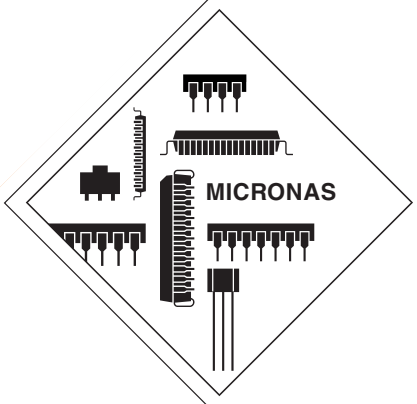


ADVANCE INFORMATION

HAL710
Hall-Effect Sensor with Direction Detection

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6251-478-1AI

MICRONAS

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Hall-Effect Sensor with Direction Detection

1. Introduction

The HAL 710 is a monolithic integrated Hall-effect sensor manufactured in CMOS technology with two independent Hall plates S1 and S2 spaced 2.35 mm apart. The device has two open-drain outputs:

The 'Count Output' operates like a single latched Hall switch according to the magnetic field present at Hall plate S1 (see Fig. 3–3).

The 'Direction Output' indicates the direction of a linear or rotating movement of magnetic objects.

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.

The internal circuitry evaluates the direction of the movement and updates the 'Direction Output' at every edge of the 'Count Signal' (rising and falling). The Direction Output is high if the target moves from Hall plate S1 to Hall plate S2. It is low if the target first passes plate S2 and later plate S1. The state of the Direction Output only changes at a rising or falling edge of the Count Output.

The design ensures a setup time for the Direction Output with respect to the corresponding Count Signal edge of 1/2 clock periods (1 µs minimum).

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. This is required by systems determining the direction from the comparison of two transducer signals.

The sensor is designed for industrial and automotive applications and operates with supply voltages from 3.8 V to 24 V in the ambient temperature range from –40 °C up to 125 °C.

The HAL 710 is available in the SMD package SOT-89B.

1.1. Features

- generation of 'Count Signals' and 'Direction Signals'
- delay of the 'Count Signals' with respect to the 'Direction Signal' of 1 µs minimum
- switching type latching
- low sensitivity
- typical B_{ON}: 14.9 mT at room temperature
- typical B_{OFF}: –14.9 mT at room temperature
- temperature coefficient of –2000 ppm/K in all magnetic characteristics
- switching offset compensation at typically 150 kHz
- operation from 3.8 V to 24 V supply voltage
- operation with static magnetic fields 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 DIN 40839

1.2. Applications

The HAL 710 is the optimal sensor 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.

1.3. 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.

Type	Temperature Range	
	K	E
HAL710	710K	710E

1.3.1. Special Marking of Prototype Parts

Prototype parts are coded with an underscore beneath the temperature range letter on each IC. They may be used for lab experiments and design-ins but are not intended to be used for qualification test or as production parts.

1.4. Operating Junction Temperature Range

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

K: T_J = –40 °C to +140 °C

E: T_J = –40 °C to +100 °C

The relationship between ambient temperature (T_A) and junction temperature is explained in Section 4.1. on page 11.

1.5. Hall Sensor Package Codes

HALXXXPA-T

Temperature Range: K, or E

Package: SF for SOT-89B

Type: 710

Example: **HAL 710SF-K**

→ Type: 710
→ Package: SOT-89B
→ Temperature Range: T_J = –40 °C to +140 °C

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

1.6. Solderability

All packages: according to IEC68-2-58

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

Components stored in the original packaging should provide a shelf life of at least 12 months, starting from the date code printed on the labels, even in environments as extreme as 40 °C and 90% relative humidity.

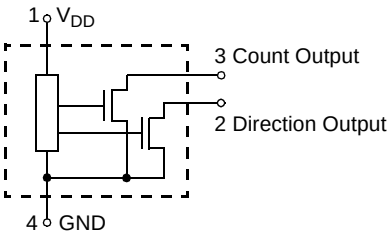


Fig. 1–1: Pin configuration

2. Functional Description

The HAL 710 is a monolithic integrated circuit with two independent subblocks consisting each 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 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.

In order to achieve good matching of the switching points of both subblocks, 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.

The output of comparator 1 (connected to S1) directly controls the ‘Count Output’. The outputs of both comparators enter the ‘Direction Detection Block’ controlling the state of the ‘Direction Output’. The ‘Direction Output’ is ’high’ if the edge at the output of comparator 1 precedes that at comparator 2. In the opposite case, ‘Direction Output’ is ’low’. The previous state of the ‘Direction Output’ is maintained between edges of the ‘Count Output’ and in case the edges at comparator 1 and comparator 2 occur in the same clock period.

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.

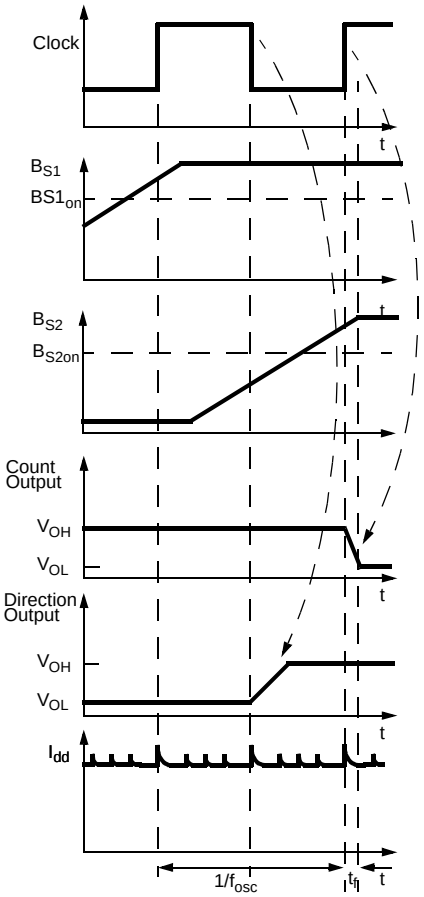


Fig. 2–1: Timing diagram

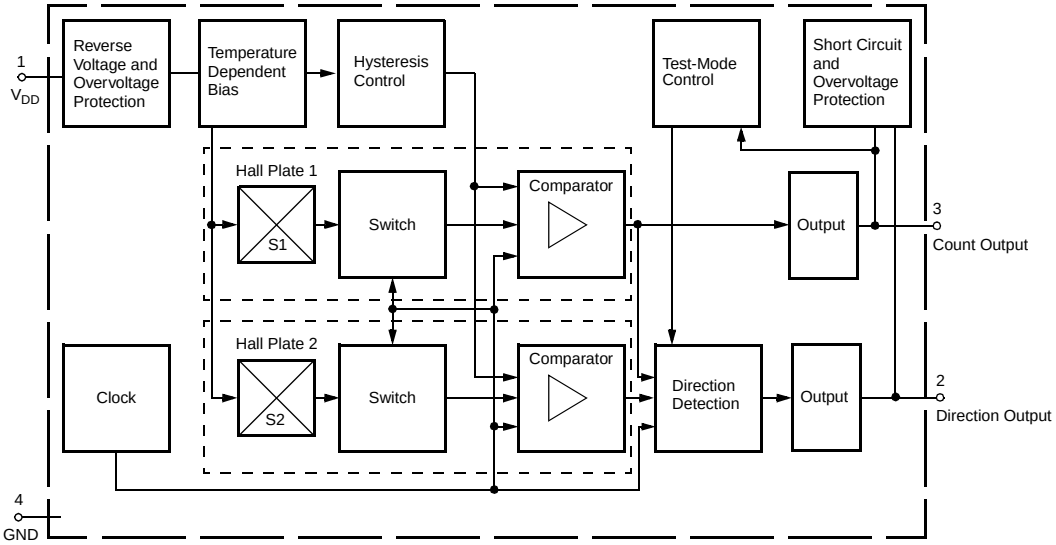


Fig. 2–2: HAL 710 block diagram

3. Specifications

3.1. Outline Dimensions

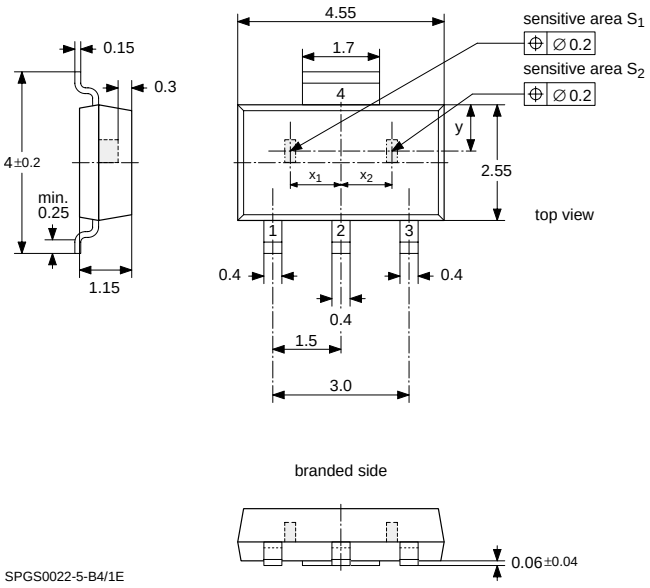


Fig. 3–1:
Plastic Small Outline Transistor Package
(SOT-89B)
Weight approximately 0.035 g
Dimensions in mm

3.2. Dimensions of Sensitive Areas

Dimensions: 0.25 mm × 0.12 mm

3.3. Positions of Sensitive Areas

	SOT-89B
x_1+x_2	(2.35±0.001) mm
$x_1=x_2$	1.175 mm nominal
y	0.975 mm nominal

Note: For all package diagrams, a mechanical tolerance of ±0.05 mm applies to all dimensions where no tolerance is explicitly given.

3.4. Absolute Maximum Ratings

Symbol	Parameter	Pin No.	Min.	Max.	Unit
V_{DD}	Supply Voltage	1	–15	28[1)]	V
$-V_P$	Supply Voltage	1	–24[2)]	28[1)]	V
$-I_{DD}$	Reverse Supply Current	1	–	50[1)]	mA
I_{DDZ}	Supply Current through Protection Device	1	–100[3)]	100[3)]	mA
V_O	Output Voltage	2, 3	–0.3	28[1)]	V
I_O	Continuous Output On Current	2, 3	–	20[1)]	mA
I_{Omax}	Peak Output On Current	2, 3	–	150[3)]	mA
I_{OZ}	Output Current through Protection Device	3	–200[3)]	200[3)]	mA
T_S	Storage Temperature Range		–65	150[5)]	°C
T_J	Junction Temperature Range		–40 –40	170[4)] 150	°C °C

[1)] as long, as T_{Jmax} is not exceeded
[2)] with a 220-Ω series resistance at pin 1 corresponding to test circuit 1
[3)] t < 2 ms
[4)] t < 1000 h
[5)] Components stored in the original packaging should provide a shelf life of at least 12 months, starting from the date code printed on the labels, even in environments as extreme as 40 °C and 90% relative humidity.

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 or any other conditions beyond those indicated in the “Recommended Operating Conditions/Characteristics” of this specification is not implied. Exposure to absolute maximum ratings conditions for extended periods may affect device reliability.

3.5. Recommended Operating Conditions

Symbol	Parameter	Pin No.	Min.	Typ.	Max.	Unit
V_{DD}	Supply Voltage	1	3.8	–	24	V
I_O	Continuous Output Current	3	0	–	10	mA
V_O	Output Voltage (output switch off)	3	0	–	24	V

3.6. Electrical Characteristics

at T_J = –40 °C to +140 °C, V_{DD} = 3.8 V to 24 V, as not otherwise specified in Conditions.
Typical Characteristics for T_J = 25 °C and V_{DD} = 5 V.

Symbol	Parameter	Pin No.	Min.	Typ.	Max.	Unit	Conditions
I_{DD}	Supply Current	1	2	5.5	9	mA	T_J = 25 °C
I_{DD}	Supply Current over Temperature Range	1		7	10	mA	
V_{DDZ}	Overvoltage Protection at Supply	1		28.5	32	V	I_{DD} = 25 mA, T_J = 25 °C, t = 20 ms
V_{OZ}	Overvoltage Protection at Output	2,3		28	32	V	I_{OH} = 25 mA, T_J = 25 °C, t = 20 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	–	130	150	–	kHz	T_J = 25 °C
f_{osc}	Internal sampling frequency over Temperature Range	–	100	150	–	kHz	
t_{en}(O)	Enable Time of Output after Setting of V_{DD}			50	100	µs	V_{DD} = 12 V, B>B_{on} + 2 mT or B<B_{off} – 2 mT
t_r	Output Rise Time	2,3		1.2		µs	V_{DD} = 12 V, R_L= 20 kΩ, C_L= 20 pF
t_f	Output FallTime	2,3		0.2	1.6	µs	V_{DD} = 12 V, R_L= 20 kΩ, C_L= 20 pF
R_{thSB} SOT-89B	Thermal Resistance Junction to Substrate Backside	–	–	150	200	K/W	Fiberglass Substrate 30 mm x 10mm x 1.5mm, pad size see Fig. 3–2

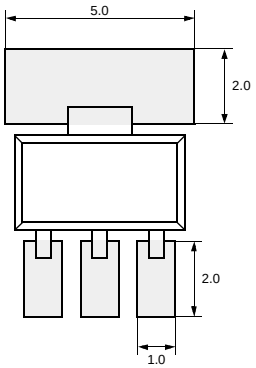


Fig. 3–2: Recommended pad size for SOT-89B
Dimensions in mm

3.7. Magnetic Characteristics

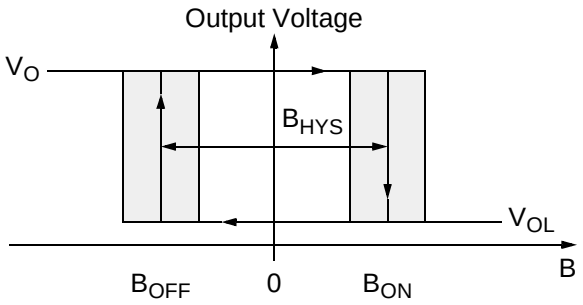


Fig. 3–3: Definition of magnetic switching points for the HAL710

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

3.7.1. Magnetic Thresholds

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

at T_J = –40 °C to +140 °C, V_{DD} = 3.8 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	12.5	16.3	20	–20	–16.3	–12.5	mT
25 °C	10.7	14.9	19.1	–19.1	–14.9	–10.7	mT
100 °C	tbd	tbd	tbd	tbd	tbd	tbd	mT
140 °C	6.0	10.9	16.0	–16.0	–10.9	–6.0	mT

3.7.2. Matching B_{S1} and B_{S2}

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

at T_J = –40 °C to +140 °C, V_{DD} = 3.8 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	–7.5	0	7.5	–7.5	0	7.5	mT
25 °C	–7.5	0	7.5	–7.5	0	7.5	mT
100 °C	–7.5	0	7.5	–7.5	0	7.5	mT
140 °C	–7.5	0	7.5	–7.5	0	7.5	mT

3.7.3. Hysteresis Matching

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

at T_J = –40 °C to +140 °C, V_{DD} = 3.8 V to 24 V, as not otherwise specified

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

Parameter	$(B_{S1on} - B_{S1off}) / (B_{S2on} - B_{S2off})$			Unit
T_j	Min.	Typ.	Max.	
–40 °C	0.85	1.0	1.2	–
25 °C	0.85	1.0	1.2	–
100 °C	0.85	1.0	1.2	–
140 °C	0.85	1.0	1.2	–

4. Application Notes

4.1. 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, the following equation is valid:

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

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:

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

4.2. Extended Operating Conditions

All sensors fulfil the electrical and magnetic characteristics when operated within the Recommended Operating Conditions (see page 8)

Supply Voltage Below 3.8 V

Typically, the sensors operate with supply voltages above 3 V, however, below 3.8 V some characteristics may be outside the specification.

Note: The functionality of the sensor below 3.8 V is not tested. For special test conditions, please contact Micronas.

4.3. Signal Delay

The extra circuitry required for the direction detection increases the latency of the ‘Count and Direction Signal’ compared to a simple switch (e.g. HAL 525). This extra delay corresponds to 0.5 and 1 clock period for the ‘Direction Signal’ and ‘Count Signal’ respectively.

4.4. Test Mode Activation

In order to obtain the normal operation as described above, two external pull-up resistors with appropriate values are required to connect each output to an external supply, such that the potential at the open-drain output rises to at least 3 V in less than 10 µs after having turned off the corresponding pull-down transistor or after having applied V_{DD}.

If the ‘Direction Output’ is pulled low externally (the potential does not rise after the internal pull-down transistor has been turned off), the device enters Manufacturer Test Mode.

Direction Detection is not functional in Manufacturer Test Mode. The device returns to ‘Normal Operation’ as soon as the ‘Count Output’ goes high.

Please note, that the presence of a Manufacturer Test Mode requires appropriate measures to prevent accidental activation (e.g. in response to EMC events).

4.5. 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 Electrical Characteristics (see page 9)

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) and the ‘Count Output’ will be low if the applied magnetic field B exceeds B_{ON}. The ‘Count Output’ will be high if B drops below B_{OFF}. The ‘Direction Output’ will have the correct state after the second edge (rising or falling) in the same direction.

The device contains a Power-On Reset circuit (POR) generating a reset when V_{DD} rises. This signal is used to initialize both outputs in the ‘Off-state’ (i.e. Output High) and to disable Test Mode. The generation of this Reset Signal is guaranteed when V_{DD} at the chip rises to minimum 3.8 V in less than 4 µs monotonically. If this condition is violated, the internal reset signal might be missing. Under these circumstances the chip will still operate according to the specification, but the risk of toggling outputs during $t_{en(O)}$ increases and 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 field then must exceed B_{ONmax}, respectively drop below B_{OFFmin}.

4.6. 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. 4–1). 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.

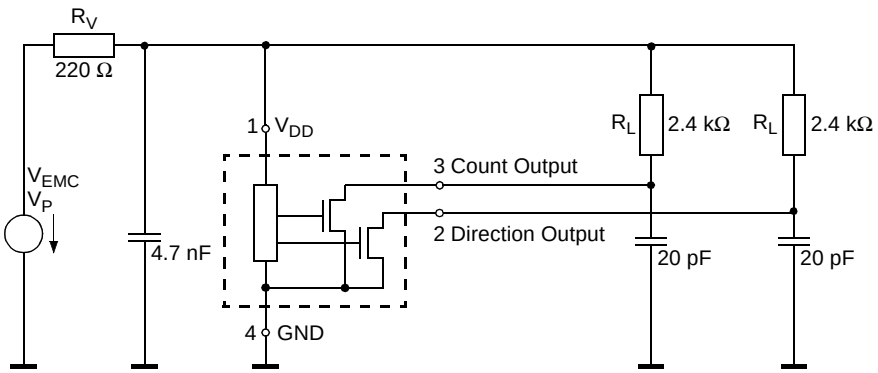


Fig. 4–1: Test circuit for EMC investigations

5. Data Sheet History

1. Advance Information: “HAL 710 Hall-Effect Sensor with Direction Detection”, Feb. 20, 2001, 6251-478-1AI. First release of the advance information.

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