that the suitable converter modulation is achieved. The digital signal is filtered in the internal low-pass filter and manipulated according to the settings stored in the EEPROM. The digital value after signal processing is readable in the D/A-READOUT register. Depending on the programmable magnetic range of the Hall IC, the operating range of the A/D converter is from −15 mT...+15 mT up to −150 mT...+150 mT.

During further processing, the digital signal is multiplied with the sensitivity factor, added to the quiescent output voltage level and limited according to the clamping voltage levels. The result is converted to an analog signal and stabilized by a push-pull output stage.

The D/A-READOUT at any given magnetic field depends on the programmed magnetic field range, the low-pass filter, SENSITIVITY, VOQ, TC values and CLAMP-LOW and CLAMP-HIGH. The D/A-READOUT range is min. 0 and max. 16383.

Note During application design, it should be taken into consideration that the maximum and minimum D/A-READOUT should not violate the error band of the operational range.

MODE register

The MODE register contains all bits used to configure the A/D converter and the different output modes.

Table 3–1: MODE register of HAL830 / HAL835

MODE										
Bit Number	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Parameter	RANGE	Reserved	OUTPUT-MODE			FILTER		RANGE (together with bit 9)		Reserved

Magnetic Range

The RANGE bits define the magnetic field range of the A/D converter.

Table 3–2: Magnetic Range HAL 835

Magnetic Range	**RANGE**	
MODE	**MODE [9]**	**MODE [2:1]**
±15 mT	1	00
±30 mT	0	00
±60 mT	0	01
±80 mT	0	10
±100 mT	0	11
±150 mT	1	11

Table 3–3: Magnetic Range HAL 830

Magnetic Range	**RANGE**	
	MODE [9]	**MODE [2:1]**
±30 mT	0	00
±60 mT	0	01
±80 mT	0	10
±100 mT	0	11
±150 mT	1	11

Filter

The FILTER bits define the –3 dB frequency of the digital low-pass filter.

Table 3–4: FILTER bits defining the–3 dB frequency

–3 dB Frequency	MODE [4:3]
80 Hz	00
500 Hz	10
1 kHz	11
2 kHz	01

Output Format

The OUTPUTMODE bits define the different output modes of HAL83x.

Table 3–5: OUTPUTMODE for HAL835

Output Format	MODE [7:5]
Analog Output (12 bit)	000
Multiplex Analog Output (continuously)	001
Multiplex Analog Output (external trigger)	011
Burn-In Mode	010
PWM	110
PWM (inverted polarity)	111

Table 3–6: OUTPUTMODE for HAL830

Output Format	MODE [7:5]
Analog Output (12 bit)	000

In **Analog Output** mode the sensor provides an ratiometric 12 bit analog output voltage between 0 V and 5 V.

In **Multiplex Analog Output** mode the sensor delivers two analog 7-bit values. The 7 LSB (least significant bits) and the 7 MSB of the output value are transmitted separately. This enables the sensor to transmit a 14-bit signal to the 8-bit A/D converter of an ECU with the advantage of achieving a higher signal-to-noise ratio in a disturbed environment.

– In external trigger mode the ECU can switch the output of the sensor between LSB and MSB by changing the current flow direction through the sensor's output. In case the output is pulled up by a 10 kΩ resistor, the sensor sends the MSB. If the output is pulled down, the sensor will send the LSB. Maximum refresh rate is about 500 Hz (2 ms).

– In continuous mode the sensor transmits first LSB and then MSB continuously and the ECU must listen to the data stream sent by the sensor.

In the Multiplex Analog Output mode 1 LSB is represented by a voltage level change of 39 mV. In Analog Output mode with14 bit 1 LSB would be 0.31 mV.

In **Burn-In Mode** the signal path of the sensors DSP is stimulated internally without applied magnetic field. In this mode the sensor provides a "saw tooth" shape output signal. Shape and frequency of the saw tooth signal depend on the programming of the sensor.
This mode can be used for Burn-In test in the customers production line.

In **PWM** mode the sensor provides an 11 bit PWM output. The PWM period is 8 ms and the output signal will change between 0 V and 5 V supply voltage. The magnetic field information is coded in the duty cycle of the PWM signal. The duty cycle is defined as the ratio between the high time "s" and the period "d" of the PWM signal (see Fig. 3–6).

Note The PWM signal is updated with the rising edge. If the duty cycle is evaluated with a microcontroller, the trigger-level for the measurement value should be the falling edge. Please use the rising edge to measure the PWM period.

For PWM (inverted) the duty-cycle value is then inverted. Meaning that a 70% duty-cycle in normal PWM mode is 30% duty-cycle in PWM (inverted) mode.

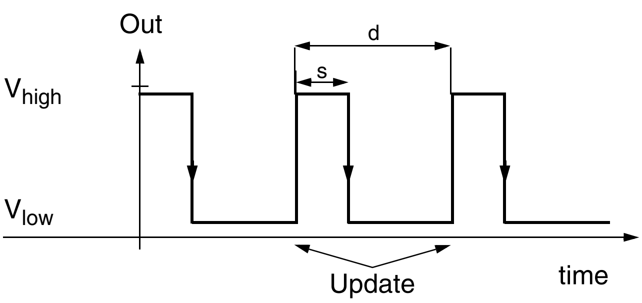


Fig. 3–6: Definition of PWM signal

TC Register

The temperature dependence of the magnetic sensitivity can be adapted to different magnetic materials in order to compensate for the change of the magnetic strength with temperature. The adaptation is done by programming the TC (Temperature Coefficient) and the TCSQ registers (Quadratic Temperature Coefficient). Thereby, the slope and the curvature of the temperature dependence of the magnetic sensitivity can be matched to the magnet and the sensor assembly. As a result, the output voltage characteristic can be constant over the full temperature range. The sensor can compensate for linear temperature coefficients ranging from about –3100 ppm/K up to 1000 ppm/K and quadratic coefficients from about –7 ppm/K² to 2 ppm/K².
The full TC range is separated in the following four TC range groups (see Table 3–7 and Table 5–1 on page 40).

Table 3–7: TC-Range Groups

TC-Range [ppm/k]	**TC-Range Group** (see also Table 5–1 on page 40)
–3100 to –1800 **(not for ±15mT range)**	0
–1750 to –550 **(not for ±15mT range)**	2
–500 to +450 (default value)	1
+450 to +1000	3

TC (5 bit) and TCSQ (3 bit) have to be selected individually within each of the four ranges. For example 0 ppm/k requires TC-Range = 1, TC = 15 and TCSQ = 1. Please refer to Section 5.3. for more details.

Sensitivity

The SENSITIVITY register contains the parameter for the multiplier in the DSP. The Sensitivity is programmable between –4 and 4. For V_{SUP} = 5 V, the register can be changed in steps of 0.00049.

For all calculations, the digital value from the magnetic field of the D/A converter is used. This digital information is readable from the D/A-READOUT register.

$$\text{SENSITIVITY} = \frac{\Delta V_{OUT} \times 16383}{(\Delta \text{D/A-READOUT} \times V_{DD})} \times \text{Sens}_{INITIAL}$$

VOQ

The VOQ register contains the parameter for the adder in the DSP. V_{OQ} is the output signal without external magnetic field (B = 0 mT) and programmable from $-V_{SUP}$ (–100% duty-cycle) up to V_{SUP} (100% duty-cycle). For V_{SUP} = 5 V, the register can be changed in steps of 4.9 mV (0.05% duty-cycle).

Note: If V_{OQ} is programmed to a negative value, the maximum output signal is limited to:

$$V_{OUTmax} = V_{OQ} + V_{SUP}$$

Clamping Levels

The output signal range can be clamped in order to detect failures like shorts to V_{SUP} or GND or an open circuit.

The CLAMP-LOW register contains the parameter for the lower limit. The lower clamping limit is programmable between 0 V (min. duty-cycle) and $V_{SUP}/2$ (50% duty-cycle). For V_{SUP} = 5 V, the register can be changed in steps of 9.77 mV (0.195% duty-cycle).

The CLAMP-HIGH register contains the parameter for the upper limit. The upper clamping voltage is programmable between 0 V (min. duty-cycle) and V_{SUP} (max. duty-cycle). For V_{SUP} = 5 V, in steps of 9.77 mV (0.195% duty-cycle).

GP Register

The register GP0 to GP 3 can be used to store some information, like production date or customer serial number. TDK-Micronas will store production Lot number, wafer number and x,y coordinates in registers GP1 to GP3. The total register contains of four blocks with a length of 13 bit each.The customer can read out this information and store it in his production data base for reference or he can store own production information instead.

Note This register has no redundancy (and guarantee is limited) for traceability.

To read/write this register it is mandatory to read/write all GP register one after the other starting with GP0. In case of writing the registers it is necessary to first write all registers followed by one store sequence at the end. Even if only GP0 should be changed all other GP registers must first be read and the read out data must be written again to these registers.

LOCK

By setting the 1-bit register all registers will be locked and the sensor will no longer respond to any supply voltage modulation. This bit is active after the first power-off and power-on sequence after setting the LOCK bit. EMC properties of the HAL83x is only guaranteed for locked devices.

Warning **This register cannot be reset!**

D/A-READOUT

This 14-bit register delivers the actual digital value of the applied magnetic field after the signal processing. This register can be read out and is the basis for the calibration procedure of the sensor in the system environment.

Note The MSB and LSB are reversed compared with all the other registers. Please reverse this register after readout.

Note **HAL835:** During calibration it is mandatory to select the Analog Output as output format. The D/A-Readout register can be read out only in the Analog Output mode. For all other modes the result read back from the sensor will be a 0. After the calibration the output format can than easily be switched to the wanted output mode, like PWM.

3.4. Calibration Procedure

3.4.1. General Procedure

For calibration in the system environment, the application kit from TDK-Micronas is recommended. It contains the hardware for generation of the serial telegram for programming (Programmer Board Version 5.1) and the corresponding software (PC83x) for the input of the register values.

For the individual calibration of each sensor in the customer application, a two point adjustment is recommended. The calibration shall be done as follows:

Step 1: Input of the registers which need not be adjusted individually

The magnetic circuit, the magnetic material with its temperature characteristics, the filter frequency, the output mode and the GP register value are given for this application. Therefore, the values of the following register blocks should be identical for all sensors of the customer application.

- FILTER
  (according to the maximum signal frequency)
- RANGE
  (according to the maximum magnetic field at the sensor position)
- OUTPUTMODE
- TC, TCSQ and TC-RANGE
  (depends on the material of the magnet and the other temperature dependencies of the application)
- GP
  (if the customer wants to store own production information. It is not necessary to change this register)

As the clamping levels are given. They have an influence on the D/A-Readout value and have to be set therefore after the adjustment process.

Write the appropriate settings into the HAL83x registers.

Step 2: Initialize DSP

As the D/A-READOUT register value depends on the settings of SENSITIVITY, VOQ and CLAMP-LOW/HIGH, these registers have to be initialized with defined values, first:

– $VOQ_{INITIAL}$ = 2.5 V

– Clamp-Low = 0 V

– Clamp-High = 4.999 V

– $Sens_{INITIAL}$ (see Table 3–8)

Table 3–8: $Sens_{INITIAL}$

3dB Filter frequency	$Sens_{INITIAL}$
80 Hz	0.464
500 Hz	0.3
1 kHz	0.321
2 kHz	0.641

Step 3: Define Calibration Points

The calibration points 1 and 2 can be set inside the specified range. The corresponding values for V_{OUT1} and V_{OUT2} result from the application requirements.

$$\text{LowClampingVoltage} \le V_{OUT1,2} \le \text{HighClampingVoltage}$$

For highest accuracy of the sensor, calibration points near the minimum and maximum input signal are recommended. The difference of the output voltage between calibration point 1 and calibration point 2 should be more than 3.5 V.

Step 4: Calculation of V_{OQ} and Sensitivity

Set the system to calibration point 1 and read the register D/A-READOUT. The result is the value D/A-READOUT1.

Now, set the system to calibration point 2, read the register D/A-READOUT again, and get the value D/A-READOUT2.

With these values and the target values V_{OUT1} and V_{OUT2}, for the calibration points 1 and 2, respectively, the values for Sensitivity and V_{OQ} are calculated as:

$$\text{Sensitivity} = \text{Sens}_{\text{INITIAL}} \times \frac{(\text{Vout2} - \text{Vout1})}{(\text{D/A-Readout2} - \text{D/A-Readout1})} \times \frac{16383}{5}$$

$$\text{Voq} = \text{Vout2} - \left[\left(\frac{5 \times \text{D/A-Readout2}}{16383} - \text{Voq}_{\text{INITIAL}}\right) \times \frac{\text{Sensitivity}}{\text{Sensitivity}_{\text{INITIAL}}}\right]$$

This calculation has to be done individually for each sensor.

Next, write the calculated values for Sensitivity and V_{OQ} into the IC for adjusting the sensor. At that time it is also possible to store the application specific values for Clamp-Low and Clamp-High into the sensors EEPROM.The sensor is now calibrated for the customer application. However, the programming can be changed again and again if necessary.

Note For a recalibration, the calibration procedure has to be started at the beginning (step 1). A new initialization is necessary, as the initial values from step 1 are overwritten in step 4.

Step 5: Locking the Sensor

The last step is activating the LOCK function by programming the LOCK bit. Please note that the LOCK function becomes effective after power-down and power-up of the Hall IC. The sensor is now locked and does not respond to any programming or reading commands.

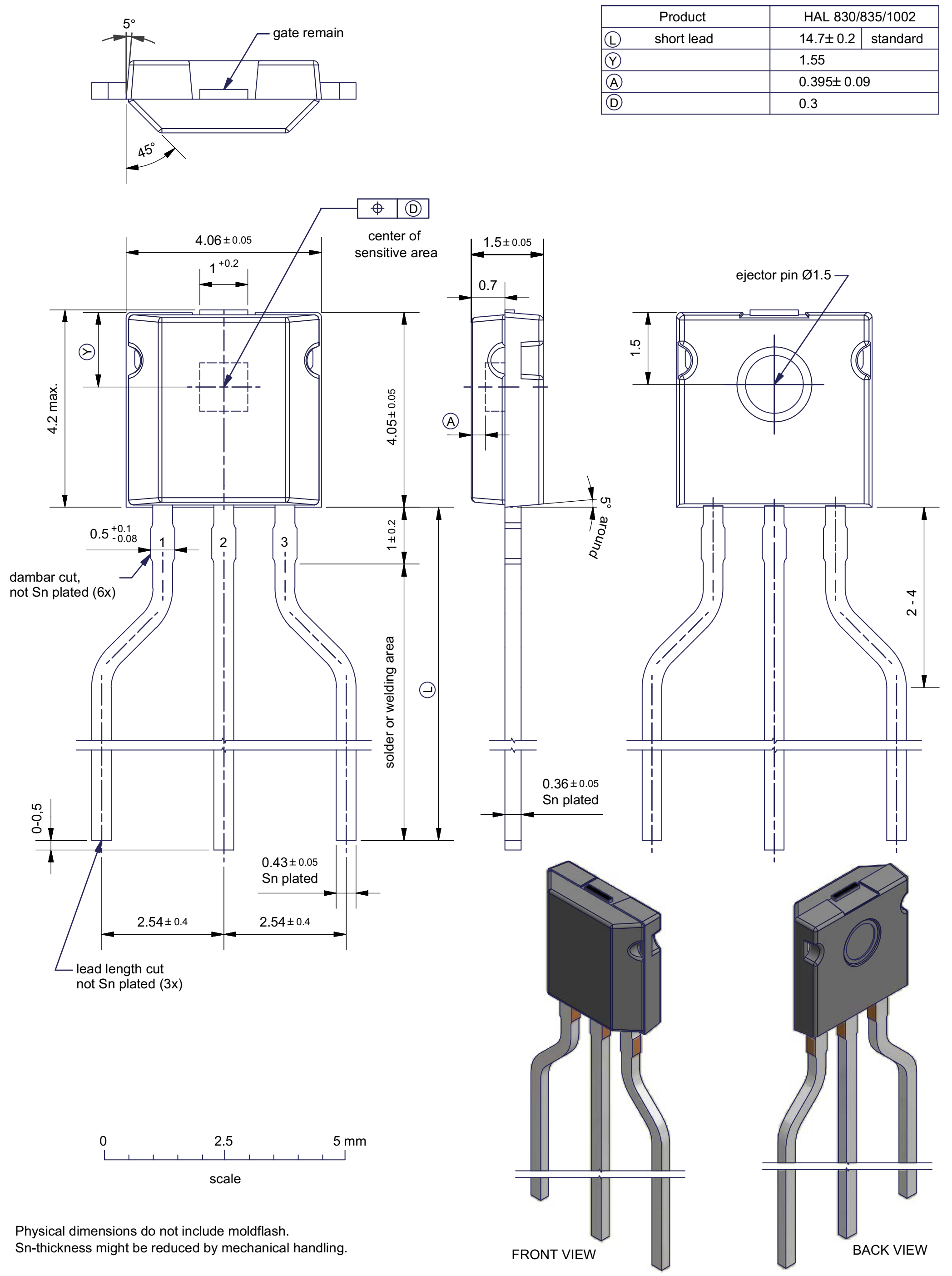
Note It is mandatory to lock the sensor.

Warning **This register can not be reset!**

4. Specifications

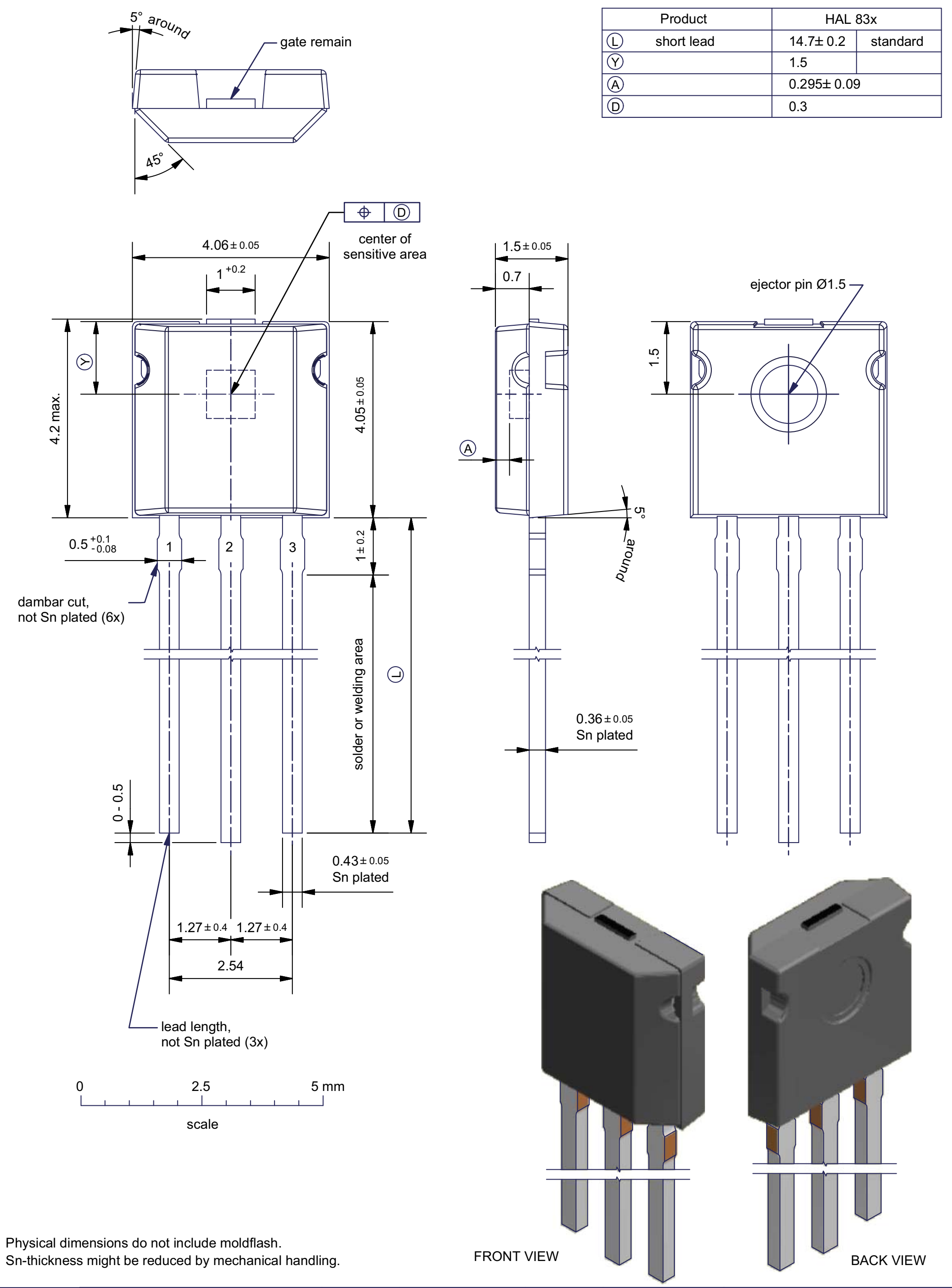
4.1. Outline Dimensions

Product		HAL 830/835/1002	
L	short lead	14.7± 0.2	standard
Y		1.55	
A		0.395± 0.09	
D		0.3	



PACKAGE	ISSUE DATE (YY-MM-DD)	JEDEC STANDARD ITEM NO.	JEDEC STANDARD ISSUE	ANSI	REVISION DATE (YY-MM-DD)	REV.NO.	DRAWING-NO.	SPECIFICATION TYPE	SPECIFICATION NO.
TO92UT-1	17-12-11				17-12-11	1	CUTS00031031.1	ZG	2087_Ver.01

Fig. 4–1:
TO92UT-1 Plastic Transistor Standard UT package, 3 leads, spread
Weight approximately 0.12 g

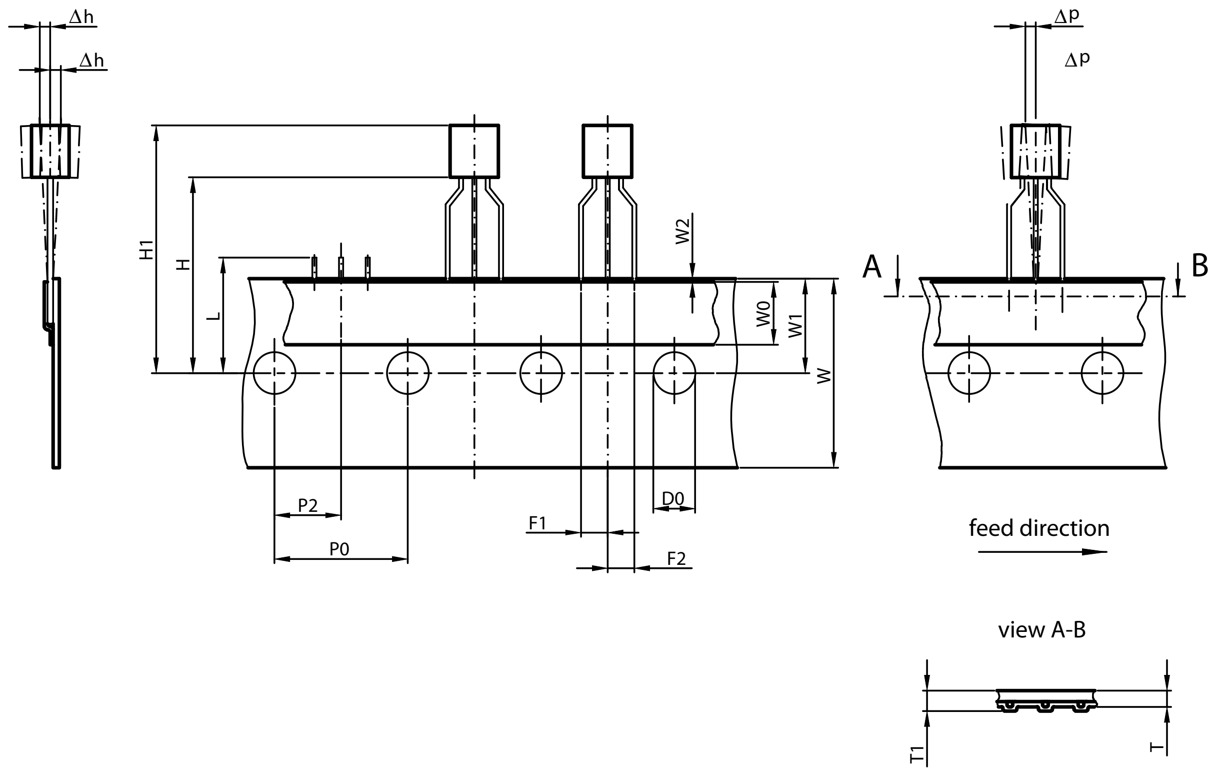


Product	HAL 83x	
Ⓛ short lead	14.7± 0.2	standard
Ⓨ	1.5	
Ⓐ	0.295± 0.09	
Ⓓ	0.3	

Physical dimensions do not include moldflash.
Sn-thickness might be reduced by mechanical handling.

PACKAGE	ISSUE DATE (YY-MM-DD)	JEDEC STANDARD		ANSI	REVISION DATE (YY-MM-DD)	REV.NO.	DRAWING-NO.	SPECIFICATION	
		ITEM NO.	ISSUE					TYPE	NO.
TO92UT-2	17-04-21				17-04-21	1	CUTI00032501.1	ZG	2081_Ver.01

Fig. 4–2:
TO92UT-2 Plastic Transistor Standard UT package, 3 pins
Weight approximately 0.12 g



all dimensions in mm
other dimensions see drawing of bulk
max. allowed tolerance over 20 hole spacings ±1.0

	H	H1	
		TO92UA	TO92UT
Short leads	18 - 20	21 - 23.1	22 - 24.1
Long leads	24 - 26	27 - 29.1	28 - 30.1

UNIT	D0	F1	F2	Δh	L	P0	P2	Δp	T	T1	W	W0	W1	W2
mm	4.0	2.74 2.34	2.74 2.34	±1.0	11.0 max	13.2 12.2	7.05 5.65	±1.0	0.5	0.9	18.0	6.0	9.0	0.3

JEDEC STANDARD		ANSI	ISSUE DATE YY-MM-DD	DRAWING-NO.	ZG-NO.
ISSUE	ITEM NO.				
-	ICE 60286-2		16-07-18	06632.0001.4	ZG001032_Ver.06

Fig. 4–3:
TO92UA/UT: Dimensions ammopack inline, spread