PRELIMINARY DATA SHEET

HAL300
Differential Hall Effect Sensor IC

Edition May 7, 1997
6251-345-4PD

MICRONAS
INTERMETALL

Differential Hall Effect Sensor IC
in CMOS technology

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

Features:

– distance between Hall plates: 2.05 mm

– operates from 4.5 V to 24 V supply voltage

– overvoltage and reverse-voltage protection

– short-circuit protected open-drain output

– operates with magnetic fields from DC to 10 kHz

– switching offset compensation at 57 kHz

– output turns low with magnetic south pole on branded side of package and with a higher magnetic flux density in sensitive area S1 as in S2

– output state does not change if magnetic field is removed

– on-chip temperature compensation circuitry minimizes shifts in on and off points and hysteresis over temperature and supply voltage

– the decrease of magnetic flux density caused by rising temperature in the sensor system is compensated by a built-in negative temperature coefficient of hysteresis

– ideal sensor for ignition timing, anti-lock brake systems and revolution counting with rotating magnets in extreme automotive and industrial environments

– EMC corresponding to DIN 40839

Marking Code

Type	Temperature Range		
	A	E	C
HAL 300S, HAL 300UA	300A	300E	300C

Operating Junction Temperature Range

A: T_J = –40 °C to +170 °C

E: T_J = –40 °C to +100 °C

C: T_J = 0 °C to +100 °C

Designation of Hall Sensors

HAL XXXPP-T

Temperature Range: A, E, or C
Package: UA for TO-92UA,
S for SOT-89A
Type: 300

Example: **HAL 300UA–E**

→ Type: 300
→ Package:TO-92UA
→ Temperature Range: T_J = –40 °C to +100 °C

Solderability

– Package SOT-89A: according to IEC68-2-58

– Package TO-92UA: according to IEC68-2-20

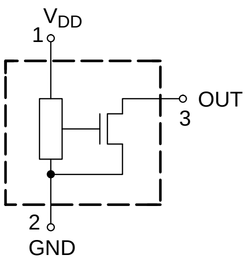


Fig. 1: Pin configuration

Functional Description

This Hall effect sensor is a monolithic integrated circuit that switches in response to differential magnetic fields. If magnetic fields with flux lines at right angles to the sensitive areas are applied to the sensor, the biased Hall plates forces Hall voltages proportional to this fields. The difference of the Hall voltages is compared with the actual threshold level in the comparator. The temperature-dependent bias increases the supply voltage of the Hall plates and adjusts the switching points to the decreasing induction of magnets at higher temperatures. If the differential magnetic field exceeds the threshold levels, the open drain output switches to the appropriate state. The built-in hysteresis eliminates oscillation and provides switching behavior of output without bounce.

Magnetic offset is compensated for by using the “switching offset compensation technique”. Therefore, an internal oscillator provides a two phase clock. The difference of the Hall voltages are sampled at the end of the first phase. At the end of the second phase, both sampled and momentary differential Hall voltages are averaged and compared with the actual switching point. Subsequently, the open drain output switches to the appropriate state. The time from crossing the magnetic switch level to switching of output can vary between zero and $1/f_{OSC}$.

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 values ranging from 0 V to –15 V.

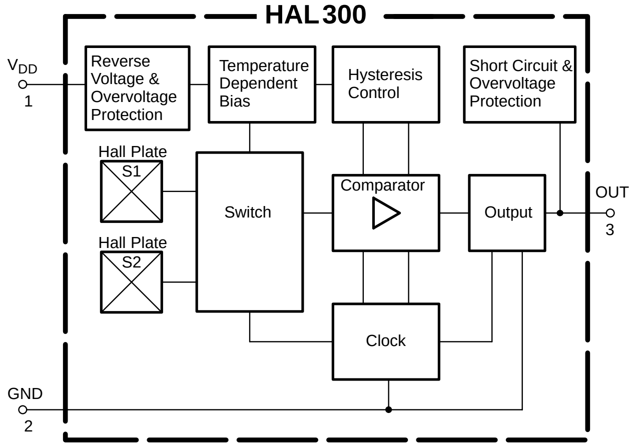


Fig. 2: HAL 300 block diagram

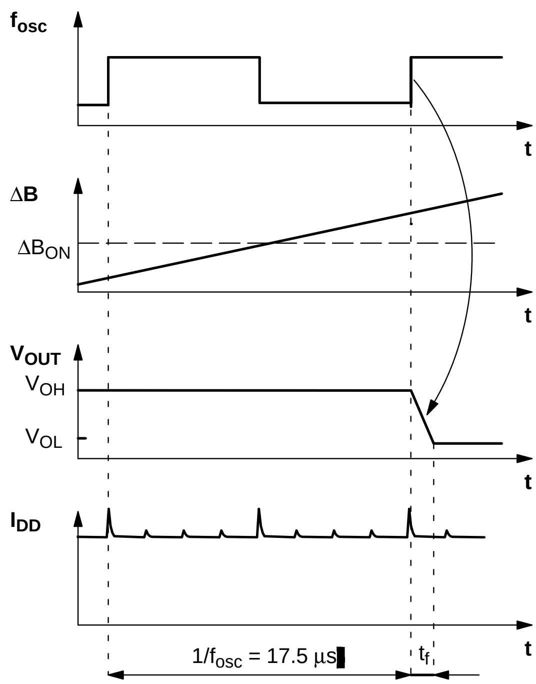


Fig. 3: Timing diagram

Outline Dimensions

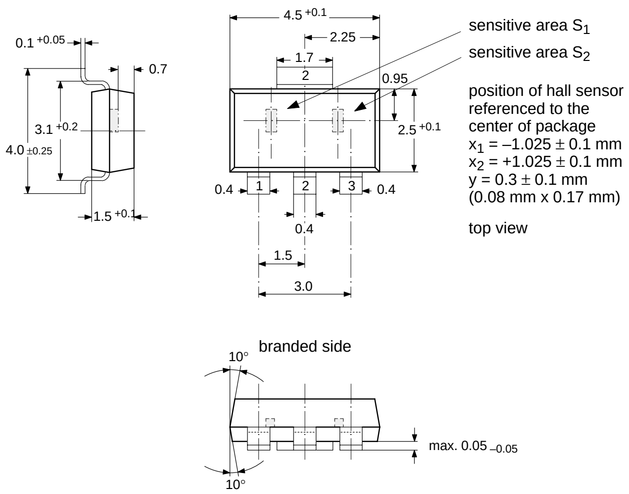


Fig. 4:
Plastic Small Outline Transistor Package
(SOT-89A)
Weight approximately 0.04 g
Dimensions in mm

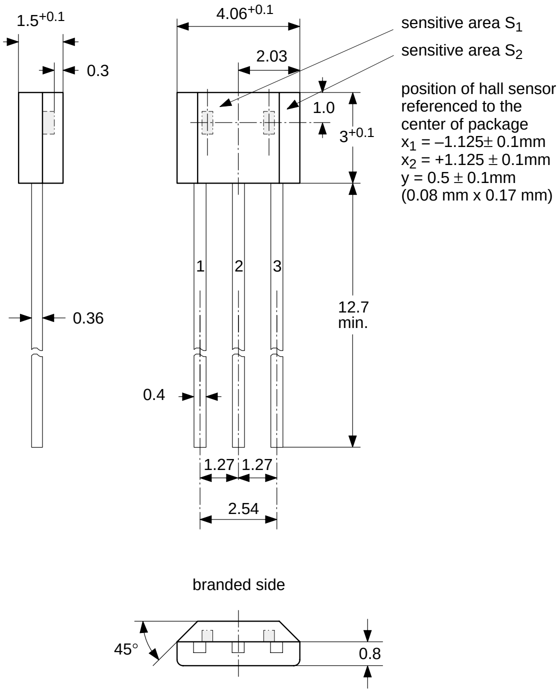


Fig. 5:
Plastic Transistor Single Outline Package
(TO-92UA)
Weight approximately 0.12 g
Dimensions in mm

Absolute Maximum Ratings

Symbol	Parameter	Pin No.	Min.	Max.	Unit
V_{DD}	Supply Voltage	1	–15 –24[2)]	28[1)]	V
V_{OH}	Output Off Voltage	3	–	28[1)]	V
I_O	Continuous Output On Current	3	–	30	mA
I_O	Peak Output On Current	3	–	250[3)]	mA
$–I_{DD}$	Reverse Supply Current	1		50[1)]	mA
I_{DDZ}	Supply Current through Protection Diode	1	–300	300[3)]	mA
T_s	Storage Temperature Range		–65	150	°C
T_J	Junction Temperature Range		–40 –40	150 170[4)]	°C

1) as long as $T_J$max 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

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.

Recommended Operating Conditions

Symbol	Parameter	Pin No.	Min.	Typ.	Max.	Unit
V_{DD}	Supply Voltage	1	4.5	–	24	V
I_O	Continuous Output On Current	3	–	–	20	mA
R_v	Series Resistor	1	–	–	270	Ω

Electrical Characteristics at T_J = –40 °C to +170 °C , V_{DD} = 4.5 V to 24 V, as not otherwise specified
Typical Characteristics for T_J = 25 °C and V_{DD} = 12 V

Symbol	Parameter	Pin No.	Min.	Typ.	Max.	Unit	Test Conditions
I_{DD}	Supply Current	1	4.0	5.5	6.8	mA	T_J = 25 °C
I_{DD}	Supply Current over Temperature Range	1	3.0	5.5	7.5	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	3	–	28	32	V	I_{OL} = 25 mA, T_J = 25 °C, t = 20 ms
V_{OL}	Output Voltage	3	–	180	220	mV	V_{DD} = 12 V, I_O = 20 mA, T_J = 25 °C
V_{OL}	Output Voltage over Temperature Range	3	–	180	400	mV	I_O = 20 mA
I_{OH}	Output Leakage Current	3	–	0.06	1	µA	V_{OH} = 4.5 V...24 V, $\Delta B < \Delta B_{OFF}$, T_J = 25 °C
I_{OH}	Output Leakage Current over Temperature Range	3	–	0.06	10	µA	V_{OH} = 4.5 V...24 V, $\Delta B < \Delta B_{OFF}$, $T_J \leq$ 150 °C
f_{osc}	Internal Oscillator Chopper Frequency	–	47	57	78	kHz	
f_{osc}	Internal Oscillator Chopper Frequency over Temperature Range	–	42	57	78	kHz	
$t_{en(O)}$	Enable Time of Output after Setting of V_{DD}	3	–	35	–	µs	V_{DD} = 12 V, $\Delta B < \Delta B_{ON}$ – 2mT, $\Delta B > \Delta B_{OFF}$ + 2mT
t_r	Output Rise Time	3	–	80	400	ns	V_{DD} = 12 V, RL = 820 Ω, CL = 20 pF
t_f	Output Fall Time	3	–	45	400	ns	V_{DD} = 12 V, RL = 820 Ω, CL = 20 pF
R_{thJSB} case SOT-89A	Thermal Resistance Junction to Substrate Backside		–	150	200	K/W	Fiberglass Substrate 30 mm x 10 mm x 1.5mm, pad size see Fig. 7
R_{thJS} case TO-92UA	Thermal Resistance Junction to Soldering Point		–	150	200	K/W	

Magnetic Characteristics at T_J = –40 °C to +170 °C, V_{SUP} = 4.5 V to 24 V, as not otherwise specified,
Typical Characteristics for V_{DD} = 12 V

Magnetic flux density values of switching points (Test condition: B_0 < 10 mT)
Positive flux density values refer to the magnetic south pole at the branded side ot the package. $\Delta B = B_{S1} - B_{S2}$

Parameter	–40 °C			25 °C			100 °C			170 °C			Unit
	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
On point ΔB_{ON} $B_{S1} - B_{S2} > \Delta B_{ON}$	0.2	1.07	1.7	0.2	1.0	1.7	0.2	0.93	1.7	0	0.86	1.7	mT
Off point ΔB_{OFF} $B_{S1} - B_{S2} < \Delta B_{OFF}$	–1.7	–0.79	–0.2	–1.7	–0.75	–0.2	–1.7	–0.69	–0.2	–1.7	–0.64	0	mT
Hysteresis $\Delta B_{HYS} = \Delta B_{ON} - \Delta B_{OFF}$	1.2	1.86	2.6	1.2	1.75	2.6	1.2	1.62	2.6	1.0	1.5	2.6	mT

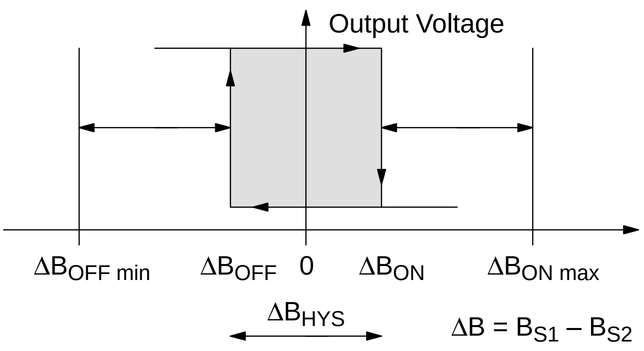


Fig. 6: Definition of switching points and hysteresis

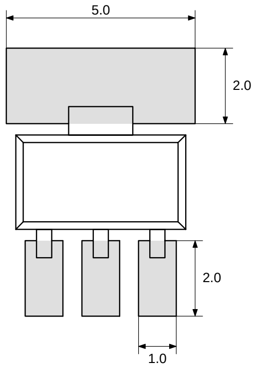
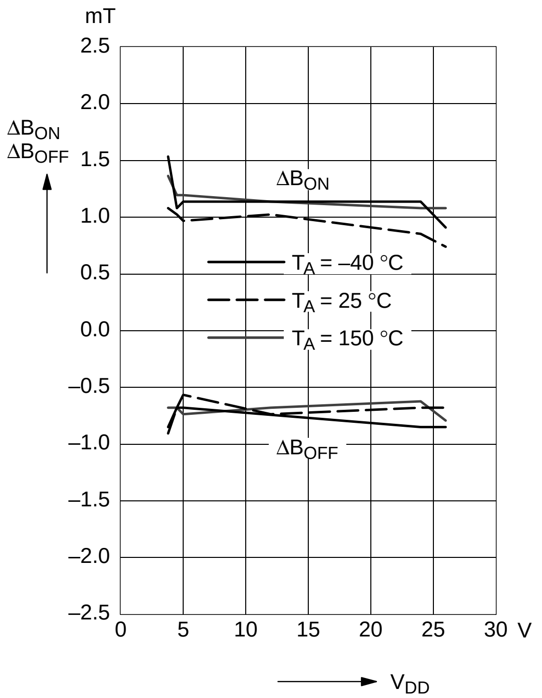
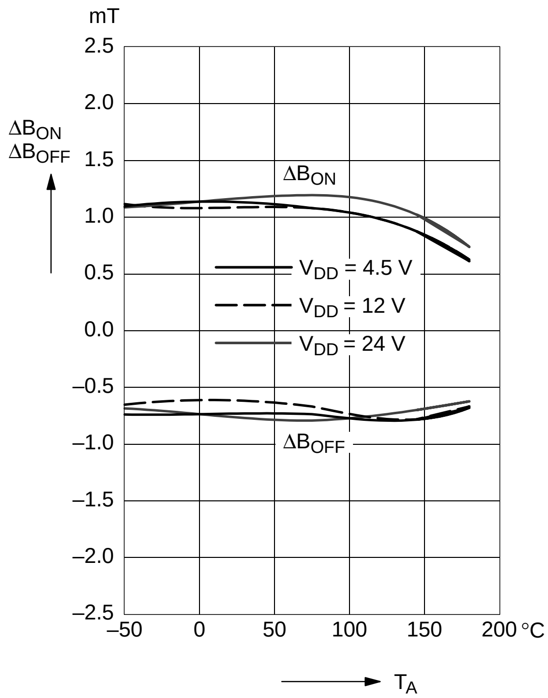


Fig. 7: Recommended pad size SOT-89A
Dimensions in mm

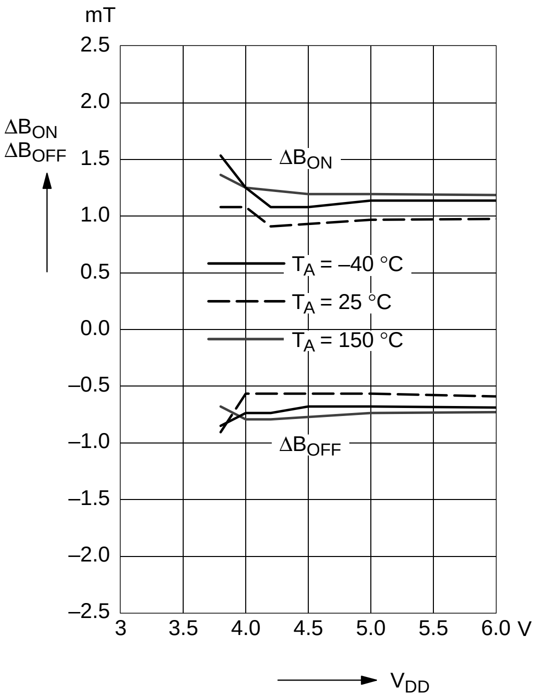
Typical magnetic switch points versus supply voltage



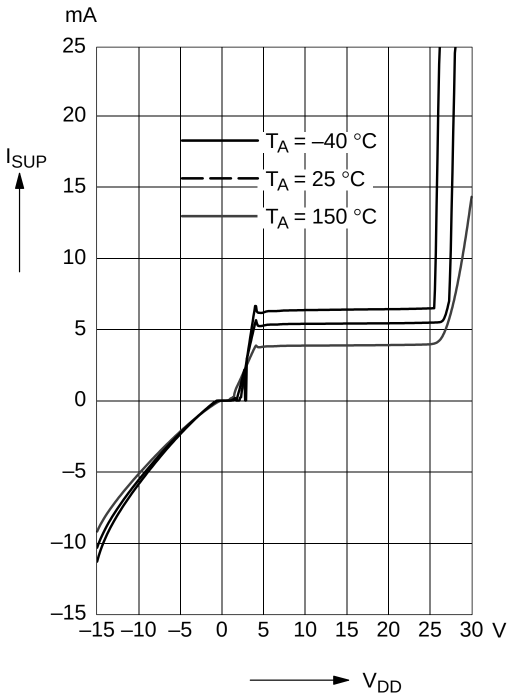
Typical magnetic switch points versus ambient temperature



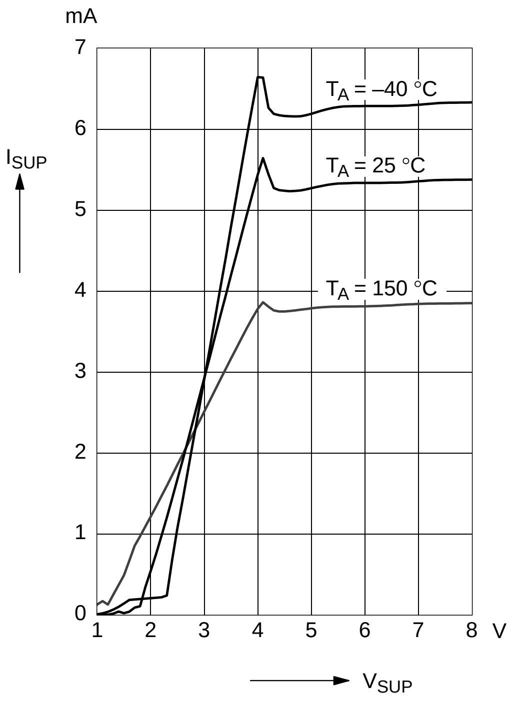
Typical magnetic switch points versus supply voltage



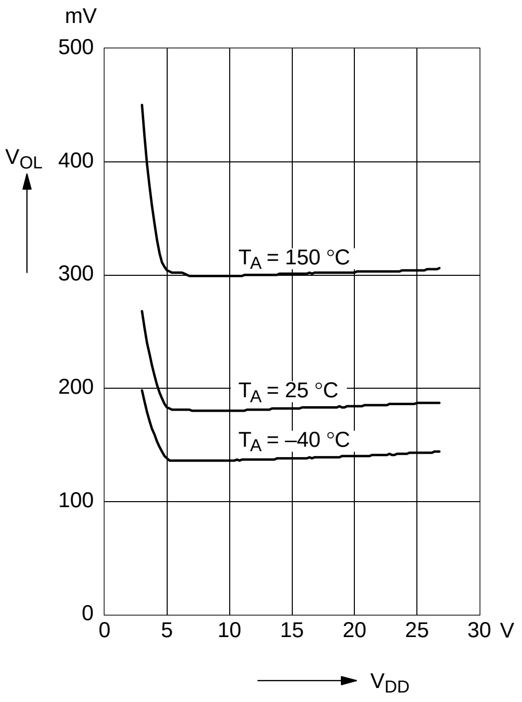
Typical supply current versus supply voltage



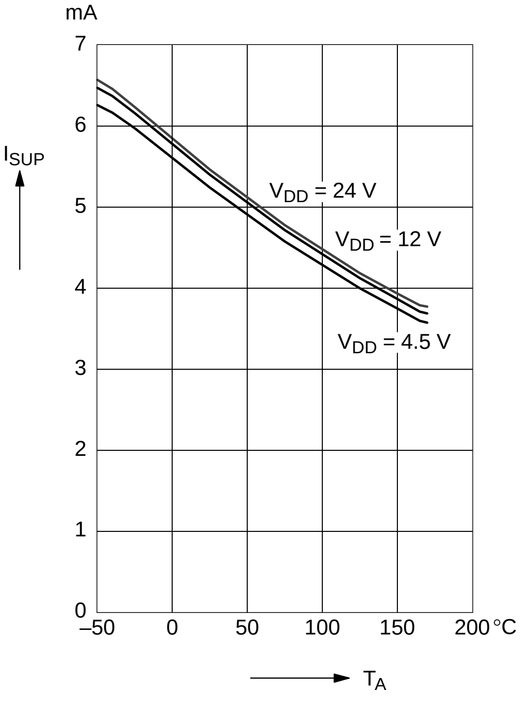
Typical supply current versus supply voltage



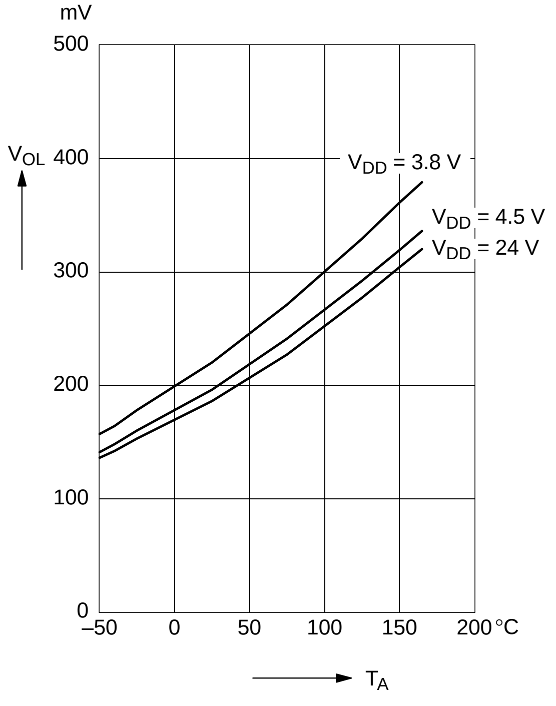
Typical output low voltage versus supply voltage
I_O = 20 mA

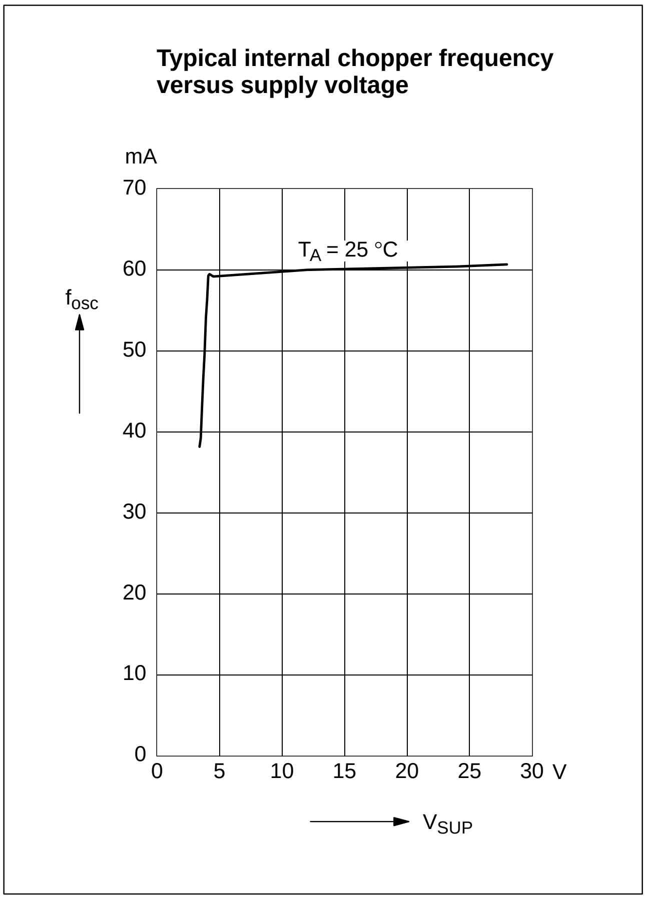


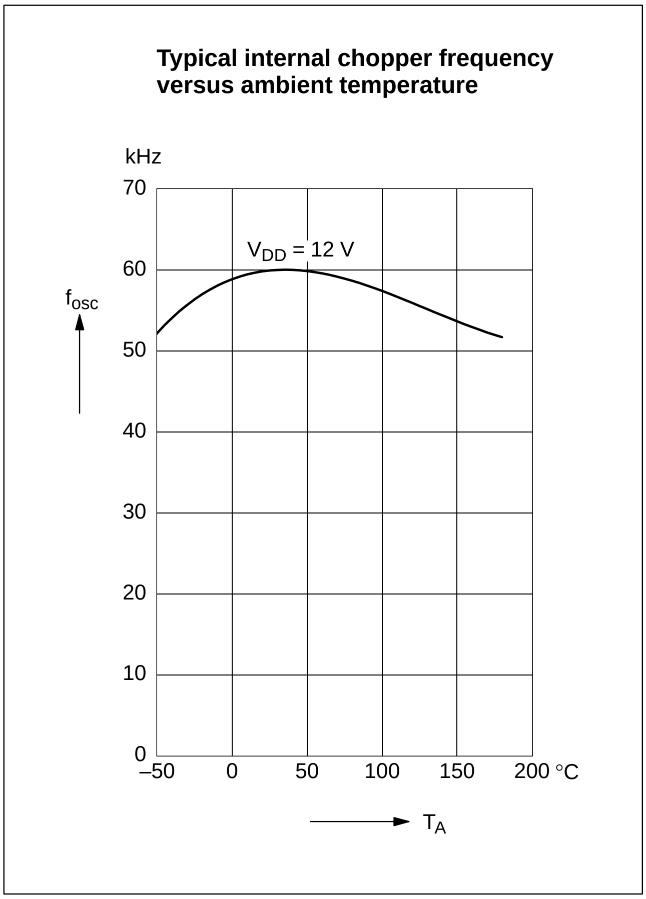
Typical supply current versus ambient temperature

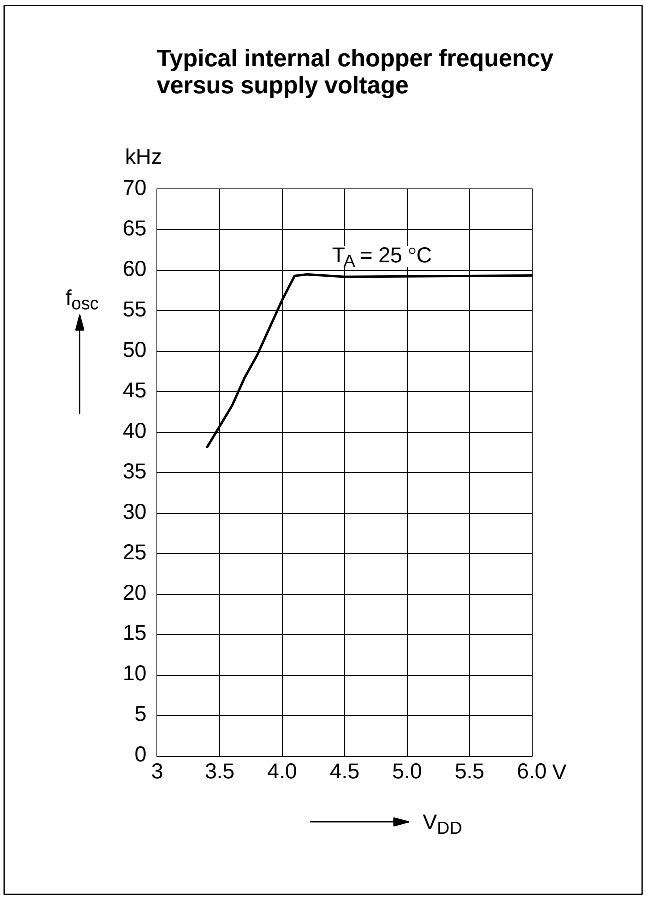


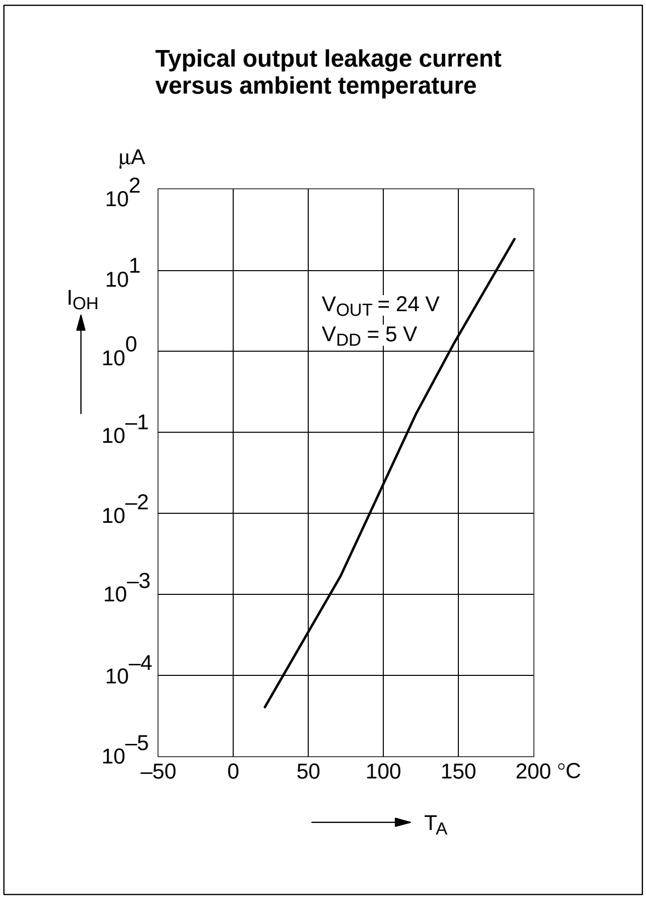
Typical output low voltage versus ambient temperature
I_O = 20 mA

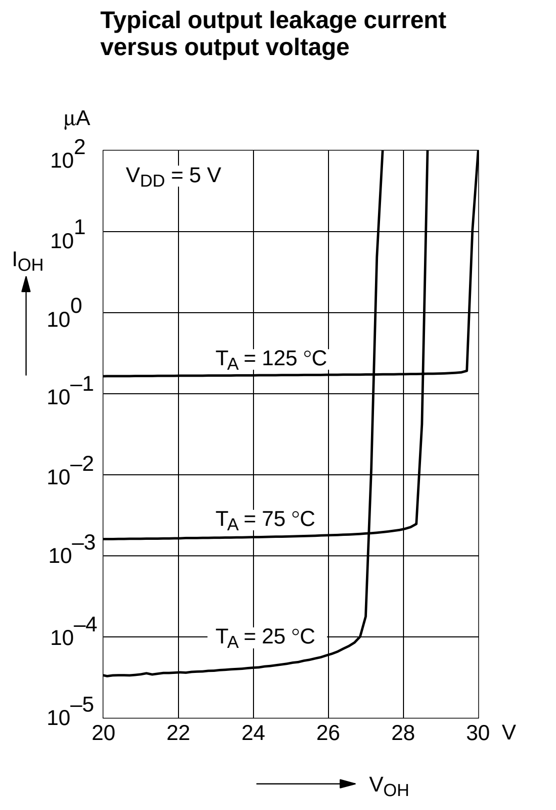



Typical internal chopper frequency
versus supply voltage
mA
70
60
50
40
30
20
10
0
f_osc
T_A = 25 °C
0
5
10
15
20
25
30 V
V_SUP


Typical internal chopper frequency
versus ambient temperature
kHz
70
60
50
40
30
20
10
0
f_osc
V_DD = 12 V
–50
0
50
100
150
200 °C
T_A


Typical internal chopper frequency
versus supply voltage
kHz
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
f_osc
T_A = 25 °C
3
3.5
4.0
4.5
5.0
5.5
6.0 V
V_DD


Typical output leakage current
versus ambient temperature
µA
10^2
10^1
10^0
10^–1
10^–2
10^–3
10^–4
10^–5
I_OH
V_OUT = 24 V
V_DD = 5 V
–50
0
50
100
150
200 °C
T_A



Application Note

For electromagnetic immunity, it is recommended to apply a 4.7 nF capacitor between V_{DD} (pin 1) and Ground (pin 2).

For automotive applications, a 220 Ω series resistor to pin 1 is recommended.

Because of the I_{DD} peak at 4.1 V, the series resistor should not be greater than 270 Ω.

The series resistor and the capacitor should be placed as close as possible to the IC.

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 equations are valid:

– for SOT-89A: $\Delta T = I_{DD} * V_{DD} * R_{thJSB}$

– for TO-92UA: $\Delta T = I_{DD} * V_{DD} * R_{thJA}$

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.

Test Circuits for Electromagnetic Compatibility

Test pulses V_{EMC} corresponding to DIN 40839.

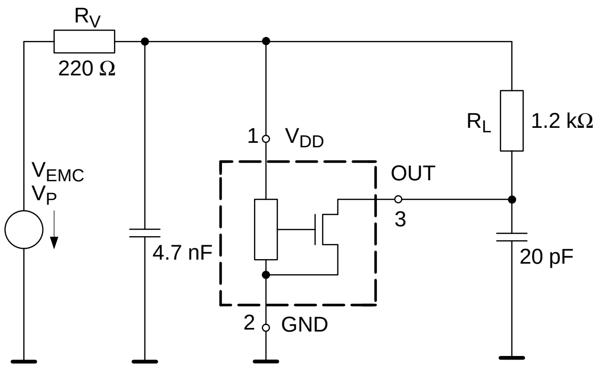


Fig. 8: Test circuit 2: test procedure for class A

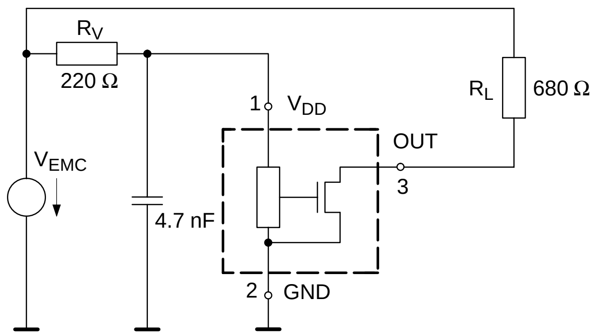


Fig. 9: Test circuit 1: test procedure for class C

Interferences conducted along supply lines in 12 V onboard systems

Product standard: DIN 40839 part 1

Pulse	Level	U_S in V	Test circuit	Pulses/ Time	Function Class	Remarks
1	IV	–100	1	5000	C	5 s pulse interval
2	IV	100	1	5000	C	0.5 s pulse interval
3a	IV	–150	2	1 h	A	
3b	IV	100	2	1h	A	
4	IV	–7	2	5	A	
5	IV	86.5	1	10	C	10 s pulse interval

Electrical transient transmission by capacitive and inductive coupling via lines other than the supply lines

Product standard: DIN 40839 part 3

Pulse	Level	U_S in V	Test circuit	Pulses/ Time	Function Class	Remarks
1	IV	–30	2	500	A	5 s pulse interval
2	IV	30	2	500	A	0.5 s pulse interval
3a	IV	–60	2	10 min	A	
3b	IV	40	2	10 min	A	

Radiated Disturbances

Product standard: DIN 40839 part4

Test Conditions

– Temperature: Room temperature (22...25 °C)

– Supply voltage: 13 V

– Lab Equipment: TEM cell 220 MHz (VW standard)
with adaptor board 455 mm, device 80 mm over ground

– Frequency range: 5...220 MHz; 1 MHz steps

– Test circuit 2 with R_L = 1.2 kΩ

Tested Devices and Results

Type	Field strength	Modulation	Result
HAL 300	> 200 V/m	1 kHz 80 %	output voltage stable on the level high or low[1]
[1] low level < 0.4 V, high level > 90% of V_{DD}			

Data Sheet History

1. Preliminary data sheet: "HAL 300 Differential Hall Effect Sensor IC", Sept. 30, 1992, 6251-345-1PD. First release of the preliminary data sheet.

2. Preliminary data sheet: "HAL 300 Differential Hall Effect Sensor IC", Nov. 6, 1992, 6251-345-2PD. Second release of the preliminary data sheet.

3. Preliminary data sheet: "HAL 300 Differential Hall Effect Sensor IC", June 14, 1994, 6251-345-3PD. Third release of the preliminary data sheet.

4. Preliminary data sheet: "HAL 300 Differential Hall Effect Sensor IC", May 7, 1997, 6251-345-4PD. Fourth release of the preliminary data sheet. Major changes:

– outline dimensions for TO-92UA package changed

– page 10: "Ambient Temperature"

– oscillator frequency limits changed

– hysteresis limits changed

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