

## HAL621, HAL629 Hall Effect Sensor Family

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## Hall Effect Sensor Family in CMOS technology

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

### 1. Introduction

The HAL62x family consists of different Hall switches produced in CMOS technology. All sensors include a temperature-compensated Hall plate with active offset compensation, a filter, a comparator, and an open-drain output transistor. The comparator compares the actual magnetic flux through the Hall plate (Hall voltage) with the fixed reference values (switching points). Accordingly, the output transistor is switched on or off. The sensors of this family differ in their magnetic characteristics.

All sensors contain an enhanced internal signal processing for very high repeatability requirements of the output signal. These sensors are the optimal solution for CAM and crank sensor applications.

The active offset compensation leads to magnetic parameters which are robust against mechanical stress effects. In addition, the magnetic characteristics are constant in the full supply voltage and temperature range.

The sensors are designed for industrial and automotive applications and operate with supply voltages from 4.2 V to 24 V in the ambient temperature range from -40 °C up to 150 °C.

All sensors are available in the SMD-package (SOT-89B) and in the leaded version (TO-92UA).

#### 1.1. Features:

- switching offset compensation at typically 360 kHz
- signal processing with chopper stabilized filter
- operates from 4.2 V to 24 V supply voltage
- operates with static magnetic fields and dynamic magnetic fields up to 15 kHz
- overvoltage protection at all pins
- reverse-voltage protection at  $V_{DD}$ -pin
- magnetic characteristics are robust against mechanical stress effects
- short-circuit protected open-drain output by thermal shut down
- constant switching points over a wide supply voltage range
- ideal sensor for applications in extreme automotive and industrial environments
- EMC and ESD optimized design

### 1.2. Family Overview

The types differ according to the magnetic flux density values for the switching points and the mode of switching.

Type	Switching Behavior	Sensitivity	see Page
621	bipolar	very high	12
629	unipolar	medium	14

**Note:** The HAL629 is the improved successor of the HAL 628 with the same magnetic characteristics.

#### Bipolar Switching Sensors:

The output turns low with the magnetic south pole on the branded side of the package and turns high with the magnetic north pole on the branded side. The output state is not defined for all sensors if the magnetic field is removed again. Some sensors will change the output state and some sensors will not.

#### Unipolar Switching Sensors:

The output turns low with the magnetic south pole on the branded side of the package and turns high if the magnetic field is removed. The sensor does not respond to the magnetic north pole on the branded side.

## 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		
	A	K	E
HAL 621	621A	621K	621E
HAL 629	629A	629K	629E

### 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 tests or as production parts.

## 1.4. Operating Junction Temperature Range

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

**A:**  $T_J = -40\text{ °C to }+170\text{ °C}$

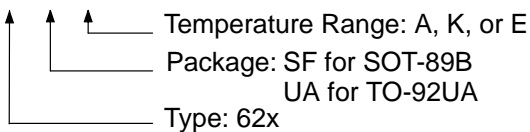
**K:**  $T_J = -40\text{ °C to }+140\text{ °C}$

**E:**  $T_J = -40\text{ °C to }+100\text{ °C}$

The relationship between ambient temperature ( $T_A$ ) and junction temperature is explained in section 5.1. on page 16.

## 1.5. Hall Sensor Package Codes

HALXXXPA-T



Example: **HAL 629UA-E**

→ Type: 629

→ Package: TO-92UA

→ Temperature Range:  $T_J = -40\text{ °C to }+100\text{ °C}$

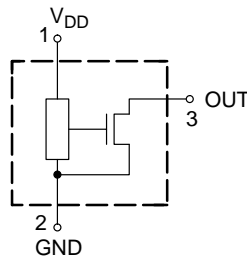
Hall sensors are available in a wide variety of packaging versions and quantities. For more detailed information, please refer to the brochure: "Ordering Codes for Hall Sensors".

## 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 HAL62x sensors are monolithic integrated circuits which switch in response to magnetic fields. If a magnetic flux perpendicular to the sensitive area is applied to the sensor, the Hall plate generates a Hall voltage proportional to this field.

The total voltage which appears at the Hall plate is influenced by offset voltages (e. g. caused by mechanical stress). This offset voltage is compensated for by cyclic commutation of the connections for current flow and voltage measurement which makes the switching offset compensation technique possible. Therefore, an internal oscillator provides a clock. The output voltage of the switched Hall plate contains the Hall voltage as a DC or low frequency signal and the offset voltage as an AC signal at the chopper frequency. The following chopper stabilized low-pass filter suppresses the offset voltage and the output signal is the offset compensated Hall voltage.

The following comparator block compares this offset compensated Hall voltage with the defined switching points  $B_{ON}$ . It remains in this state as long as the magnetic field does not fall below the release point  $B_{OFF}$ . If the magnetic field falls below  $B_{OFF}$ , the transistor is switched off until the magnetic field once again exceeds  $B_{ON}$ . The built-in hysteresis eliminates oscillation.

According to the principle of the circuit, there is a fixed delay time  $t_{delay}$  of typical 25  $\mu s$  from crossing the magnetic thresholds to the switching of the output (see Fig. 2-2).

The temperature-dependent bias regulates the supply voltage of the Hall plates and adjusts the switching points to the decreasing induction of magnets at higher temperatures.

The output is short circuit protected by limiting high currents and by sensing overtemperature. Shunt protection devices clamp voltage peaks at the Output-pin 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  $-15 V$ .

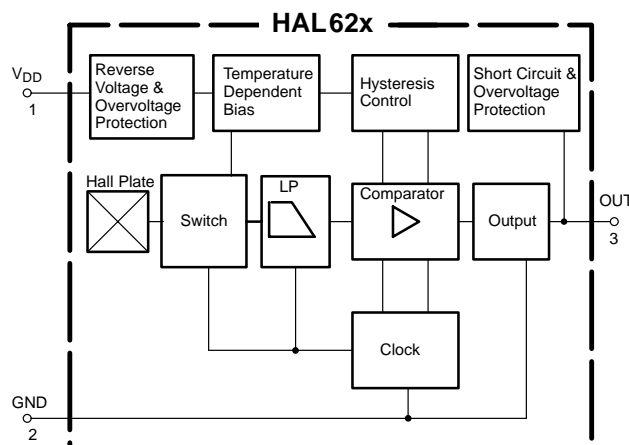


Fig. 2-1: HAL62x block diagram

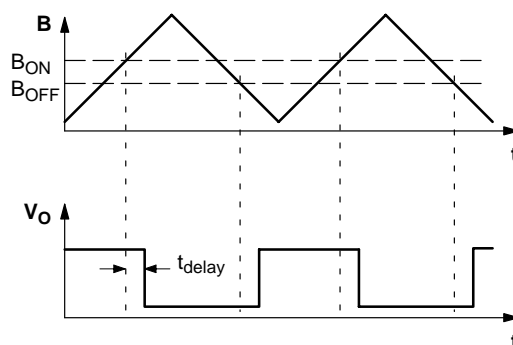
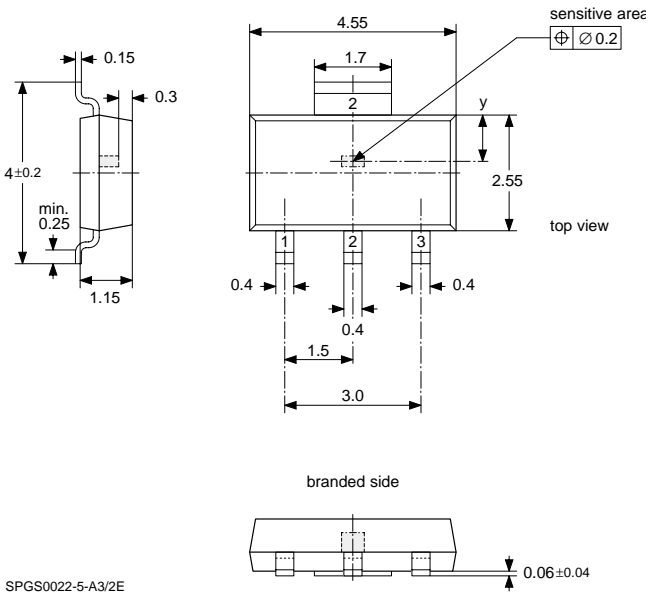


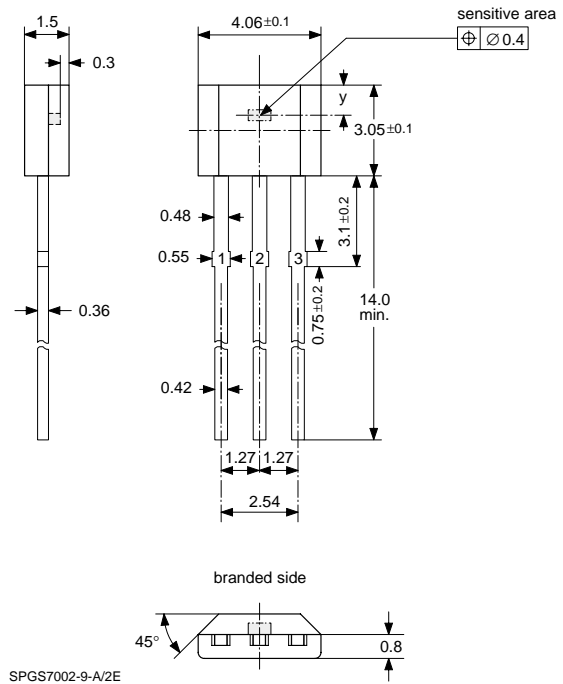
Fig. 2-2: Timing diagram

## 3. Specifications

### 3.1. Outline Dimensions



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



**Fig. 3-2:**  
Plastic Transistor Single Outline Package  
(TO-92UA)  
Weight approximately 0.12 g  
Dimensions in mm

### 3.2. Dimensions of Sensitive Area

0.12 mm x 0.12 mm

### 3.3. Positions of Sensitive Areas

	SOT-89B	TO-92UA
x	center of the package	center of the package
y	0.975 mm nominal	1.0 mm nominal

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

An improvement of the TO-92UA package with reduced tolerances will be introduced end of 2001.

### 3.4. Absolute Maximum Ratings

Symbol	Parameter	Pin No.	Min.	Max.	Unit
$V_{DD}$	Supply Voltage	1	-15	28 <sup>1)</sup>	V
$-V_P$	Test Voltage for Supply	1	-24 <sup>2)</sup>	-	V
$-I_{DD}$	Reverse Supply Current	1	-	50 <sup>1)</sup>	mA
$I_{DDZ}$	Supply Current through Protection Device	1	-200 <sup>3)</sup>	200 <sup>3)</sup>	mA
$V_O$	Output Voltage	3	-0.3	28 <sup>1)</sup>	V
$I_O$	Continuous Output On Current	3	-	50 <sup>1)</sup>	mA
$I_{Omax}$	Peak Output On Current	3	-	250 <sup>3)</sup>	mA
$I_{OZ}$	Output Current through Protection Device	3	-200 <sup>3)</sup>	200 <sup>3)</sup>	mA
$T_S$	Storage Temperature Range <sup>5)</sup>		-65	150	°C
$T_J$	Junction Temperature Range		-40 -40	150 170 <sup>4)</sup>	°C

1) as long as  $T_{Jmax}$  is not exceeded

2) with a 220  $\Omega$  series resistance at pin 1 (see Fig. 4–9)

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.	Max.	Unit
$V_{DD}$	Supply Voltage	1	4.2	24	V
$I_O$	Continuous Output On Current	3	0	20	mA
$V_O$	Output Voltage (output switched off)	3	0	24	V

### 3.6. Electrical Characteristics at $T_J = -40\text{ }^\circ\text{C}$ to $+170\text{ }^\circ\text{C}$ , $V_{DD} = 4.2\text{ V}$ to $24\text{ V}$ , as not otherwise specified in Conditions Typical Characteristics for $T_J = 25\text{ }^\circ\text{C}$ and $V_{DD} = 12\text{ V}$

Symbol	Parameter	Pin No.	Min.	Typ.	Max.	Unit	Conditions
$I_{DD}$	Supply Current	1	3.6	4.5	5.4	mA	$T_J = 25\text{ }^\circ\text{C}$
$I_{DD}$	Supply Current over Temperature Range	1	2.2	4.5	7.2	mA	
$V_{DDZ}$	Overvoltage Protection at Supply	1	–	28.5	32.5	V	$I_{DD} = 25\text{ mA}$ , $T_J = 25\text{ }^\circ\text{C}$ , $t = 20\text{ ms}$
$V_{OZ}$	Overvoltage Protection at Output	3	–	28	32.5	V	$I_{OH} = 25\text{ mA}$ , $T_J = 25\text{ }^\circ\text{C}$ , $t = 20\text{ ms}$
$V_{OL}$	Output Voltage	3	–	160	280	mV	$I_{OL} = 20\text{ mA}$ , $T_J = 25\text{ }^\circ\text{C}$
$V_{OL}$	Output Voltage over Temperature Range	3	–	160	400	mV	$I_{OL} = 20\text{ mA}$
$I_{OH}$	Output Leakage Current	3	–	0.01	0.1	$\mu\text{A}$	Output switched off, $T_J = 25\text{ }^\circ\text{C}$ , $V_{OH} \leq 24\text{ V}$
$I_{OH}$	Output Leakage Current over Temperature Range	3	–	–	10	$\mu\text{A}$	Output switched off, $T_J \leq 150\text{ }^\circ\text{C}$ , $V_{OH} \leq 24\text{ V}$
$f_{osc}$	Internal Oscillator Chopper Frequency	–	–	360	–	kHz	$T_J = 25\text{ }^\circ\text{C}$
$t_d$	Delay Time between Switching Threshold $\Delta B$ and Edge of Output over Temperature Range	–	–	25	–	$\mu\text{s}$	$B > B_{ON} + 4\text{ mT}$ or $B < B_{OFF} - 4\text{ mT}$
$t_{en(O)}$	Enable Time of Output after Setting of $V_{DD}$	3	–	30	70	$\mu\text{s}$	$V_{DD} = 12\text{ V}$ $B > B_{ON} + 2\text{ mT}$ or $B < B_{OFF} - 2\text{ mT}$
$t_r$	Output Rise Time	3	–	0.07	0.4	$\mu\text{s}$	$V_{DD} = 12\text{ V}$ , $R_L = 820\text{ Ohm}$ , $C_L = 20\text{ pF}$
$t_f$	Output Fall Time	3	–	0.05	0.4	$\mu\text{s}$	$V_{DD} = 12\text{ V}$ , $R_L = 820\text{ Ohm}$ , $C_L = 20\text{ pF}$
$R_{thJSB}$ case SOT-89B	Thermal Resistance Junction to Substrate Backside	–	–	150	200	K/W	Fiberglass Substrate 30 mm x 10 mm x 1.5mm, pad size see Fig. 3–3
$R_{thJA}$ case TO-92UA	Thermal Resistance Junction to Soldering Point	–	–	150	200	K/W	

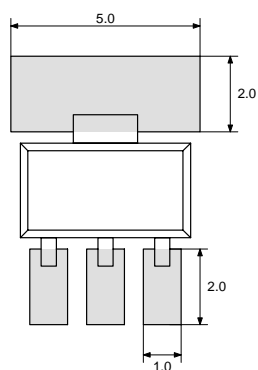


**3.7. Magnetic Characteristics Overview** at  $T_J = -40\text{ °C}$  to  $+170\text{ °C}$ ,  $V_{DD} = 4.2\text{ V}$  to  $24\text{ V}$ ,  
 Typical Characteristics for  $V_{DD} = 12\text{ V}$

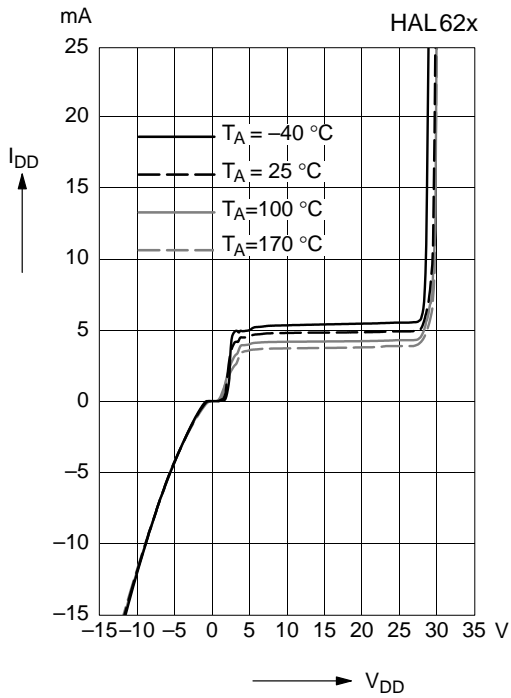
Magnetic flux density values of switching points.  
 Positive flux density values refer to the magnetic south pole at the branded side of the package.

Sensor Switching Type	Parameter $T_J$	On point $B_{ON}$			Off point $B_{OFF}$			Hysteresis $B_{HYS}$			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
HAL 621 bipolar	-40 °C	-1	1.2	4	-3	-0.7	2	1	1.9	3	mT
	25 °C	-1	1.4	4	-3	-0.6	2	1	2	3	mT
	170 °C	-1	1.6	4	-3	-0.4	2	1	1.9	3	mT
HAL 629 unipolar	-40 °C	14.5	17.6	20.5	12.5	15.7	20	1	1.9	3	mT
	25 °C	14	17	20	12	15	19	1	2	3	mT
	170 °C	11.5	15.6	19.2	10	13.7	17.2	1	1.9	3	mT

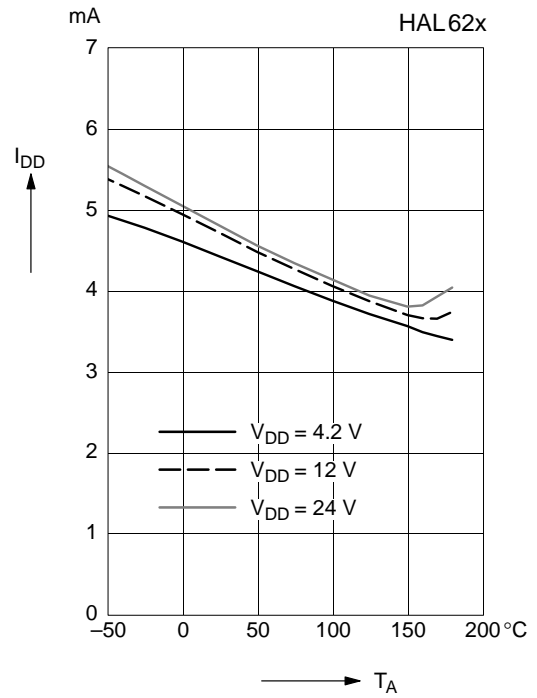
**Note:** For detailed descriptions of the individual types, see pages 12 and following.



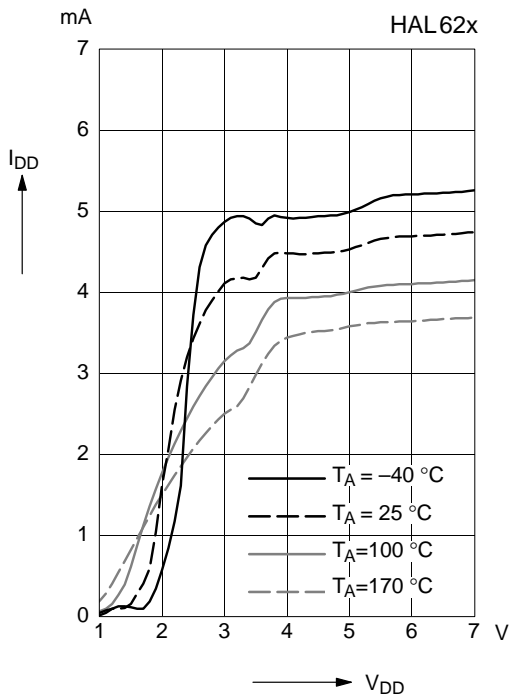
**Fig. 3-3:** Recommended pad size SOT-89B  
 Dimensions in mm



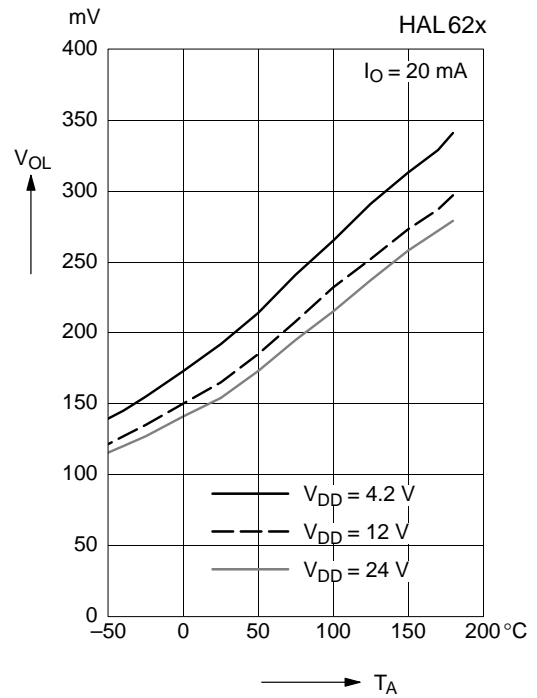
**Fig. 3-4:** Typical supply current versus supply voltage



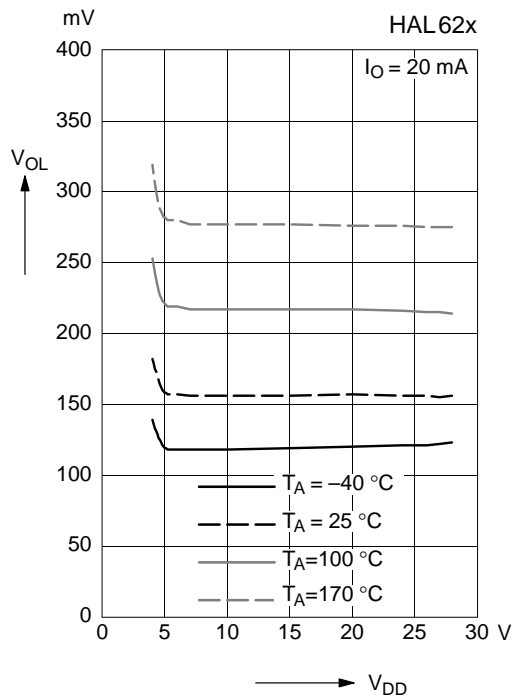
**Fig. 3-6:** Typical supply current versus ambient temperature



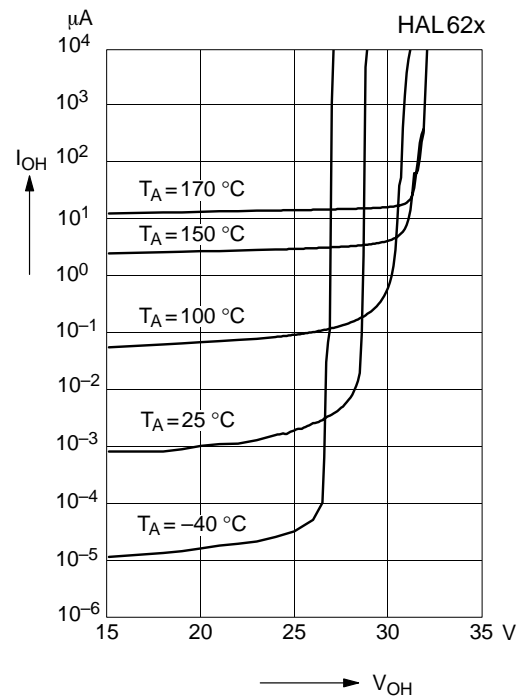
**Fig. 3-5:** Typical supply current versus supply voltage



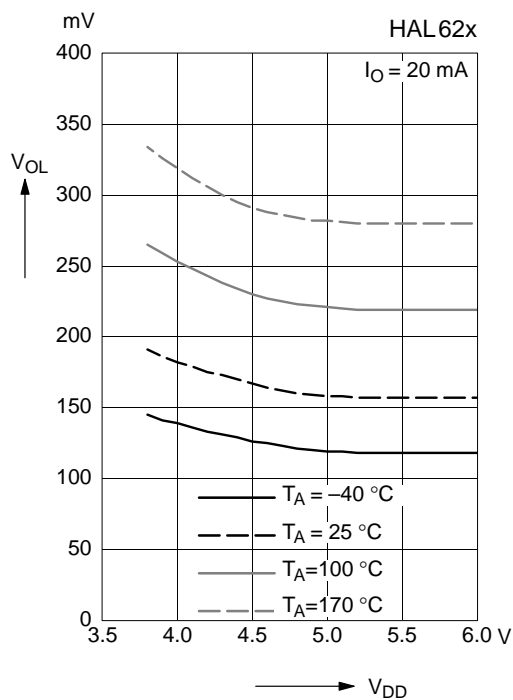
**Fig. 3-7:** Typical output low voltage versus ambient temperature



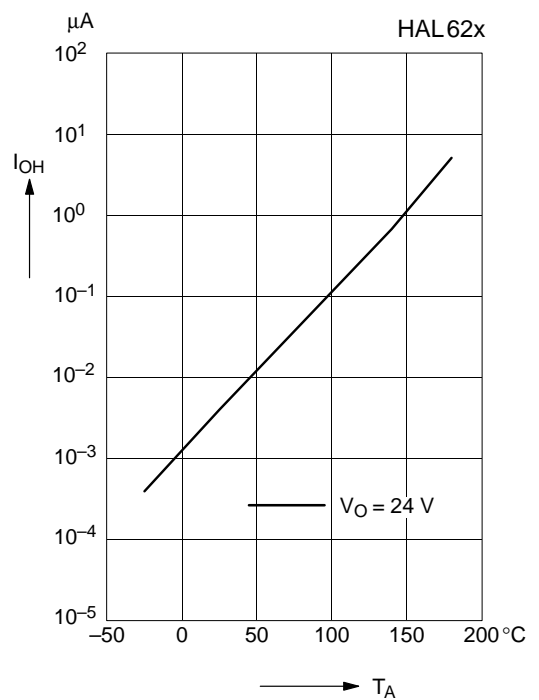
**Fig. 3-8:** Typical output low voltage versus supply voltage



**Fig. 3-10:** Typical output leakage current versus output voltage



**Fig. 3-9:** Typical output low voltage versus supply voltage



**Fig. 3-11:** Typical output leakage current versus ambient temperature

## 4. Type Description

### 4.1. HAL621

The HAL621 is a very sensitive bipolar switching sensor (see Fig. 4–1).

The output turns low with the magnetic south pole on the branded side of the package and turns high with the magnetic north pole on the branded side. The output state is not defined for all sensors if the magnetic field is removed again. Some sensors will change the output state and some sensors will not.

For correct functioning in the application, the sensor requires both magnetic polarities (north and south) on the branded side of the package.

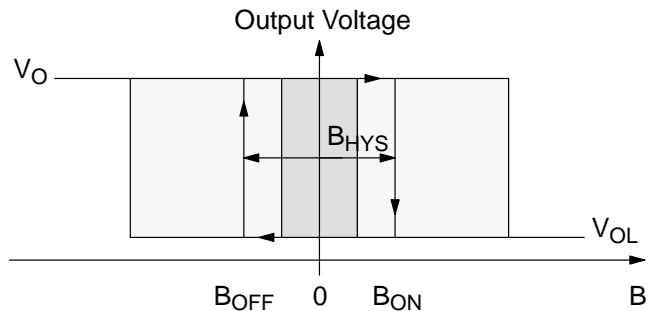
#### Magnetic Features:

- switching type: bipolar
- very high sensitivity
- typical  $B_{ON}$ : 1.4 mT at room temperature
- typical  $B_{OFF}$ : –0.6 mT at room temperature
- operates with static magnetic fields and dynamic magnetic fields up to 15 kHz

## Applications

The HAL621 is the optimal sensor for all applications with alternating magnetic signals and weak magnetic amplitude at the sensor position such as:

- applications with large airgap or weak magnets,
- rotating speed measurement,
- crank shaft sensors,
- CAM shaft sensors, and
- magnetic encoders.



**Fig. 4–1:** Definition of magnetic switching points for the HAL621

**Magnetic Characteristics** at  $T_J = -40\text{ °C}$  to  $+170\text{ °C}$ ,  $V_{DD} = 4.2\text{ V}$  to  $24\text{ V}$ ,  
Typical Characteristics for  $V_{DD} = 12\text{ V}$

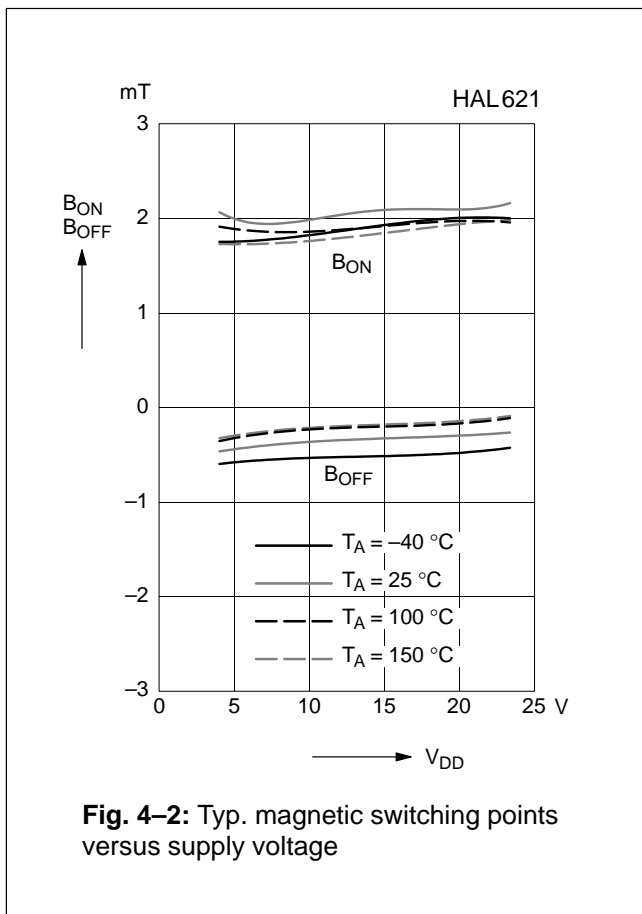
Magnetic flux density values of switching points.

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

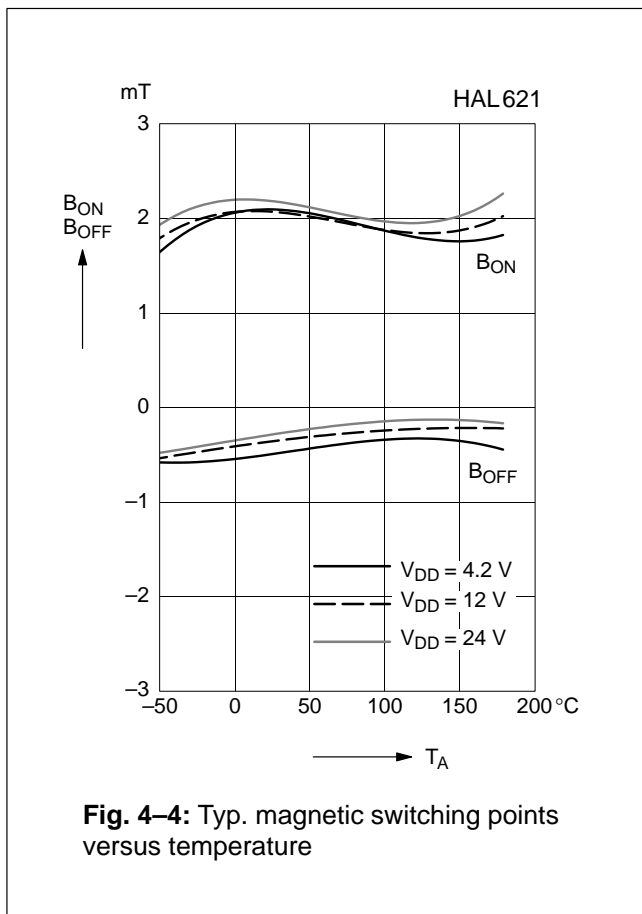
Parameter $T_J$	On point $B_{ON}$			Off point $B_{OFF}$			Hysteresis $B_{HYS}$			Magnetic Offset $B_{OFFSET}$			Unit
	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
–40 °C	–1	1.2	4	–3	–0.7	2	1	1.9	3		0.2		mT
25 °C	–1	1.4	4	–3	–0.6	2	1	2	3		0.4		mT
100 °C	–1	1.4	4	–3	–0.5	2	1	1.9	3		0.4		mT
140 °C	–1	1.5	4	–3	–0.4	2	1	1.9	3		0.5		mT
170 °C	–1	1.6	4	–3	–0.4	2	1	1.9	3		0.6		mT

The hysteresis is the difference between the switching points  $B_{HYS} = B_{ON} - B_{OFF}$

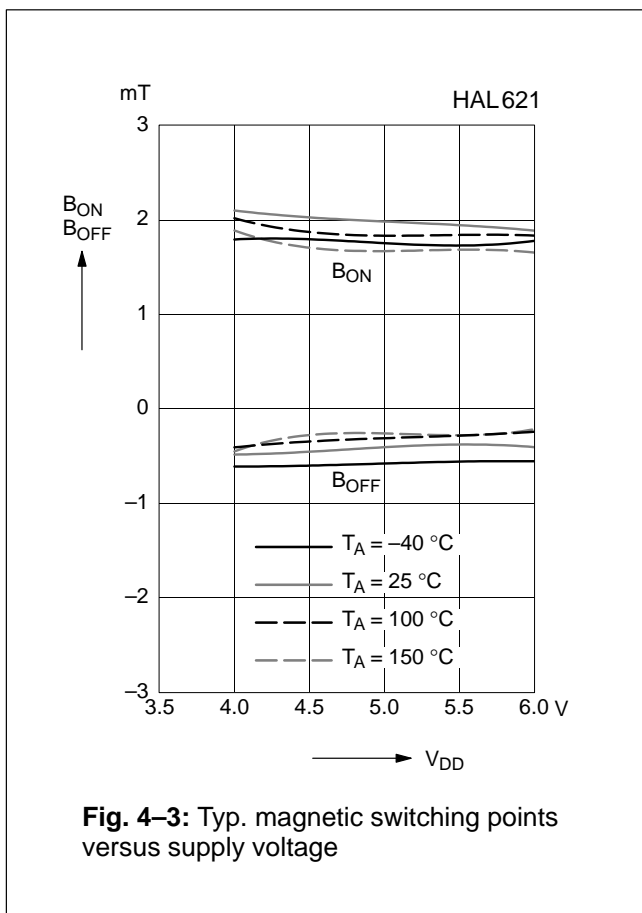
The magnetic offset is the mean value of the switching points  $B_{OFFSET} = (B_{ON} + B_{OFF}) / 2$



**Fig. 4-2:** Typ. magnetic switching points versus supply voltage



**Fig. 4-4:** Typ. magnetic switching points versus temperature



**Fig. 4-3:** Typ. magnetic switching points versus supply voltage

## 4.2. HAL629

The HAL629 is an unipolar switching sensor (see Fig. 4–5). The HAL629 is the improved successor of the HAL628 with the same magnetic characteristics.

The output turns low with the magnetic south pole on the branded side of the package and turns high if the magnetic field is removed. The sensor does not respond to the magnetic north pole on the branded side.

For correct functioning in the application, the sensor requires only the magnetic south pole on the branded side of the package.

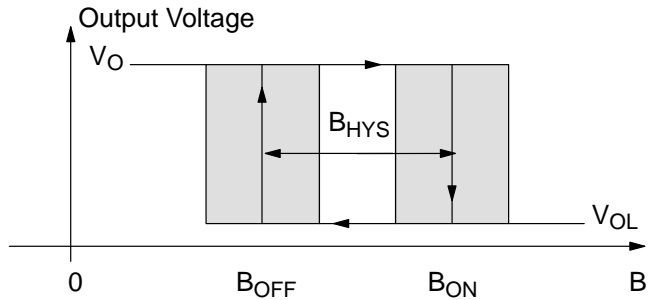
### Magnetic Features:

- switching type: unipolar
- medium sensitivity
- typical  $B_{ON}$ : 17 mT at room temperature
- typical  $B_{OFF}$ : 15 mT at room temperature
- operates with static magnetic fields and dynamic magnetic fields up to 15 kHz
- typical temperature coefficient of magnetic switching points is  $-600$  ppm/K

## Applications

The HAL629 is the optimal sensor for applications with one magnetic polarity such as:

- solid state switches,
- contactless solution to replace micro switches,
- position and end point detection, and
- rotating speed measurement.



**Fig. 4–5:** Definition of magnetic switching points for the HAL629

**Magnetic Characteristics** at  $T_J = -40$  °C to  $+170$  °C,  $V_{DD} = 4.2$  V to 24 V, Typical Characteristics for  $V_{DD} = 12$  V

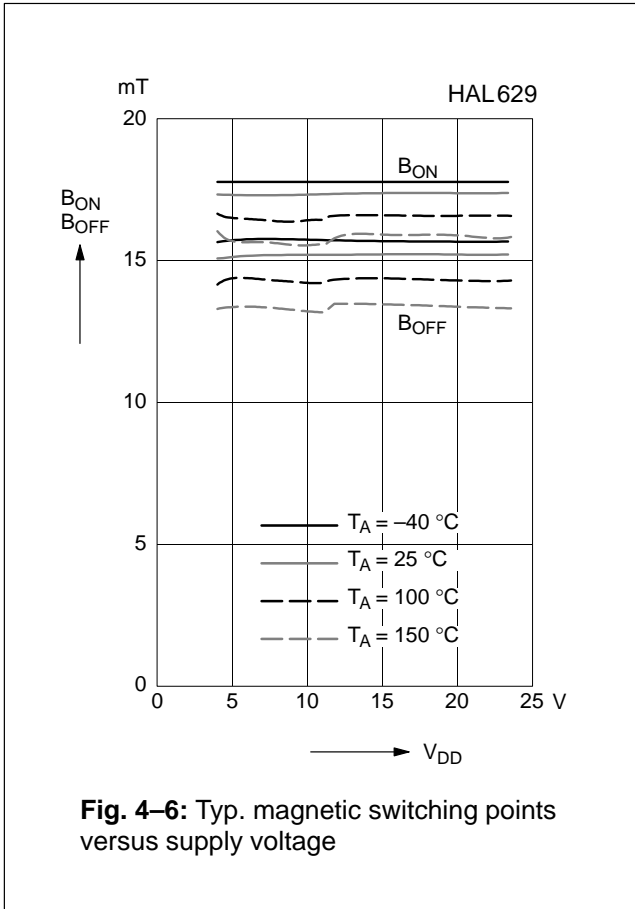
Magnetic flux density values of switching points.

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

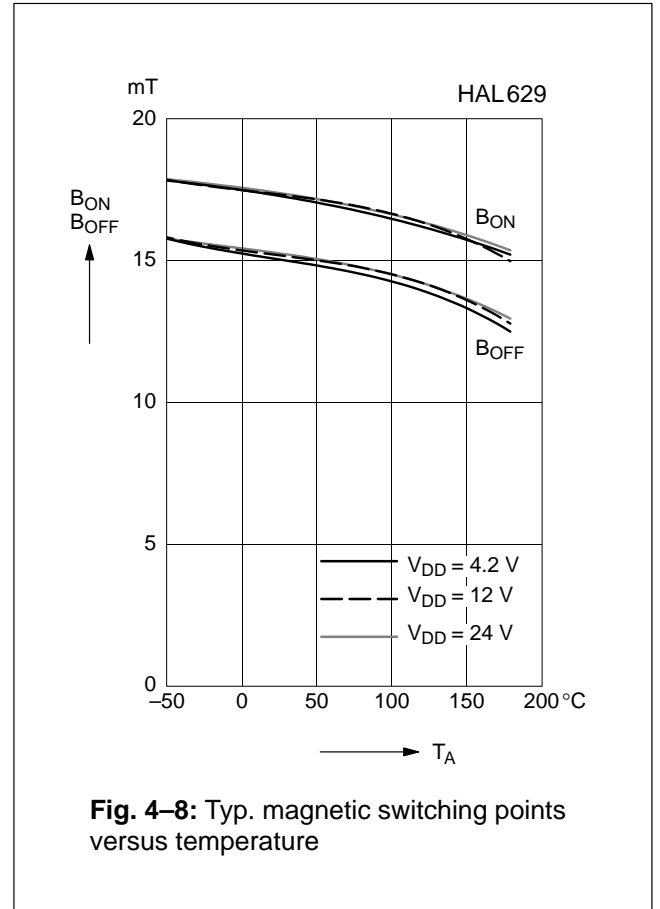
Parameter $T_J$	On point $B_{ON}$			Off point $B_{OFF}$			Hysteresis $B_{HYS}$			Magnetic Offset			Unit
	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
$-40$ °C	14.5	17.6	20.5	12.5	15.7	20	1	1.9	3		16.6		mT
$25$ °C	14	17	20	12	15	19	1	2	3		16		mT
$100$ °C	12.7	16.3	19.6	11	14.4	18.1	1	1.9	3		15.4		mT
$140$ °C	12.1	15.9	19.4	10.4	14	17.6	1	1.9	3		15		mT
$170$ °C	11.5	15.6	19.2	10	13.7	17.2	1	1.9	3		14.6		mT

The hysteresis is the difference between the switching points  $B_{HYS} = B_{ON} - B_{OFF}$

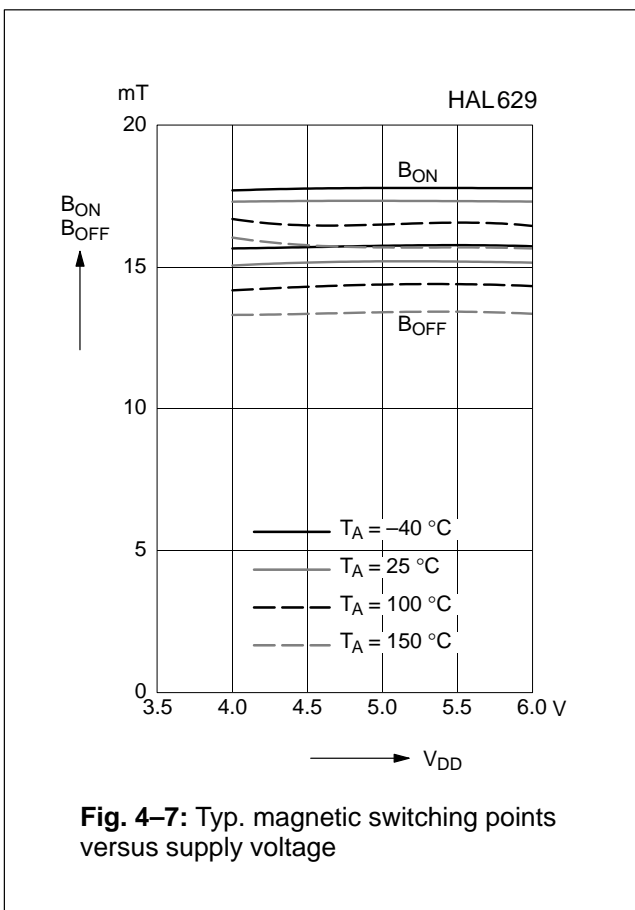
The magnetic offset is the mean value of the switching points  $B_{OFFSET} = (B_{ON} + B_{OFF}) / 2$



**Fig. 4-6:** Typ. magnetic switching points versus supply voltage



**Fig. 4-8:** Typ. magnetic switching points versus temperature



**Fig. 4-7:** Typ. magnetic switching points versus supply voltage

## 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, the following equation is valid:

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

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. 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 8).

During the initialization time, the output state is not defined and the output can toggle. After  $t_{en(O)}$ , the output will be low if the applied magnetic field  $B$  is above  $B_{ON}$ . The output will be high if  $B$  is below  $B_{OFF}$ .

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

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### 5.3. EMC and ESD

For applications with disturbances on the supply line or radiated disturbances, a series resistor and a capacitor are recommended (see figure 4–9). The series resistor and the capacitor should be placed as closely as possible to the sensor.

Applications with this arrangement passed the EMC tests according to the product standards DIN 40839.

**Note:** The international standard ISO 7637 is similar to the used product standard DIN 40839.

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

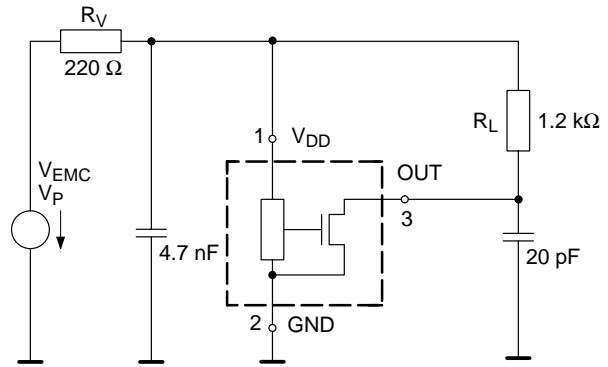


Fig. 4–9: Test circuit for EMC investigations

## 6. Data Sheet History

1. Final data sheet: “HAL621, HAL629, Hall Effect Sensor Family”, Feb. 3, 2000, 6251-504-1DS. First release of the final data sheet.

2. Final data sheet: “HAL621, HAL629, Hall Effect Sensor Family”, Feb. 5, 2001, 6251-504-2DS. Second release of the final data sheet. Major changes:

- position of sensitive area in SOT-89B package changed

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