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Hardware
Documentation

Data Sheet

HAL® 855

Programmable Linear Hall-Effect Sensor with Arbitrary Output Characteristic

Edition Jan. 12, 2010
DSH000149_004EN

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– HAL

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Choppered Offset Compensation protected by Micronas patents no. US5260614, US5406202, EP0525235, and EP0548391.

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Contents

Programmable Linear Hall-Effect Sensor with Arbitrary Output Characteristic

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

1. Introduction

The HAL 855 is a member of the Micronas family of programmable linear Hall sensors. As an extension to the HAL8x5 family, the HAL 855 offers an arbitrary output characteristic and individual programming of different sensors which are in parallel to the same supply voltage.

The HAL 855 is an universal magnetic field sensor based on the Hall effect. The IC is designed and produced in sub-micron CMOS technology and can be used for angle or distance measurements if combined with a rotating or moving magnet. The major characteristics like magnetic field range, output characteristic, output format, sensitivity, shift (offset), PWM period and the temperature coefficients are programmable in a non-volatile memory. The output characteristic can be set with 32 setpoints.

The HAL 855 features a temperature-compensated Hall plate with choppered offset compensation, an A/D-converter, digital signal processing, an EEPROM memory with redundancy and lock function for the calibration data, a serial interface for programming the EEPROM, and protection devices at all pins. The internal digital signal processing is of great benefit because analog offsets, temperature shifts, and mechanical stress do not degrade the sensor accuracy.

The HAL 855 is programmable by means of modulating the supply voltage. No additional programming pin is needed. The easy programmability allows a 2-point calibration by adjusting the output signal 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. This offers a low-cost alternative for all applications that presently need mechanical adjustment or laser trimming for calibrating the system.

In addition, the temperature compensation of the Hall IC can be fitted to all 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 Micronas. The sensors are designed for automotive or industrial applications. They operate with ambient temperatures from –40 °C up to 150 °C. The HAL 855 is available in the very small leaded package TO92UT-1 and TO92UT-2.

1.1. Major Applications

Due to the sensor's versatile programming characteristics, the HAL 855 is the optimal system solution for applications such as:

– contactless potentiometers,

– rotary position measurement (e.g., pedal sensor),

– fluid level measurement,

– linear position detection, and

– magnetic field detection.

1.2. Features

– high-precision linear Hall effect sensors with different output formats

– various programmable magnetic characteristics with non-volatile memory

– programmable output characteristic (32 setpoints with 9-bit resolution)

– programmable output formats (PWM or serial Biphase-M)

– programmable PWM period

– open-drain output

– digital signal processing

– temperature characteristics programmable for matching all common magnetic materials

– programming by modulation of the supply voltage

– lock function and built-in redundancy for EEPROM memory

– operates from –40 °C up to 150 °C ambient temperature

– operates from 4.5 V up to 18 V supply voltage

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

– choppered offset compensation

– overvoltage protection on all pins

– reverse-voltage protection on V_{DD} pin

– magnetic characteristics extremely robust against mechanical stress

– short-circuit-protected output

– EMC-optimized design

– programmable slew rate for optimized EMI behavior

1.3. Marking Code

The HAL 855 has a marking on the package surface (branded side). This marking includes the name of the sensor and the temperature range.

Type	Temperature Range	
	A	K
HAL 855	855A	855K

1.4. Operating Junction Temperature Range (T_J)

The Hall sensors from Micronas are specified to the chip temperature (junction temperature T_J).

A: T_J = –40 °C to +170 °C

K: T_J = –40 °C to +140 °C

The relationship between ambient temperature (T_A) and junction temperature is explained in Section 4.5. on page 28.

1.5. Hall Sensor Package Codes

HALXXXPA-T

Temperature Range: A and K
Package: UT for TO92UT-1/-2
Type: 855

Example: **HAL855UT-K**

→ Type: 855
→ Package: TO92UT
→ Temperature Range: T_J = –40°C to +140°C

Hall sensors are available in a wide variety of packaging versions and quantities. For more detailed information, please refer to the brochure: “Micronas Hall Sensors: Ordering Codes, Packaging, Handling”.

1.6. Solderability and Welding

Soldering

During soldering reflow processing and manual reworking, a component body temperature of 260°C should not be exceeded.

Welding

Device terminals should be compatible with laser and resistance welding. Please note that the success of the welding process is subject to different welding parameters which will vary according to the welding technique used. A very close control of the welding parameters is absolutely necessary in order to reach satisfying results. Micronas, therefore, does not give any implied or express warranty as to the ability to weld the component.

1.7. Pin Connections and Short Descriptions

Pin No.	Pin Name	Type	Short Description
1	V_{DD}	IN	Supply Voltage and Programming Pin
2	GND		Ground
3	OUT	OUT	Open-Drain Output and Selection Pin

HAL855

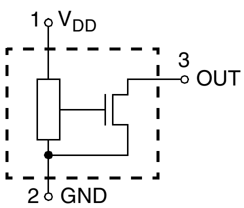


Fig. 1–1: Pin configuration

2. Functional Description

2.1. General Function

The HAL 855 is a monolithic integrated circuit which provides an output signal proportional to the magnetic flux through the Hall plate.

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, converted to the different digital output formats (PWM and Biphase-M serial protocol) and provided by an open-drain output transistor stage. The function and the parameters for the DSP are explained in Section 2.2. on page 8.

The setting of the LOCK register disables the programming of the EEPROM memory for all time. 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. 2–1). After detecting a command, the sensor reads or writes the memory and answers with a digital signal on the output pin. The output is switched off during the communication.

When no command is detected or processed and the supply voltage is within the recommended operating range the PWM or Biphase-M output is enabled.

It is possible to program several sensors individually if they are in parallel to the same supply and ground line. The selection of each sensor is done via its output pin.

Internal temperature compensation circuitry and the choppered offset compensation enables operation over the full temperature range with minimal changes in accuracy and high offset stability. The circuitry also rejects offset shifts due to mechanical stress from the package. The non-volatile memory consists of redundant EEPROM cells. In addition, the sensor IC is equipped with devices for overvoltage and reverse-voltage protection at all pins.

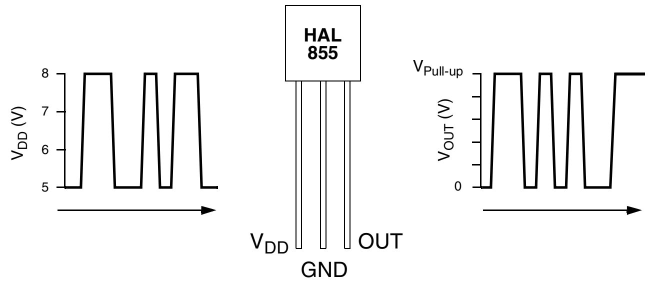


Fig. 2–1: Programming with V_{DD} modulation

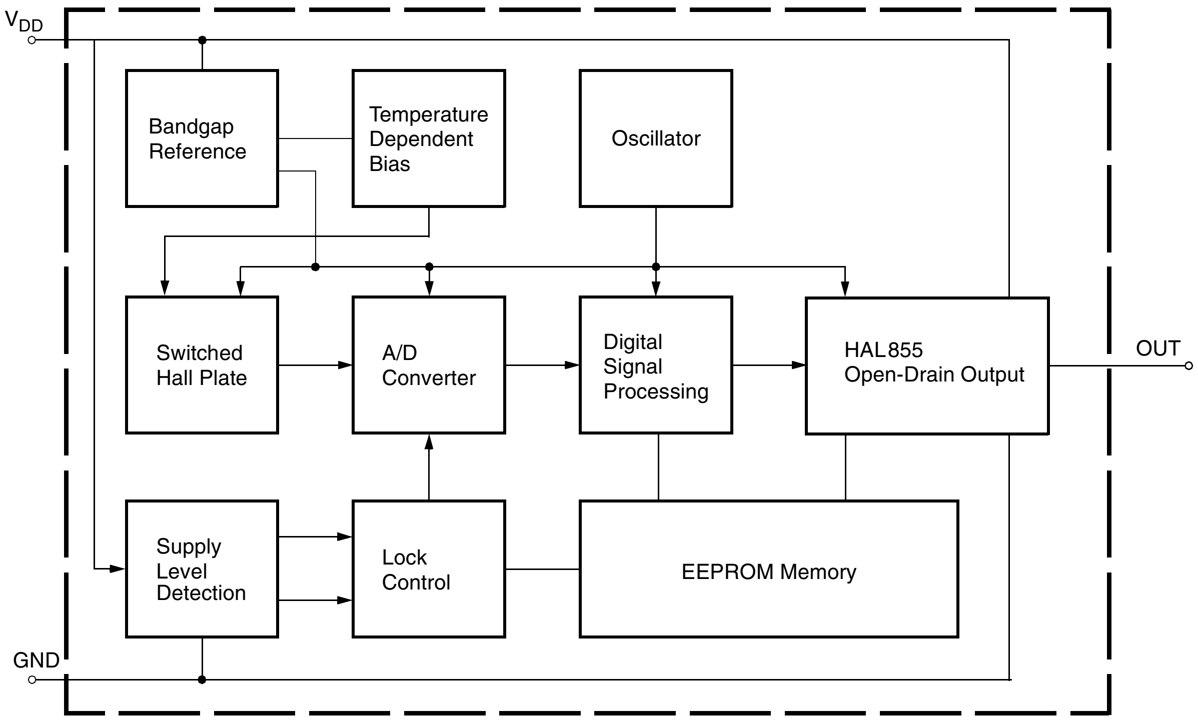


Fig. 2–2: HAL 855 block diagram

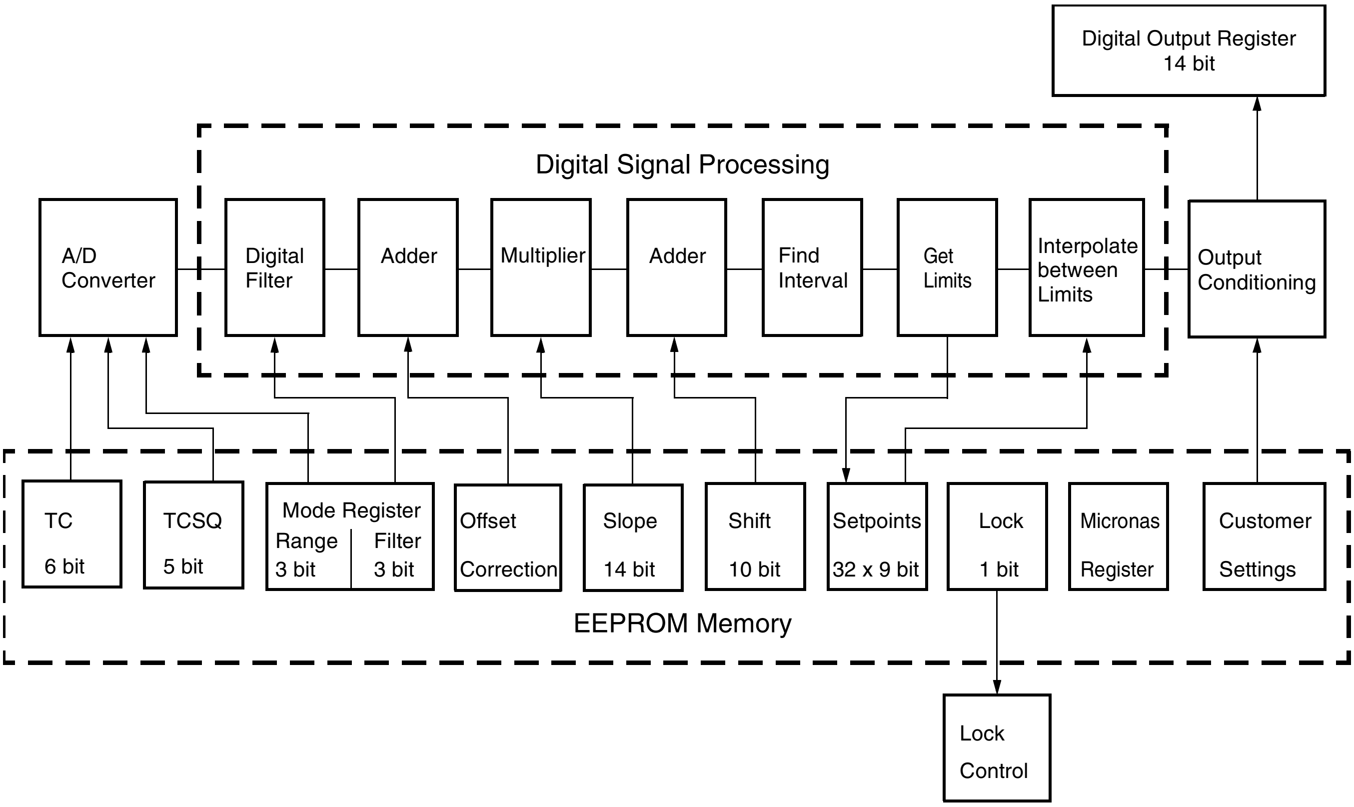


Fig. 2–3: Details of EEPROM and digital signal processing

2.2. Digital Signal Processing and EEPROM

The DSP is the major part of this sensor and performs the signal conditioning. The parameters for the DSP are stored in the EEPROM registers. The details are shown in Fig. 2–3 on page 7.

Terminology:

SLOPE: name of the register or register value

Slope: name of the parameter

The EEPROM registers consist of three groups:

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

The parameters SLOPE and SHIFT are used for the individual calibration of the sensor in the magnetic circuit.

– The parameter Shift corresponds to the output signal at B = 0 mT.

– The parameter Slope defines the magnetic sensitivity.

Group 2 contains the registers for defining the output characteristics: OUTPUT FORMAT, OUTPUT PERIOD or OUTPUT BITTIME, SLEW RATE and OUTPUT CHARACTERISTIC.

The shape of the output signal is determined by the output characteristic, which, in turn, is defined by the 32 setpoints of the sensor. A value for each of the setpoints must be defined. The setpoints are distributed evenly along the magnetic field axis allowing linear interpolation between the 32 setpoints (see Fig. 2–4).

Group 3 contains the PARTNUMBER, the Micronas registers, and LOCK for the locking of all registers. After locking, the PARTNUMBER register is only available in Biphase-M output mode. The Micronas registers are programmed and locked during production and are read-only for the customer. These registers are used for oscillator frequency trimming and several other special settings.

An external magnetic field generates a Hall voltage on the Hall plate. The A/D-converter 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. 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 DIGITAL OUTPUT register. Depending on the programmable magnetic range of the Hall IC, the operating range of the A/D converter is from −30 mT ... +30 mT up to −150 mT... +150 mT.

During further processing, the digital signal is calculated based on the values of slope, shift, and the defined output characteristic. The result is converted to the different digital output formats (PWM and Biphase-M) and stabilized by a open-drain output transistor stage.

The DIGITAL OUTPUT value at any given magnetic field depends on the settings of the magnetic field range, the low-pass filter, TC, TCSQ values and the programmed output characteristic. The DIGITAL OUTPUT range is min. 0 to max. 4095.

Note: During application design, it should be taken into consideration that DIGITAL OUTPUT should not saturate in the operational range of the specific application.

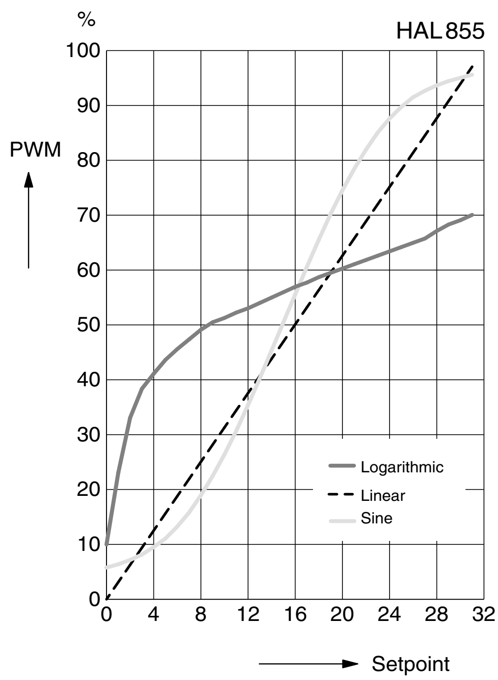


Fig. 2–4: Example for different output characteristics

Mode

The MODE register consists of four “sub”-registers defining the magnetic and output behavior of the sensor. The RANGE bits are the three lowest bits of the MODE register; they define the magnetic field range of the A/D converter. The next three bits (FILTER) define the –3 dB frequency of the digital low pass filter. The next sub-register is the FORMAT register, and it defines the different output formats as described below. This sub-register also consists of 3 bits. The last three MSBs define the OUTPUT PERIOD of the PWM signal.

Range

Table 2–1: RANGE register definition

Magnetic Field Range	Bit Setting
–30 mT...30 mT	0
–40 mT...40 mT	4
–60 mT...60 mT	5
–75 mT...75 mT	1
–80 mT...80 mT	6
–90 mT...90 mT	2
–100 mT...100 mT	7
–150 mT...150 mT	3

Filter

Table 2–2: FILTER register definition

–3 dB Frequency	Bit Setting
80 Hz	0
160 Hz	1
500 Hz	2
1 kHz	3
2 kHz	4

Output Format

The HAL 855 provides two different output formats: a PWM and Biphase-M output.

PMW output is a pulse width modulated output. The signal is defined by the ratio of pulse width to pulse period.

The Biphase-M output is a serial protocol. A logical “0” is coded as no output level change within the bit time. A logical “1” is coded as an output level change between 50% and 80% of the bit time. After each bit, an output level change occurs (see Section 3.6.1. on page 23).

Table 2–3: OUTPUT FORMAT register definition

Output Format	Bit Setting
PWM	2
Biphase-M	4[1)]
Biphase-M (test)	5[2)]

1) In case of OUTPUT FORMAT = 4 the continuous Biphase-M output will be active after locking the device. In order to test the Biphase-M output with non-locked sensors OUTPUT FORMAT = 5 has to be used.
2) writing OUTPUT FORMAT = 5 will activate the Biphase-M output for test purpose. The test can be deactivated by switching the device off.

Output Period

The OUTPUT PERIOD register defines the PWM period of the output signal.

Table 2–4: OUTPUT PERIOD register definition

PWM Output Period	Bit Setting
128 ms; 12-bit resolution	0
64 ms; 12-bit resolution	1
32 ms; 12-bit resolution	2
16 ms; 12-bit resolution	3
8 ms; 12-bit resolution	4
4 ms; 11-bit resolution	5
2 ms; 10-bit resolution	6
1 ms; 9-bit resolution	7

Output Bittime

The OUTPUT BITTIME register defines the bit time of the Biphase-M output signal. OUTPUT BITTIME is “sub”-register of the SPECIAL CUSTOMER register.

Table 2–5: OUTPUT BITTIME register definition

Biphase-M Output Bit Time	Bit Setting
40 µs	0
84 µs	1
168 µs	2
320 µs	3
700 µs	11
1.6 ms	4
3.2 ms	5
6.4 ms	7

Note: Setting the Biphase-M bit time to 40 µs simultaneously switches the programming telegram to the same bit time. Hence after writing the OUTPUT BITTIME register the timing of the programming device has to be set accordingly.

TC and TCSQ

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 adaption is done by programming the TC (Linear 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 signal characteristic can be fixed over the full temperature range. The sensor can compensate for linear temperature coefficients ranging from about –2100 ppm/K up to 600 ppm/K and quadratic coefficients from about –5 ppm/K^2 to 5 ppm/K^2. Please refer to Section 4.4. on page 27 for the recommended settings for different linear temperature coefficients.

Slope

The SLOPE register contains the parameter for the multiplier in the DSP. The Slope is programmable between –4 and 4. The register can be changed in steps of 0.00049. Slope = 1 corresponds to an increase of the output signal by 100% if the digital value at the A/D-converter output increases by 2048.

For all calculations, the digital value after the digital signal processing is used. This digital information is readable from the DIGITAL OUTPUT register.

Shift

The SHIFT register contains the parameter for the adder in the DSP. Shift is the output signal without external magnetic field (B = 0 mT) and programmable from –100% up to 100%. For calibration in the system environment, a 2-point adjustment procedure is recommended. The suitable Slope and Shift values for each sensor can be calculated individually by this procedure.

Part Number

In case of Biphase-M output, a part number can be defined. This part number will be sent during power-on of the sensor if the PARTNUMBER ENABLE bit is set. Afterwards, the sensor will send the digital value corresponding to the applied magnetic field.

– The PARTNUMBER ENABLE bit is part of the SPECIAL CUSTOMER register.

– The OUTPUT PERIOD register defines the time interval for which the part number is sent.

Output Characteristic

The OUTPUT CHARACTERISTIC register defines the shape of the sensor output signal. It consists of 32 setpoints. Each setpoint can be set to values between 0 and 511 LSB. The output characteristic has to be monotonic increasing (Setpoint0 ≤ Setpoint1 ≤ SetpointN).

LOCKR

By setting this 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.

Warning: This register cannot be reset!

Digital Output

This 12-bit register delivers the actual digital value of the applied magnetic field after the signal processing. This register can only be read out, and it is the basis for the calibration procedure of the sensor in the system environment.

Offset Correction

The OFFSET CORRECTION register allows to adjust the digital offset of the built-in A/D-converter. The digital offset can be programmed to –3/4, –1/2, –1/4, 0, +1/4, +1/2, +3/4 of full-scale.

Table 2–6: OFFSET CORRECTION register definition

Offset Correction	Bit Setting
–3/4	28
–1/2	29
–1/4	30
0	0
1/4	17
1/2	18
3/4	19

Slew Rate

The SLEW RATE register is a “sub”-register of the CURRENTSOURCE register. The output fall time of the HAL 855 depends on the SLEW RATE register setting and the external load circuit.

Note: The output rise time is purely due to the external load and is not controlled by the SLEW RATE register.

Table 2–7: SLEW RATE register definition

Typ. Slew Rate (3.6 kΩ pull-up, 4.7 nF)	Bit Setting
0.3 µs	0
0.8 µs	1
1.2 µs	2
1.5 µs	3

Note: The slew rate can be programmed to optimize the EMI behavior of the application.

2.3. Calibration Procedure

2.3.1. General Procedure

For calibration in the system environment, the application kit from Micronas is recommended. It contains the hardware for the generation of the serial telegram for programming (Programmer Board Version 5.1) and the corresponding software (PC85x) for the input of the register values.

For the individual calibration of each sensor in the customer application, a two-point adjustment is recommended (see Fig. 2–5 on page 13 for an example). 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 part number and the output format are given for this application.

Therefore, the values of the following registers 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)
- TC and TCSQ
  (depends on the material of the magnet and the other temperature dependencies of the application)
- OUTPUT FORMAT
  (according to the application requirements)
- OUTPUT PERIOD
  (according to the application requirements)
- PARTNUMBER
  (in case Biphase-M output format is used)
- OFFSET CORRECTION
- SLEW RATE

Write the appropriate settings into the HAL 855 registers.

Step 2: Initialize DSP

As the DIGITAL OUTPUT register value depends on the settings of SLOPE, SHIFT and the OUTPUT CHARACTERISTIC, these registers have to be initialized with defined values, first:

- $Shift_{INITIAL}$ = 50%
- OUTPUT CHARACTERISTIC = 'Linear Standard' (Setpoint 0 = 0, Setpoint 1 = 16, Setpoint 2 = 32, ..., Setpoint 31 = 496).
- $Slope_{INITIAL}$ depends on the setting of the digital low-pass filter (see Table 2–8).

Table 2–8: Initial slope values

–3 dB Frequency	$Slope_{INITIAL}$
80	0.2578
160	0.2578
500	0.1938
1000	0.1938
2000	0.3398

Step 3: Define Calibration Points

For highest accuracy of the sensor, calibration points near the minimum and maximum input signal are recommended.

Define nominal values $DOUT1_{NOM}$ and $DOUT2_{NOM}$ of the DIGITAL OUTPUT register at the calibration points 1 and 2, respectively.

Note: Micronas software PC85x uses default settings $DOUT1_{NOM}$ = 0 and $DOUT2_{NOM}$ = 3968.

The output is clamped to Setpoint 0 and Setpoint 31. In the case of “Linear Standard'”, Setpoint 0 corresponds to DIGITAL OUTPUT = 0, while Setpoint 31 corresponds to DIGITAL OUTPUT = 3968.

Step 4: Calculation of Shift and Slope

Set the system to calibration point 1 and read the register DIGITAL OUTPUT. The result is the value DOUT1.

Now, set the system to calibration point 2, read the register DIGITAL OUTPUT, and get the value DOUT2.

With these values, the settings for Sensitivity and Shift are calculated as:

$$Slope = Slope_{INITIAL} \times \frac{(DOUT2_{NOM} - DOUT1_{NOM})}{(DOUT2 - DOUT1)}$$

$$Shift = \frac{100\%}{4096} \times \left(DOUT2_{NOM} - \frac{(DOUT2 - 2048) \times Slope}{Slope_{INITIAL}}\right)$$

Write the calculated values for Slope, Shift, and the desired output characteristic into the EEPROM. The sensor is now calibrated for the customer application.

As long as the LOCK bit is not set, the calibration procedure can be applied repeatedly.

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 for $Slope_{INITIAL}$, $Shift_{INITIAL}$ and output characteristic are overwritten in step 4.

Step 5: Locking the Sensor

The last step is activating the LOCK function with the "LOCK" command. 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.

Warning: This register cannot be reset!

2.3.2. Example: Calibration of an Angle Sensor

The following description explains the calibration procedure using an angle sensor with a HAL 855 as an example. The required output characteristic is shown in Fig. 2–5.

– the angle range is from –25° to 25°

– temperature coefficient of the magnet: –500 ppm/K

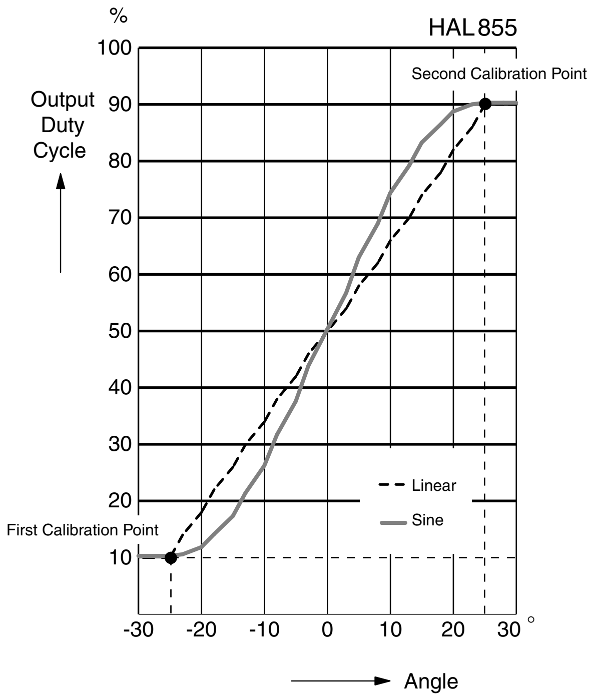


Fig. 2–5: Example for output characteristics

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

The register values for the following registers are given for all applications:

– FILTER
  Select the filter frequency: 500 Hz
– RANGE
  Select the magnetic field range: 40 mT
– TC
  For this magnetic material: 6
– TCSQ
  For this magnetic material: 14
– OUTPUT FORMAT
  Select the output format: PWM
– OUTPUT PERIOD
  Select the output format: 8 ms
– PARTNUMBER
  For this example: 1
– OFFSET CORRECTION
  For this example: none
– SLEW RATE
  For this example: 0 (fastest)

Enter these values in the software, and use the “write and store” command for permanently writing the values in the registers.

Step 2: Initialize DSP

– SHIFT
  Select Shift: 50%
– SLOPE
  Select Slope: 0.1938 (see Table 2–8 on page 12)
– OUTPUT CHARACTERISTIC
  Select output characteristic: ’Linear Standard’

Step 3: Define Calibration Points

The Micronas software PC85x uses default settings $DOUT1_{NOM}$ = 0 and $DOUT2_{NOM}$ = 3968.

$DOUT1_{NOM}$ corresponds to the angle position –25°, $DOUT2_{NOM}$ to +25°.

Step 4: Calculation of Shift and Slope

There are two ways to calculate the values for Shift and Slope.

Manual Calculation:

1. Set the system to calibration point 1 (angle 1 = 25°)
2. read the register DIGITAL OUTPUT.

For our example, the result is
DIGITAL OUTPUT = DOUT1 = 3291.

3. Set the system to calibration point 2 (angle 2 = –25°)
4. read the register DIGITAL OUTPUT again.

For our example, the result is
DIGITAL OUTPUT = DOUT2 = 985.

With these measurements and the pre-programming of the sensor, the values for Slope and Shift are calculated as:

$$Slope = \frac{3968}{(985-3291)} \times 0.1938 = -0.3335$$

$$Shift = \frac{100\%}{4096} \times \left(3968 - \frac{(985-2048)\times(-0.3335)}{0.1938}\right) = 52.22\%$$

Write the calculated values for Slope and Shift and a linear output characteristic ranging from 10% to 90% output duty cycle into the EEPROM memory.

Software Calibration:

Use the menu CALIBRATE from the PC software and enter the values for the registers which are not adjusted individually. Set the system to calibration point 1 (angle 1 = 25°), hit the button “Digital Output1”, set the system to calibration point 2 (angle 2 = –25°), hit the button “Digital Output2”, and hit the button “Calculate”. The software will then calculate the appropriate Shift and Slope.

This calculation has to be done individually for each sensor. Now, select an output characteristic from the selection box “Output Characteristics” and then press the button “write and store” for programming the sensor.

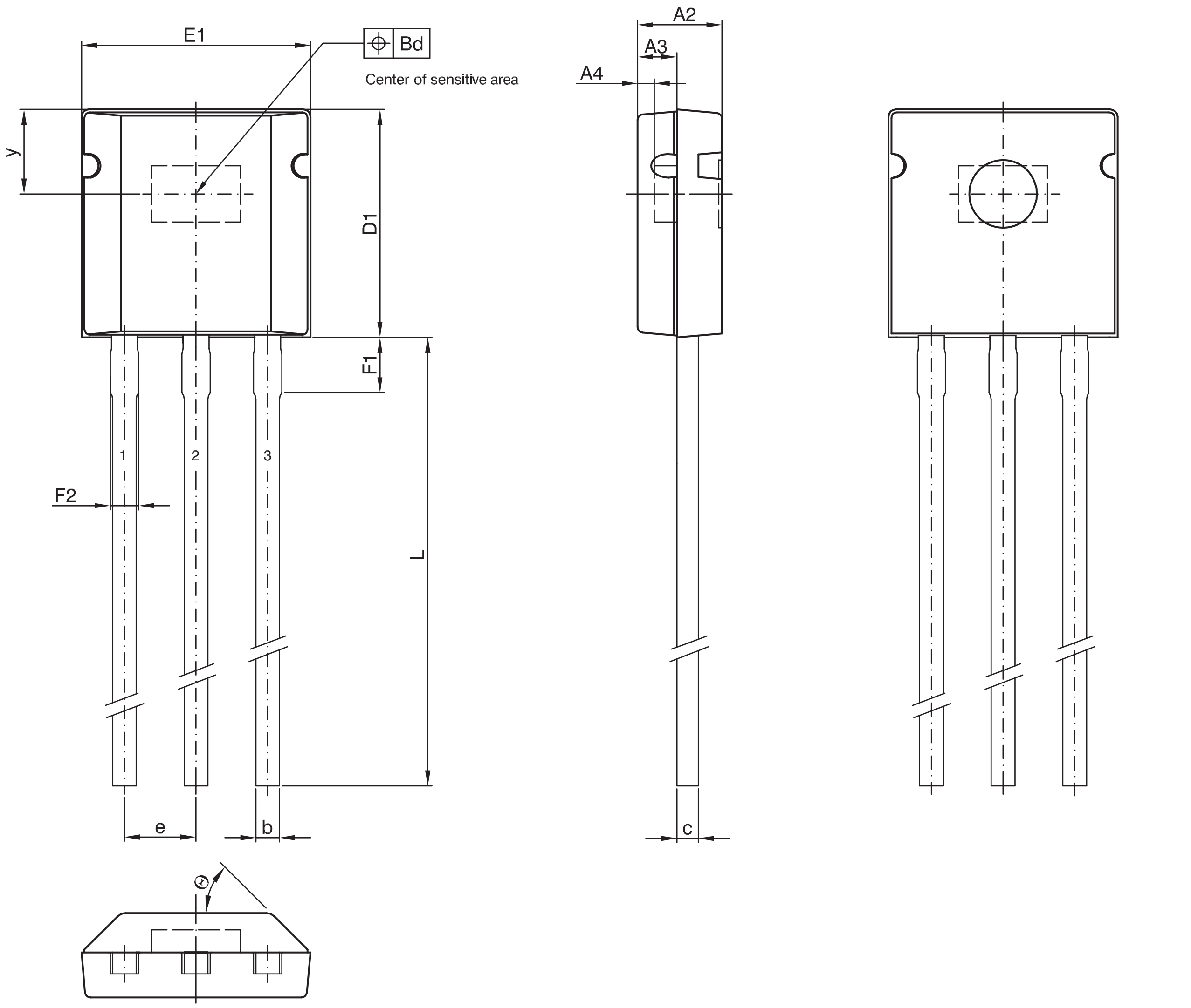
Step 5: Locking the Sensor

The last step is activating the LOCK function with the “LOCK” command. 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.

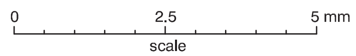
Warning: This register cannot be reset!

3. Specifications

3.1. Outline Dimensions



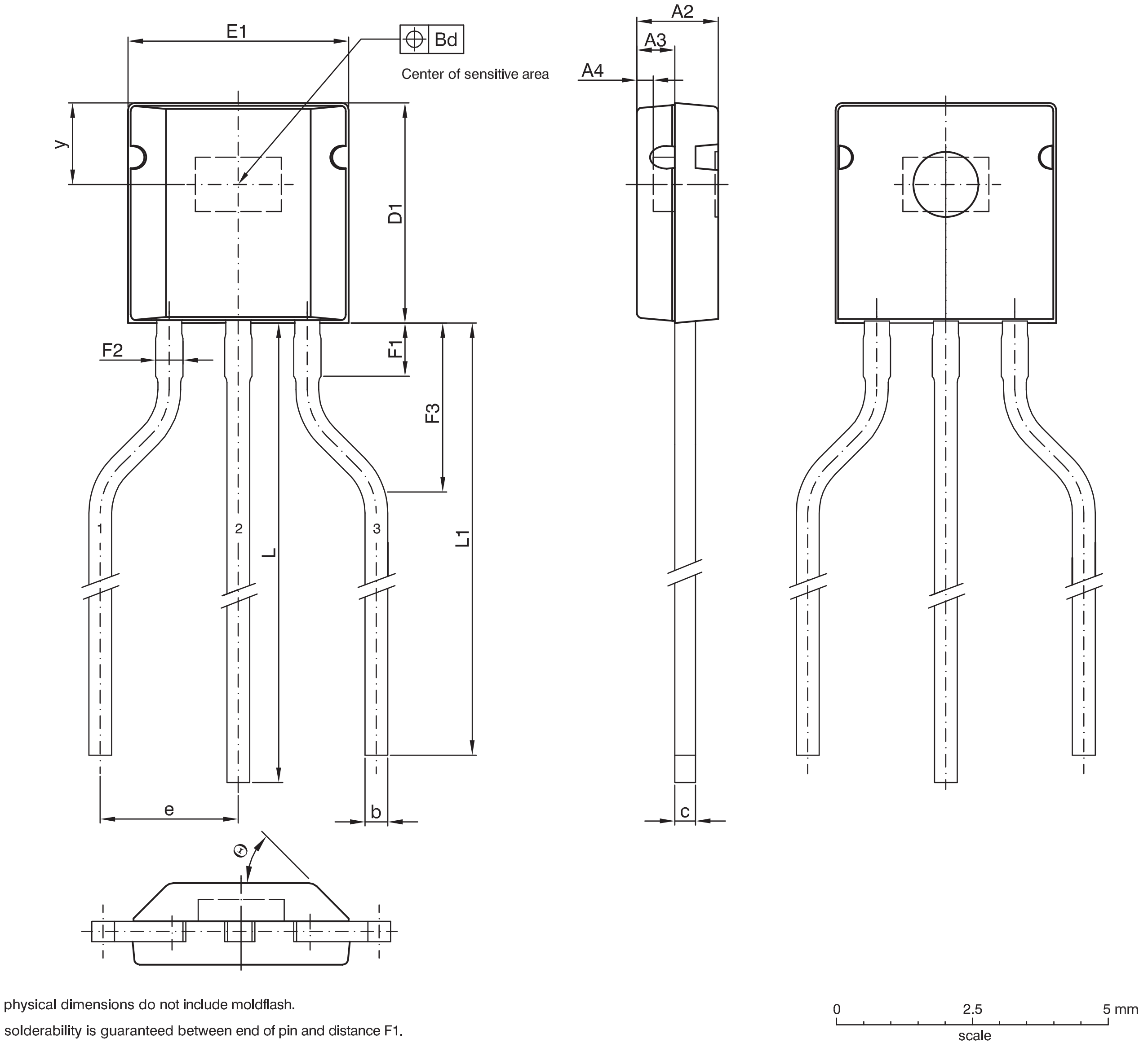
physical dimensions do not include moldflash.
solderability is guaranteed between end of pin and distance F1.
A4, Bd, y= these dimensions are different for each sensor type and are specified in the data sheet.



UNIT	A2	A3	b	c	D1	e	E1	F1	F2	L	Θ
mm	1.55 1.45	0.7	0.42	0.36	4.1 4.0	1.27	4.11 4.01	1.2 0.8	0.60 0.42	14.5 min	45°

JEDEC STANDARD		ANSI	ISSUE DATE YY-MM-DD	DRAWING-NO.	ZG-NO.
ISSUE	ITEM NO.				
-	-		07-07-02	06615.0001.4	ZG001015_Ver.05

Fig. 3–1:
TO92UT-2: Plastic Transistor Standard UT package, 3 leads, not spread
Weight approximately 0.12 g



physical dimensions do not include moldflash.
solderability is guaranteed between end of pin and distance F1.
A4, Bd, y= these dimensions are different for each sensor type and are specified in the data sheet.

UNIT	A2	A3	b	c	D1	e	E1	F1	F2	F3	L	L1	Θ
mm	1.55 1.45	0.7	0.42	0.36	4.1 4.0	2.54	4.11 4.01	1.2 0.8	0.60 0.42	4.0 2.0	14.5 min	14.0 min	45°

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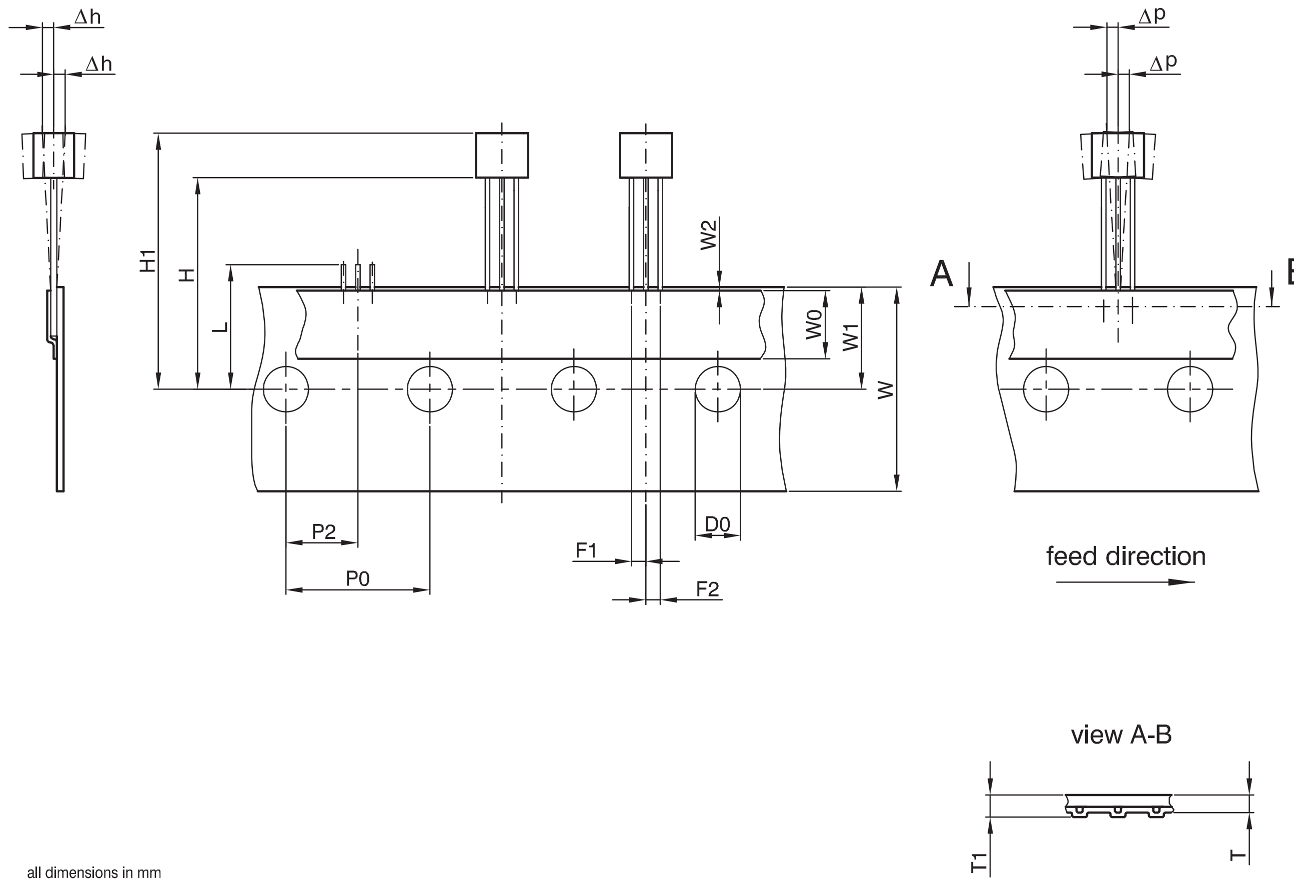
ISSUE	ITEM NO.				
-	-		07-07-02	06609.0001.4	ZG001009_Ver.05

Fig. 3–2:
TO92UT-1: Plastic Transistor Standard UT package, 3 leads, spread
Weight approximately 0.12 g



all dimensions in mm
other dimensions see drawing of bulk
max. allowed tolerance over 20 hole spacings ±1.0
H1 = this dimension is different for each sensor type and is specified in the data sheet

UNIT	D0	F1	F2	H	Δh	L	P0	P2	Δp	T	T1	W	W0	W1	W2
mm	4.0	1.47 1.07	1.47 1.07	20.0 18.0	±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

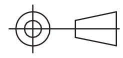
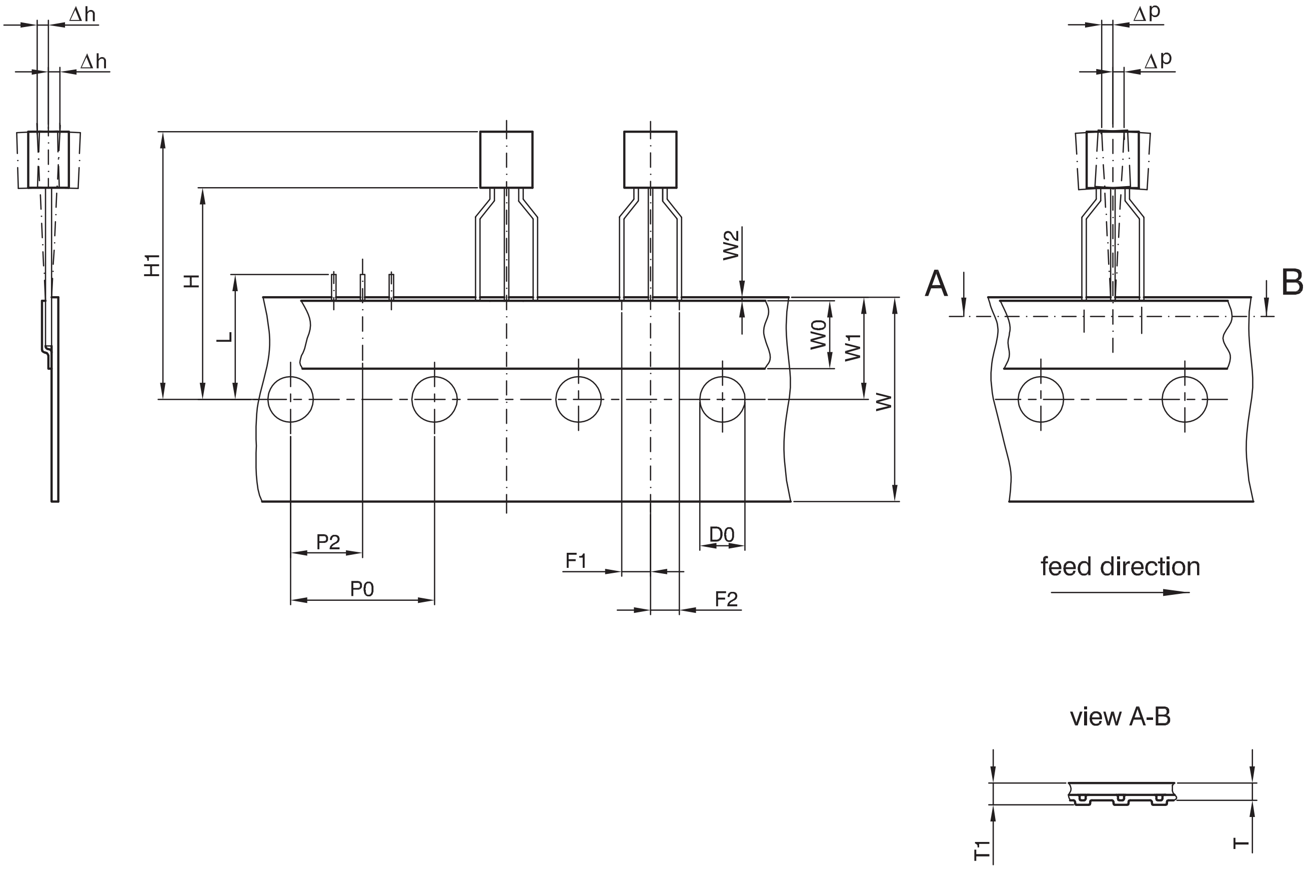
JEDEC STANDARD		ANSI	ISSUE DATE YY-MM-DD	DRAWING-NO.	ZG-NO.
ISSUE	ITEM NO.				
-	ICE 60286-2		07-01-18	06631.0001.4	ZG001031_Ver.03

Fig. 3–3:
TO92UT-2: Dimensions ammopack inline, not spread



all dimensions in mm
other dimensions see drawing of bulk
max. allowed tolerance over 20 hole spacings ±1.0
H1 = this dimension is different for each sensor type and is specified in the data sheet

UNIT	D0	F1	F2	H	Δh	L	P0	P2	Δp	T	T1	W	W0	W1	W2
mm	4.0	2.74 2.34	2.74 2.34	20.0 18.0	±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		07-01-18	06632.0001.4	ZG001032_Ver.04

Fig. 3–4:
TO92UT-1: Dimensions ammopack inline, spread

3.2. Dimensions of Sensitive Area

0.25 mm x 0.25 mm

3.3. Position of Sensitive Areas

	TO92UT-1/-2
y	1.5 mm nominal
A4	0.3 mm nominal
Bd	0.3 mm
H1	min. 22.0 mm, max. 24.1 mm

3.4. Absolute Maximum Ratings

Stresses beyond those listed in the "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only. Functional operation of the device at these conditions is not implied. Exposure to absolute maximum rating conditions for extended periods will affect device reliability.

This device contains circuitry to protect the inputs and outputs against damage due to high static voltages or electric fields; however, it is advised that normal precautions be taken to avoid application of any voltage higher than absolute maximum-rated voltages to this high-impedance circuit.

All voltages listed are referenced to ground (GND).

Symbol	Parameter	Pin No.	Min.	Max.	Unit
V_{DD}	Supply Voltage	1	–14.5[1)]	18	V
$-I_{DD}$	Reverse Supply Current	1	–	50[2)]	mA
I_Z	Current through Protection Device	1 or 3	–50[2)]	50[2)]	mA
V_{OUT}	Output Voltage	3	–0.3 >14[4)]	14 18[4)]	V V
I_{OUT}	Continuous Output Current	3	–50[2)]	50[2)]	mA
T_J	Junction Temperature Range		–40 –40	150 170[3)]	°C
N_{PROG}	Number of Programming Cycles		–	100	

[1)] t < 1 min.
[2)] as long as T_{Jmax} is not exceeded
[3)] t < 1000h
[4)] t < 100h

3.4.1. Storage and Shelf Life

The permissible storage time (shelf life) of the sensors is unlimited, provided the sensors are stored at a maximum of 30 °C and a maximum of 85% relative humidity. At these conditions, no Dry Pack is required.

Solderability is guaranteed for one year from the date code on the package.

3.5. Recommended Operating Conditions

Functional operation of the device beyond those indicated in the “Recommended Operating Conditions/Characteristics” is not implied and may result in unpredictable behavior of the device and may reduce reliability and lifetime.

All voltages listed are referenced to ground (GND).

Symbol	Parameter	Pin No.	Min.	Typ.	Max.	Unit	Remarks
V_{DD}	Supply Voltage	1	4.5	5	5.5	V	
V_{DD}	Battery Supply Voltage	1	8 6	12 12	18 18	V	T_J >125°C, R_P = 120 Ω T_J <125°C, R_P = 120 Ω
V_{DDrt}	Slowest rise time of V_{DD} to reach $V_{DD,min}$ at the sensor for correct power-up	1	– –	– –	10 1	ms ms	T_J < 125°C T_J >125°C
$V_{Pull\text{-}up}$	Output Pull-up Voltage	3	3	5	12	V	
I_{OUT}	Continuous Output Current	3	–	–	20	mA	
C_P	Protection Capacitance	1,2	4.7	4.7	1000	nF	
C_L	Load Capacitance	2,3	–	–	100	nF	

Note: Please contact Micronas application support or check available application notes in case of usage of the sensor beyond recommended operating conditions.

3.6. Characteristics

at T_J = –40 °C to +170 °C, V_{DD} = 4.5 V to 14 V, after programming and locking of the device,
at Recommended Operation Conditions if not otherwise specified in the column “Conditions”.
Typical Characteristics for T_J = 25 °C and V_{DD} = 5 V.
For all other temperature ranges this table is also valid, but only in the junction temperature range defined by the temperature range (Example: For K-Type this table is limited to T_J = –40 °C to +140 °C).
All voltages listed are referenced to ground (GND).

Symbol	Parameter	Pin No.	Min.	Typ.	Max.	Unit	Conditions
I_{DD}	Supply Current over Temperature Range	1	– –	7 7	8 10	mA mA	T_J > 125°C T_J < 125°C
I_{OH}	Output Leakage Current over Temperature Range	3	–	–	10	µA	
V_{DDZ}	Overvoltage Protection at Supply	1	–	22	–	V	
V_{OZ}	Overvoltage Protection at Output	3	–	22	–	V	
	Resolution	2,3	–	–	12	bit	1)
INL	Integral Non-Linearity over Temperature Range	2,3	–0.5	0	0.5	%	2)
f_{PWM}	PWM Output Frequency over Temperature Range	3	920 460 230 115 57 28 13 6.5	1000 500 250 125 62.5 31 15 7.5	1080 540 270 135 68 34 17 8.5	Hz Hz Hz Hz Hz Hz Hz Hz	PWM period: 1 ms; 9 bit res. PWM period: 2 ms; 10 bit res. PWM period: 4 ms; 11 bit res. PWM period: 8 ms; 12 bit res. PWM period: 16 ms; 12 bit res. PWM period: 32 ms; 12 bit res. PWM period: 64 ms; 12 bit res. PWM period: 128 ms;12 bit res.
t_{p0}	Biphase-M Output Bittime over Temperature Range	3	0.03 2	0.04 3.2	0.05 4	ms ms	Biphase-M bit time: 40 µs Biphase-M bit time: 3.2 ms
t_{p1}	Biphase-M Output Timing for Logical 1	3	50	65	80	%	
f_{ADC}	Internal ADC Frequency over Temperature Range	–	110	128	150	kHz	V_{DD} = 4.5 V to 14 V
$t_{r(O)}$	Response Time of Internal Signal3)	3	– – –	5 4 2 1	10 8 4 2	ms ms ms ms	3 dB filter frequency = 80 Hz 3 dB filter frequency = 160 Hz 3 dB filter frequency = 500 Hz 3 dB filter frequency = 2 kHz
$t_{d(O)}$	Delay Time of Internal Signal	3	–	0.1	0.5	ms	
t_{POD}	Power-Up Time (time to reach stabilized internal signal)3)		– – –	6 5 3 2	11 9 5 3	ms ms ms ms	3 dB filter frequency = 80 Hz 3 dB filter frequency = 160 Hz 3 dB filter frequency = 500 Hz 3 dB filter frequency = 2 kHz

1) if the Hall IC is programmed suitably
2) if more than 50% of the selected magnetic field range are used and the Hall IC is programmed suitably
3) The output signal is updated at the begin of each PWM period or Biphase-M period.
The update time depends on the output format settings.

Symbol	Parameter	Pin No.	Min.	Typ.	Max.	Unit	Conditions
t_{LVD}	Power-Down Time (time until output is off)			50	75	µs	
V_{LVD}	Power-Down Voltage	1	–	3.5	–	V	
V_{POD}	Power-On Reset Voltage	1	–	3.6	–	V	
BW	Small Signal Bandwidth (–3 dB)	3	–	2	–	kHz	B_{AC} < 10 mT; 3 dB Filter frequency = 2 kHz
$R_{DS,On}$	"On" Resistance R_{DS} of Output Transistor	3	– –	50 50	70 60	Ω Ω	T_J = 170°C (A-Type) T_J = 140°C (K-Type)
TO92UT Packages							
	Thermal Resistance						
R_{thja}	Junction to Air	–	–	–	235	K/W	Measured with a 1s0p board
R_{thjc}	Junction to Case	–	–	–	61	K/W	Measured with a 1s0p board
R_{thjs}	Junction to Solder Point	–	–	–	128	K/W	Measured with a 1s1p board

3.6.1. Specification of Biphase-M Output

In case of output format Biphase-M, a continuous data stream is provided. It consists of:

– 1 SYNC bit defining the bit time t_{p0},

– 14 data bits (DAT)

– 1 parity bit (DP)

– a gap (signal quiescent) of 8 x t_{p0}

The complete signal period is T = 24 x t_{p0}.

The signal quiescent level and the polarity of the SYNC bit is shown in Fig. 3–5.

Type	SYNC Bit Polarity
HAL855	negative

Definition of Biphase-M Pulses

A logical "0" is coded as no output level change within the bit time. A logical "1" is coded as an output level change between 50% and 80% of the bit time. After each bit, an output level change occurs.

Data Bits (DAT)

The 12 MSB of the 14 data bits (DAT) contain the digital output reading.

Data Parity Bit (DP)

This parity bit is "1" if the number of zeros within the 14 data bits is even. The parity bit is "0" if the number of zeros is odd.

Note: If the part number output is activated the part number will be transmitted 2 times after power-up (see also (see Fig. 4–6 on page 30). The first Biphase-M protocol respectively the first PWM period after power-up is not valid.

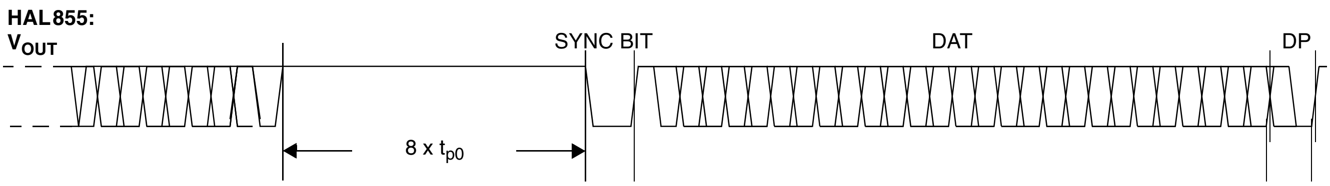


Fig. 3–5: Output format Biphase-M: continuous data stream

3.7. Magnetic Characteristics

at T_J = –40 °C to +170 °C, V_{DD} = 4.5 V to 14 V, after programming and locking of the device,
at Recommended Operation Conditions if not otherwise specified in the column “Conditions”.
Typical Characteristics for T_J = 25 °C and V_{DD} = 5 V.
For all other temperature ranges this table is also valid, but only in the junction temperature range defined by the temperature range (Example: For K-Type this table is limited to T_J = –40 °C to +140 °C).

Symbol	Parameter	Pin No.	Min.	Typ.	Max.	Unit	Conditions
B_{Offset}	Magnetic Offset	3	–1	0	1	mT	B = 0 mT, T_J = 25 °C
$\Delta B_{Offset}/\Delta T$	Magnetic Offset Change due to T_J		–15	0	15	µT/K	B = 0 mT
$\Delta\alpha$	Error of Linear Temperature Coefficient of Magnetic Sensitivity		–400	0	400	ppm/K	TC and TCSQ suitable for the application
$NL_{SB(T)}$	Integral Non-Linearity of Temperature Dependence of Sensitivity		– –	1 2	– –	% %	α < 2000 ppm/K α >= 2000 ppm/K TC and TCSQ suitable for the application
$B_{Hysteresis}$	Magnetic Hysteresis		–20	0	20	µT	Range = 30 mT, Filter = 500 Hz

Definition of Sensitivity Errors over Temperature

A ideal Hall-effect device would not be affected by temperature. Its temperature compensation would allow to compensate for a linear temperature coefficient α_{IDEAL} of a permanent magnet.

$$S_{IDEAL} = 1 + \alpha_{IDEAL} \times (T - T_0)$$

The temperature dependence of the sensitivity of a real sensor is not ideally linear. Its linear temperature coefficient α is determined by a linear least square fit.

$$S_B = S_0 \times (1 + \alpha \times (T - T_0) + res(T))$$

S_0 and α are the fit parameters, $res(T)$ the residual error.

Micronas specifies two sensitivity errors over temperature:

1. the error of the linear temperature coefficient α:

$$\Delta\alpha = \alpha - \alpha_{IDEAL}$$

2. the maximum residual error over temperature resulting from the least square fit, i.e., the integral non-linearity of the temperature dependence of sensitivity:

$$NL_{SB(T)} = max_T |res(T)|$$

3.8. Diagnosis Functions

The HAL 855 features various diagnosis functions, such as undervoltage detection and open-circuit detection. A description of the sensor's behavior is shown in the table below (Typical Characteristics for T_J = 25 °C).

Parameter	Min.	Typ.	Max.	Unit	Output Behavior
Undervoltage Detection Level $V_{DD, UV}$	3.0	3.5	4.0	V	No PWM output signal (output on high-level)
Open V_{DD} Line	–	–	–	–	No PWM output signal (output on high-level)
Open GND Line	–	–	–	–	No PWM output signal

Note: The undervoltage detection is activated only **after** locking the sensor!