MICRONAS

Hardware
Documentation

Data Sheet

HAL® 702

Dual Hall-Effect Sensor with Independent Outputs

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DSH000030_002EN

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Contents

Dual Hall-Effect Sensor with Independent Outputs

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

1. Introduction

The HAL702 is a monolithic CMOS Hall-effect sensor consisting of two independent switches controlling two independent open-drain outputs. The Hall plates of the two switches are spaced 2.35 mm apart.

The device includes temperature compensation and active offset compensation. These features provide excellent stability and matching of the switching points in the presence of mechanical stress over the whole temperature and supply voltage range.

The sensors are designed for industrial and automotive applications and operate with supply voltages from 4.5 V to 24 V in the ambient temperature range from –40 °C up to 125 °C.

The HAL702 is available in the SMD-package SOT89B-2.

1.1. Features

- two independent Hall-switches
- distance of Hall plates: 2.35 mm
- switching offset compensation at typically 150 kHz
- operation from 4.5 V to 24 V supply voltage
- operation with static and dynamic magnetic fields up to 10 kHz
- overvoltage protection at all pins
- reverse-voltage protection at V_{DD}-pin
- robustness of magnetic characteristics against mechanical stress
- short-circuit protected open-drain outputs by thermal shut down
- constant switching points over a wide supply voltage range
- EMC corresponding to ISO 7637

1.2. Marking Code

All Hall sensors have a marking on the package surface (branded side). This marking includes the name of the sensor and the temperature range.

1.3. Operating Junction Temperature Range (T_J)

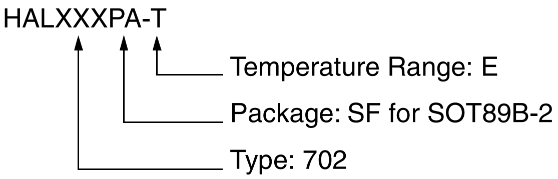
The Hall sensors from Micronas are specified to the chip temperature (junction temperature T_J).

The HAL702 is available in temperature range “E” only.

E: T_J = –40 °C to +100 °C

Note: Due to power dissipation, there is a difference between the ambient temperature (T_A) and junction temperature. Please refer to section 5.1. on page 17 for details.

1.4. Hall Sensor Package Codes



Example: **HAL702SF-E**

→ Type: 702
→ Package: SOT89B-2
→ Temperature Range: T_J = –40 °C to +100 °C

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

1.5. Solderability and Welding

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.

1.6. Pin Connections

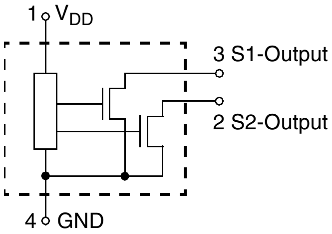


Fig. 1–1: Pin configuration

2. Functional Description

The HAL702 is a monolithic integrated circuit with two independent subblocks each consisting of a Hall plate and the corresponding comparator. Each subblock independently switches the comparator output in response to the magnetic field at the location of the corresponding sensitive area. If a magnetic field with flux lines perpendicular to the sensitive area is present, the biased Hall plate generates a Hall voltage proportional to this field. The Hall voltage is compared with the actual threshold level in the comparator. The subblocks are designed to have closely matched switching points. The output of comparator 1 attached to S1 controls the open drain output at Pin 3. Pin 2 is set according to the state of comparator 2 connected to S2.

The temperature-dependent bias – common to both subblocks – increases the supply voltage of the Hall plates and adjusts the switching points to the decreasing induction of magnets at higher temperatures. If the magnetic field exceeds the threshold levels, the comparator switches to the appropriate state. The built-in hysteresis prevents oscillations of the outputs.

The magnetic offset caused by mechanical stress is compensated for by use of “switching offset compensation techniques”. Therefore, an internal oscillator provides a two-phase clock to both subblocks. For each subblock, the Hall voltage is sampled at the end of the first phase. At the end of the second phase, both sampled and actual Hall voltages are averaged and compared with the actual switching point.

Shunt protection devices clamp voltage peaks at the output pins and V_{DD}-pin together with external series resistors. Reverse current is limited at the V_{DD}-pin by an internal series resistor up to –15 V. No external reverse protection diode is needed at the V_{DD}-pin for reverse voltages ranging from 0 V to –15 V.

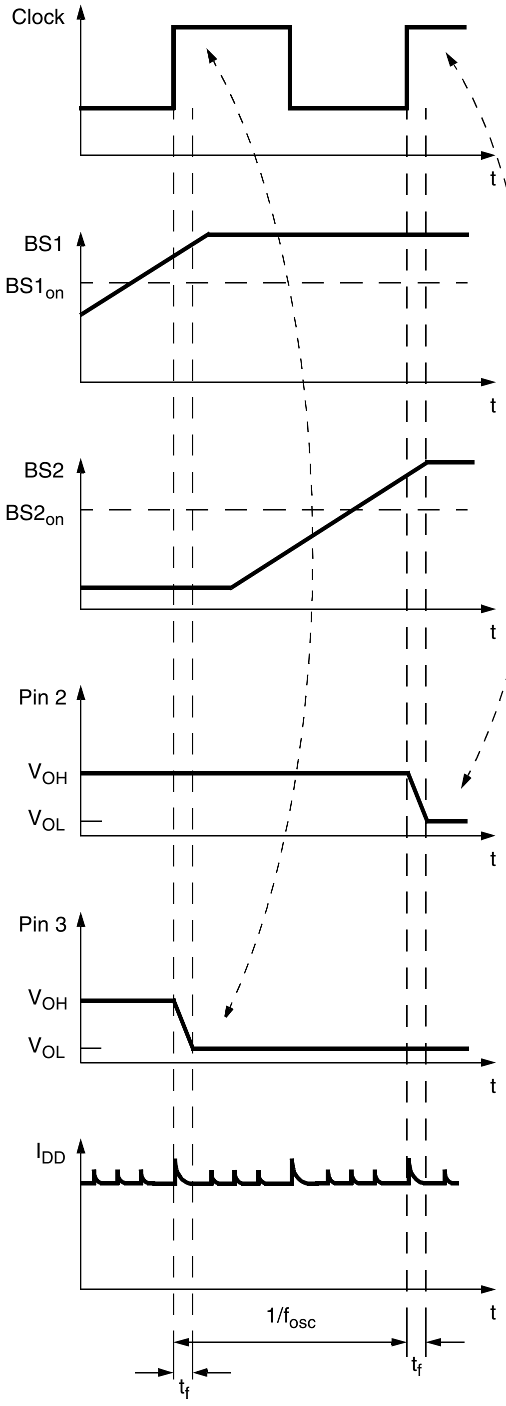


Fig. 2–1: HAL702 timing diagram with respect to the clock phase

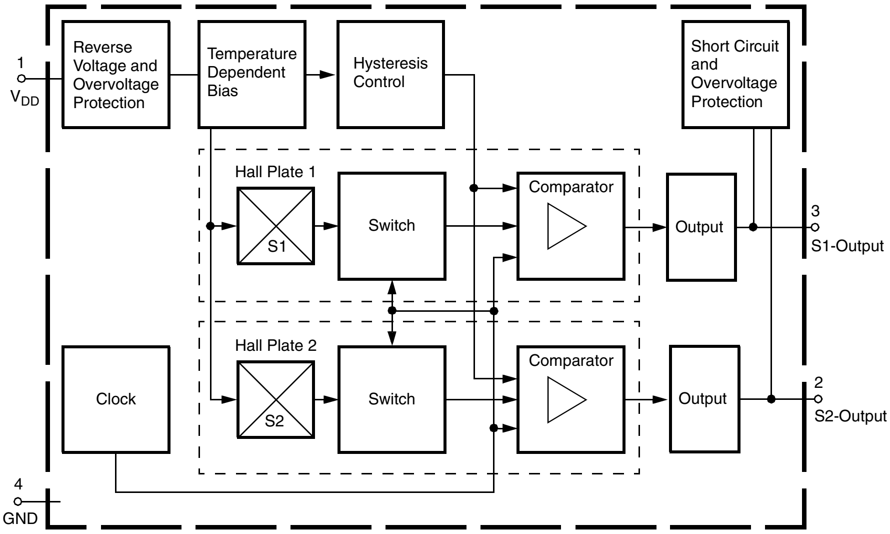
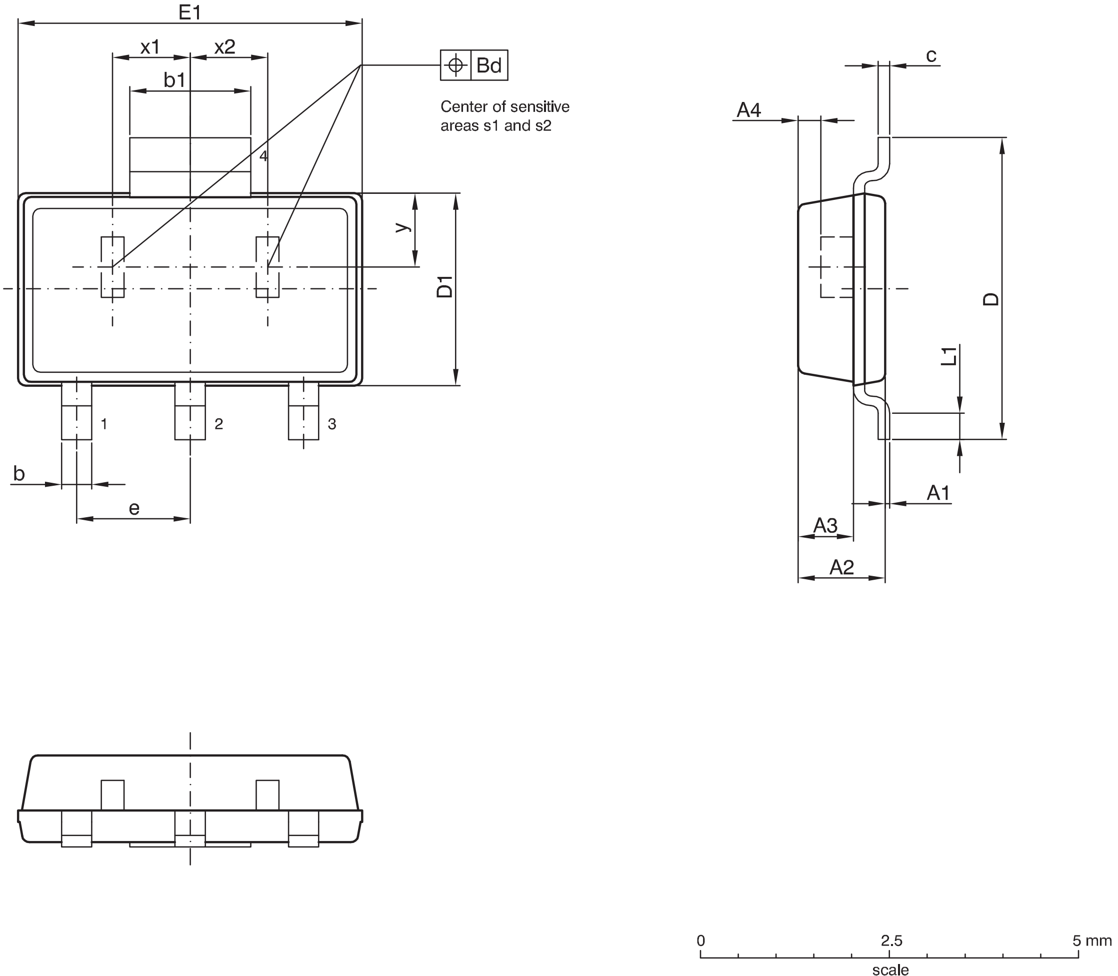


Fig. 2–2: HAL702 block diagram

3. Specifications

3.1. Outline Dimensions



physical dimensions do not include moldflash.

x1, x2, y = these dimensions are different for each sensor type and are specified in the data sheet.

UNIT	A1	A2	A3	A4	b	b1	Bd	c	D	D1	e	E1	L1
mm	0.10 0.02	1.20 1.10	0.73	0.3	0.4	1.7	0.2	0.15	4.0	2.6 2.5	1.5	4.6 4.5	0.25 min.

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ISSUE	ITEM NO.				
-	-		07-07-02	06655.0001.4	ZG001055_Ver.02

Fig. 3–1:
SOT89B-2: Plastic **S**mall **O**utline **T**ransistor package, 4 leads, with two sensitive areas
Weight approximately 0.034 g

3.2. Dimensions of Sensitive Area

0.25 mm × 0.12 mm

3.3. Positions of Sensitive Areas

	SOT89B-2
x_1+x_2	(2.35±0.001) mm
$x_1=x_2$	1.175 mm nominal
y	0.975 mm nominal

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	–15	28 1)	V
V_O	Output Voltage	2, 3	–0.3	28 1)	V
I_O	Continuous Output Current	2, 3	–	20 1)	mA
T_J	Junction Temperature Range		–40	170	°C
1) as long as T_{Jmax} is not exceeded					

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.

3.5. Recommended Operating Conditions

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

All voltages listed are referenced to ground (GND).

Symbol	Parameter	Pin No.	Min.	Typ.	Max.	Unit
V_{DD}	Supply Voltage	1	4.5	–	24	V
I_O	Continuous Output Current	3	0	–	10	mA
V_O	Output Voltage (output switch off)	3	0	–	24	V

3.6. Characteristics

at T_J = –40 °C to +100 °C, V_{DD} = 4.5 V to 24 V, GND = 0 V,
at Recommended Operation Conditions if not otherwise specified in the column “Conditions”.
Typical Characteristics for T_J = 25 °C and V_{DD} = 5 V.

Symbol	Parameter	Pin No.	Min.	Typ.	Max.	Unit	Test Conditions
I_{DD}	Supply Current	1	3	5.5	9	mA	T_J = 25 °C
I_{DD}	Supply Current over Temperature Range	1	2	7	10	mA	
V_{DDZ}	Overvoltage Protection at Supply	1	–	28.5	32	V	I_{DD} = 25 mA, T_J = 25 °C, t = 2 ms
V_{OZ}	Overvoltage Protection at Output	2, 3	–	28	32	V	I_O = 20 mA, T_J = 25 °C, t = 15 ms
V_{OL}	Output Voltage	2, 3	–	130	280	mV	I_{OL} = 10 mA, T_J = 25 °C
V_{OL}	Output Voltage over Temperature Range	2, 3	–	130	400	mV	I_{OL} = 10 mA
I_{OH}	Output Leakage Current	2, 3	–	0.06	0.1	µA	Output switched off, T_J = 25 °C, V_{OH} = 3.8 V to 24 V
I_{OH}	Output Leakage Current over Temperature Range	2, 3	–	–	10	µA	Output switched off, $T_J \leq$ 140 °C, V_{OH} = 3.8 V to 24 V
f_{osc}	Internal Sampling Frequency over Temperature Range	–	100	150	–	kHz	
$t_{en}(O)$	Enable Time of Output after Setting of V_{DD}	1	–	50	–	µs	V_{DD} = 12 V, $B > B_{on}$ + 2 mT or $B < B_{off}$ – 2 mT
t_r	Output Rise Time	2, 3	–	0.2	–	µs	V_{DD} = 12 V, R_L = 2.4 kΩ, C_L = 20 pF
t_f	Output FallTime	2, 3	–	0.2	–	µs	V_{DD} = 12 V, R_L = 2.4 kΩ, C_L = 20 pF
R_{thJSB} case SOT89B-2	Thermal Resistance Junction to Substrate Backside	–	–	150	200	K/W	Fiberglass Substrate 30 mm x 10 mm x 1.5 mm, pad size (see Fig. 3–2)

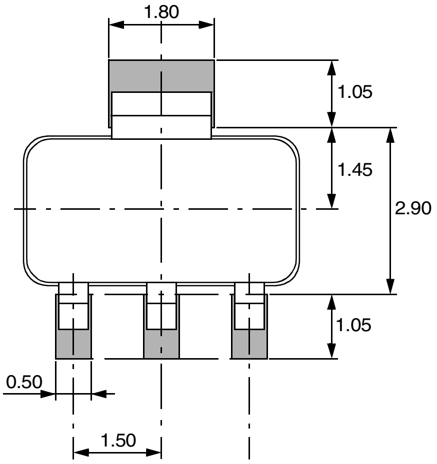

Fig. 3–2: Recommended footprint SOT89B-2, dimensions in mm
All dimensions are for reference only. The pad size may vary depending on the requirements of the soldering process.

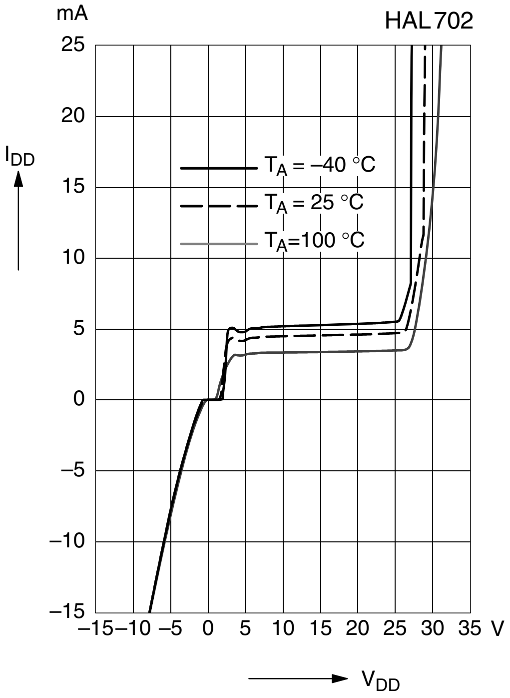

Fig. 3–3: Typical supply current versus supply voltage

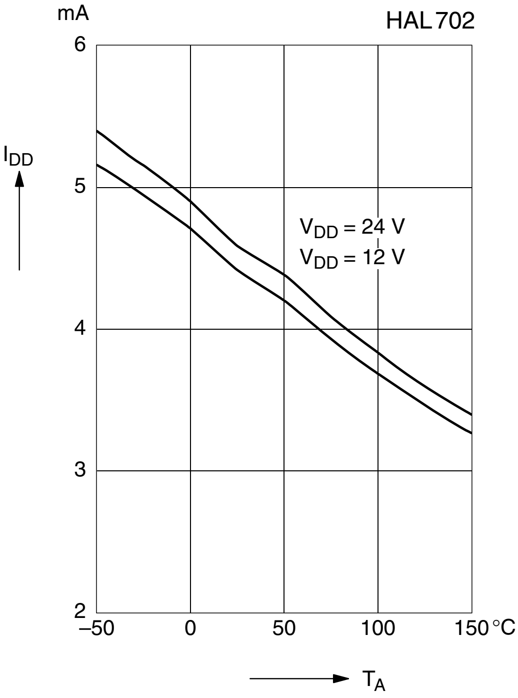

Fig. 3–5: Typical supply current versus ambient temperature

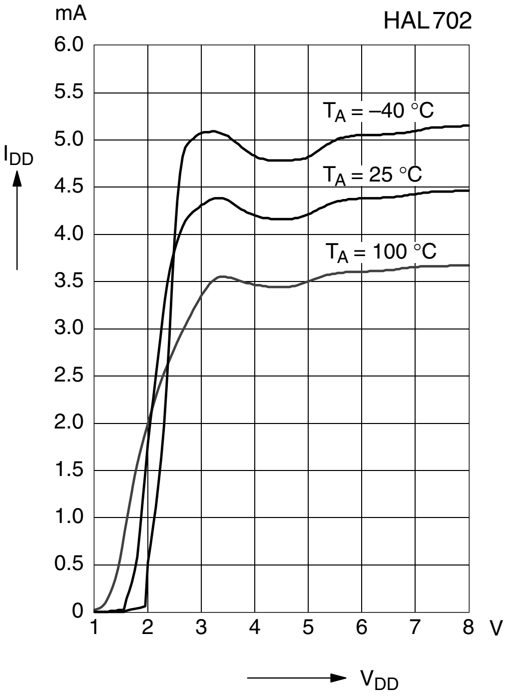

Fig. 3–4: Typical supply current versus supply voltage

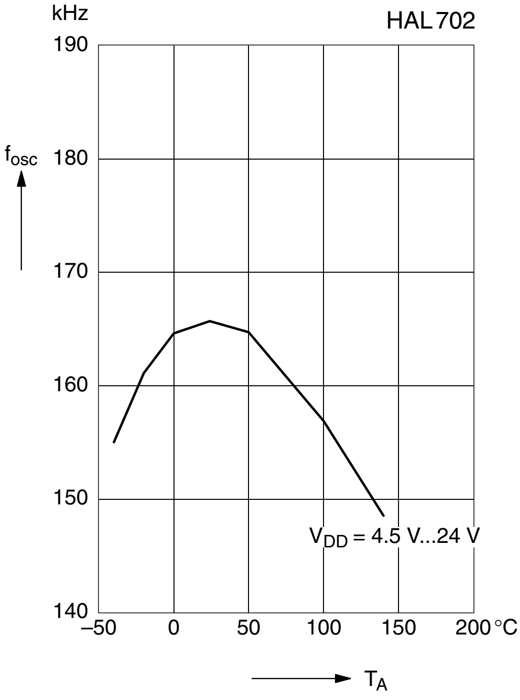

Fig. 3–6: Typ. internal chopper frequency versus ambient temperature

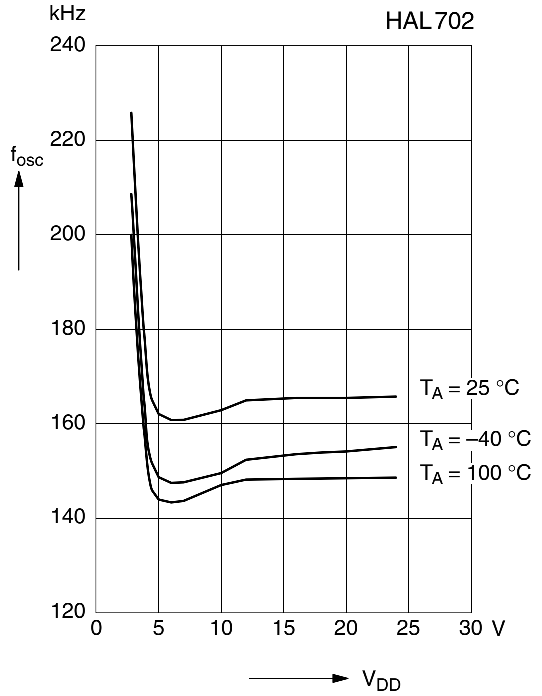

Fig. 3–7: Typ. internal chopper frequency versus supply voltage

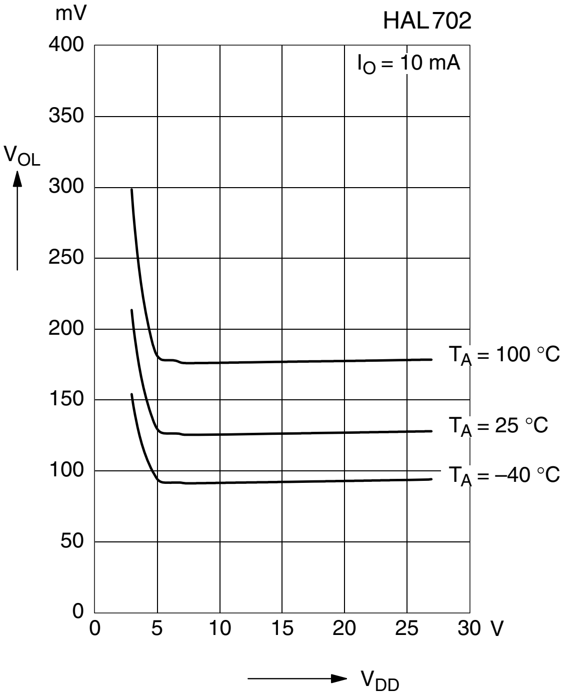

Fig. 3–9: Typical output low voltage versus supply voltage

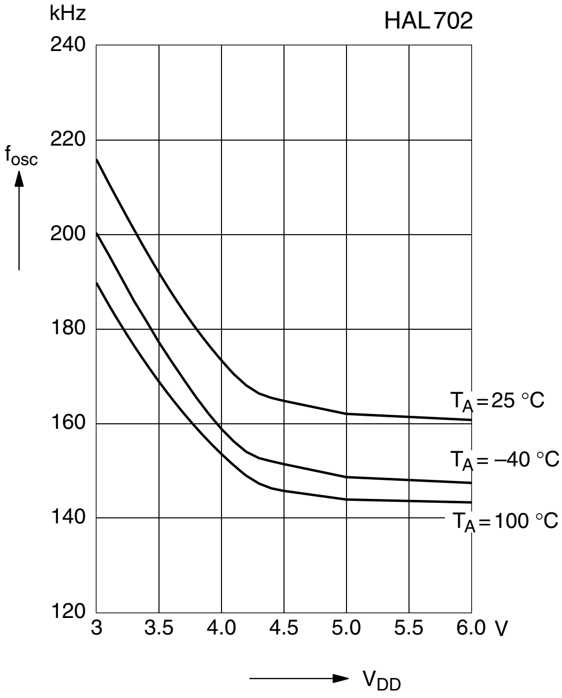

Fig. 3–8: Typ. internal chopper frequency versus supply voltage

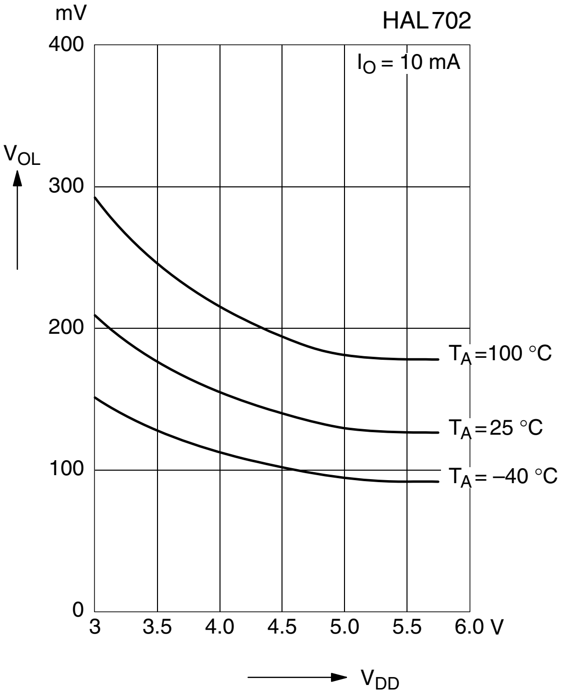

Fig. 3–10: Typical output low voltage versus supply voltage

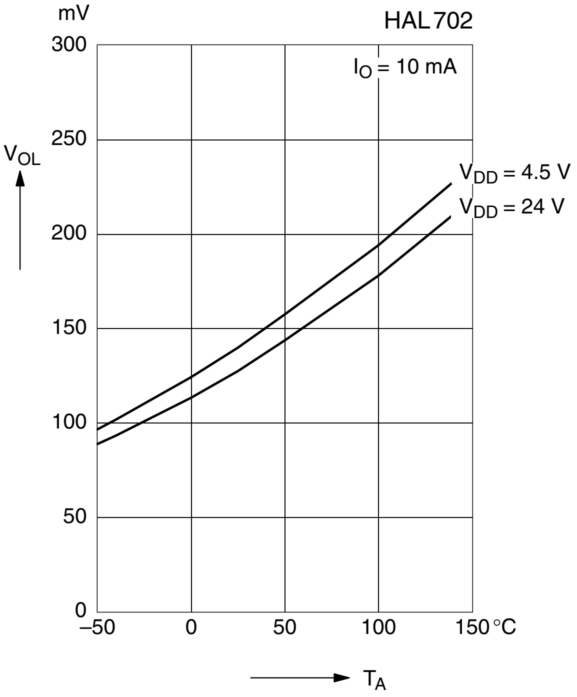

Fig. 3–11: Typical output low voltage versus ambient temperature

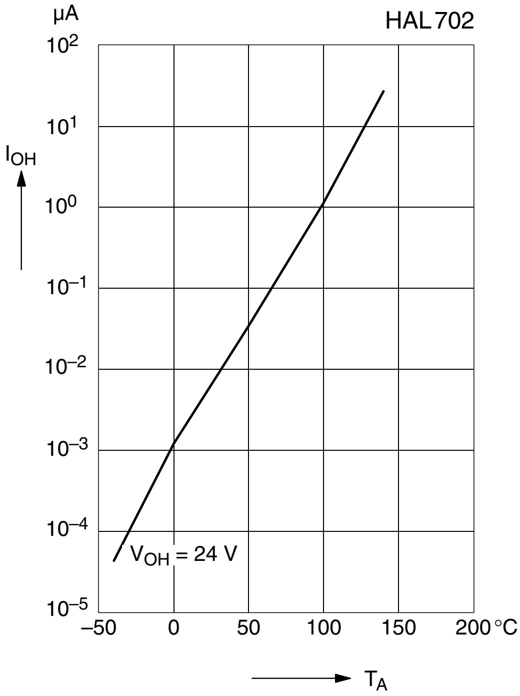

Fig. 3–13: Typical output leakage current versus ambient temperature

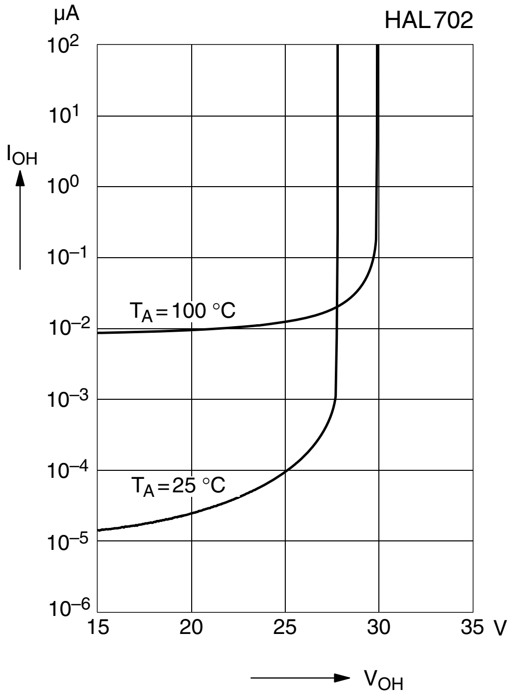

Fig. 3–12: Typical output leakage current versus output voltage

4. Type Description

4.1. HAL702

The HAL702 consists of two independent bipolar switches (see Fig. 4–1) with closely matched magnetic characteristics controlling two independent open-drain outputs. The Hall plates of the two switches are spaced 2.35 mm apart.

In combination with an active target providing a sequence of alternating magnetic north and south poles, the sensor forms a system generating the signals required to control position, speed, and direction of the target movement.

Magnetic Features

- two independent Hall-switches
- distance of Hall plates: 2.35 mm
- typical B_{ON}: 2 mT at room temperature
- typical B_{OFF}: –2 mT at room temperature
- temperature coefficient of –2000 ppm/K in all magnetic characteristics
- operation with static magnetic fields and dynamic magnetic fields up to 10 kHz

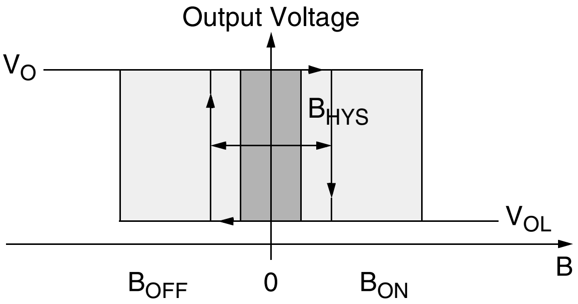

Fig. 4–1: Definition of magnetic switching points for the HAL702

Positive flux density values refer to magnetic south pole at the branded side of the package.

Applications

The HAL702 is the ideal sensors for position-control applications with direction detection and alternating magnetic signals such as:

- multipole magnet applications,
- rotating speed and direction measurement, position tracking (active targets), and
- window lifters.

Magnetic Thresholds

(quasistationary: dB/dt<0.5 mT/ms)

at T_J = –40 °C to +100 °C, V_{DD} = 4.5 V to 24 V, as not otherwise specified

Typical characteristics for T_J = 25 °C and V_{DD} = 5 V

Parameter	On-Point B_{S1on}, B_{S2on}			Off-Point B_{S1off}, B_{S2off}			Unit
T_j	Min.	Typ.	Max.	Min.	Typ.	Max.	
–40 °C	–1.5	2.0	5.5	–5.5	–2.0	1.5	mT
25 °C	–1.5	1.8	5.5	–5.5	–1.8	1.5	mT
100 °C	–3.0	1.5	5.5	–5.5	–1.5	3.0	mT

Matching B_{S1} and B_{S2}

(quasistationary: dB/dt<0.5 mT/ms)

at T_J = –40 °C to +100 °C, V_{DD} = 4.5 V to 24 V, as not otherwise specified

Typical characteristics for T_J = 25 °C and V_{DD} = 5 V

Parameter	$B_{S1on} - B_{S2on}$			$B_{S1off} - B_{S2off}$			Unit
T_j	Min.	Typ	Max.	Min.	Typ	Max.	
–40 °C	–4.0	0	4.0	–4.0	0	4.0	mT
25 °C	–4.0	0	4.0	–4.0	0	4.0	mT
100 °C	–4.0	0	4.0	–4.0	0	4.0	mT

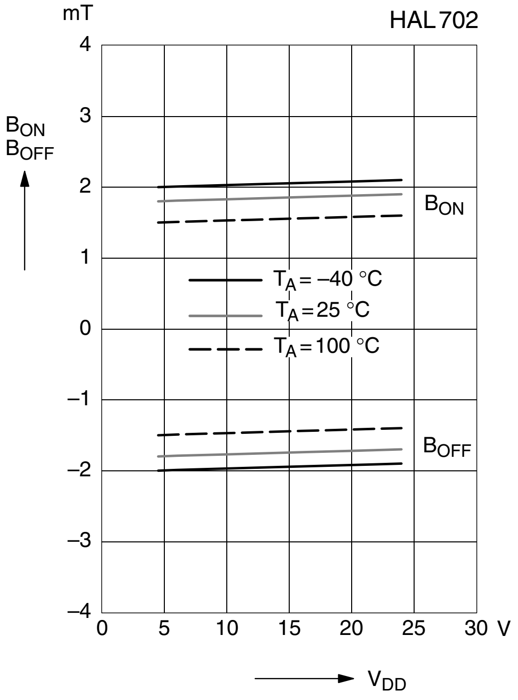

Fig. 4–2: Magnetic switching points versus supply voltage

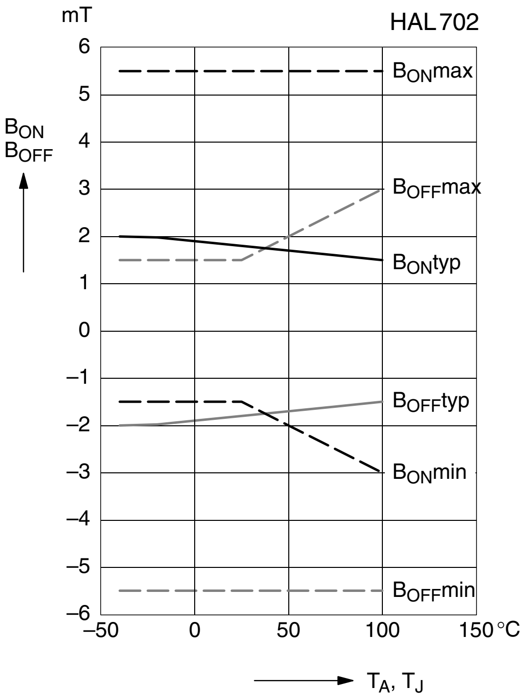

Fig. 4–3: Magnetic switching points versus ambient temperature

5. Application Notes

5.1. Ambient Temperature

Due to the internal power dissipation, the temperature on the silicon chip (junction temperature T_J) is higher than the temperature outside the package (ambient temperature T_A).

$T_J = T_A + \Delta T$

At static conditions and continuous operation, the following equation applies:

$\Delta T = I_{DD} * V_{DD} * R_{th}$

For typical values, use the typical parameters. For worst case calculation, use the max. parameters for I_{DD} and R_{th}, and the max. value for V_{DD} from the application.

For all sensors, the junction temperature range T_J is specified. The maximum ambient temperature T_{Amax} can be calculated as:

$T_{Amax} = T_{Jmax} - \Delta T$

5.2. Extended Operating Conditions

All sensors fulfill the electrical and magnetic characteristics when operated within the Recommended Operating Conditions (see Section 3.5. on page 10).

Supply Voltage Below 4.5 V

Typically, the sensors operate with supply voltages above 3 V, however, below 4.5 V some characteristics may be outside the specification.

Note: The functionality of the sensor below 4.5 V is not tested. For special test conditions, please contact Micronas.

5.3. Start-Up Behavior

Due to the active offset compensation, the sensors have an initialization time (enable time $t_{en(O)}$) after applying the supply voltage. The parameter $t_{en(O)}$ is specified in the “Characteristics” (see Section 3.6. on page 11).

During the initialization time, the output states are not defined and the outputs can toggle. After $t_{en(O)}$, both outputs will be either high or low for a stable magnetic field (no toggling). The outputs will be low if the applied magnetic flux density B exceeds B_{ON} and high if B drops below B_{OFF}.

For magnetic fields between B_{OFF} and B_{ON}, the output states of the Hall sensor after applying V_{DD} will be either low or high. In order to achieve a well-defined output state, the applied magnetic flux density must be above B_{ONmax}, respectively, below B_{OFFmin}.

5.4. EMC and ESD

For applications that cause disturbances on the supply line or radiated disturbances, a series resistor and a capacitor are recommended (see Fig. 5–1). The series resistor and the capacitor should be placed as closely as possible to the Hall sensor.

Please contact Micronas for detailed investigation reports with EMC and ESD results.

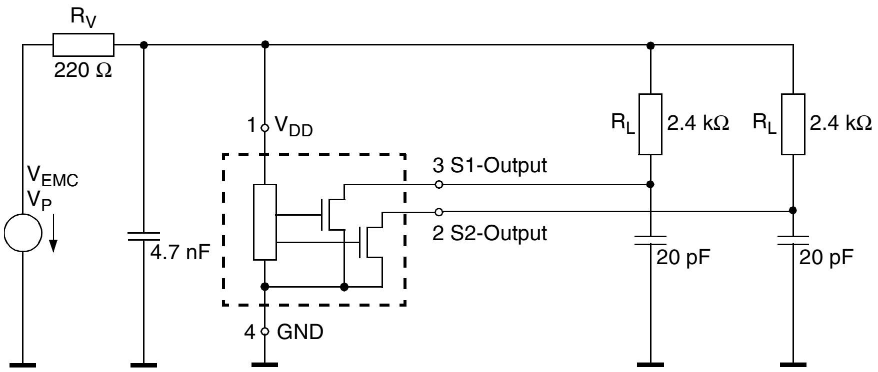

Fig. 5–1: Test circuit for EMC investigations

6. Data Sheet History

1. Data Sheet: “HAL702 Dual Hall-Effect Sensor with Independent Outputs”, April 4, 2005, 6251-669-1DS. First release of the data sheet.
2. Data Sheet: “HAL702 Dual Hall-Effect Sensor with Independent Outputs”, Feb. 11, 2009, DSH000030_002EN. Second release of the data sheet. Major changes:

- Section 1.5. “Solderability and Welding” updated
- Section 3.1.”Outline Dimensions” updated

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