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MICRONAS

Hardware
Documentation

Data Sheet

CUR 3105

Hall-Effect Current Transducer

Edition March 24, 2011
DSH000155_002EN

Copyright, Warranty, and Limitation of Liability

Micronas Patents

Choppered Offset Compensation protected by Micronas patents no. US5260614A, US5406202A, EP0525235B1 and EP0548391B1.

Sensor programming with VDD-Modulation protected by Micronas Patent No. EP 0 953 848.

Third-Party Trademarks

Contents

Hall-Effect Current Transducer

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

1. Introduction

The CUR 3105 is a new current transducer based on the Hall effect. The IC can be used for very precise current measurements. The measured current is proportional to the analog output voltage driven by the sensor's output. Major characteristics like magnetic field range, sensitivity, output quiescent voltage (output voltage at B = 0 mT), and output voltage range are programmable in a non-volatile memory. The transducer has a ratiometric output characteristic, which means that the output voltage is proportional to the current and the supply voltage. It is possible to program different transducers which are in parallel to the same supply voltage individually.

The CUR 3105 features a temperature-compensated Hall plate with choppered offset compensation, an A/D converter, digital signal processing, a D/A converter with output driver, an EEPROM memory with redundancy and lock function for the calibration data, an EEPROM for customer serial number, 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 transducers accuracy.

The CUR 3105 is programmable by modulating the supply voltage. No additional programming pin is needed. The easy programmability allows a 2-point calibration by adjusting the output voltage directly to the input signal (current). Individual adjustment of each transducer during the customer's manufacturing process is possible. With this calibration procedure, the tolerances of the IC 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.

The calculation of the individual IC characteristics and the programming of the EEPROM memory can easily be done with a PC and the application kit from Micronas.

The transducer is designed for industrial, white goods and automotive applications and operates with typically 5 V supply voltage in the wide junction temperature range from –40 °C up to 170 °C. The CUR 3105 is available in the very small leaded packages TO92UT-1 and TO92UT-2, as well as in the small eight-pin SOIC8 SMD package.

1.1. Features

– high-precision current transducer with ratiometric output and digital signal processing

– low output voltage drifts over temperature

– 12-bit analog output

– multiple programmable magnetic characteristics in a non-volatile memory (EEPROM) with redundancy and lock function

– open-circuit (ground and supply line break detection) with 5 kΩ pull-up and pull-down resistor, overvoltage and undervoltage detection

– for programming an individual transducer within several ICs in parallel to the same supply voltage, a selection can be done via the output pin

– programmable clamping function

– programming through modulation of the supply voltage

– operates from –40 °C up to 170 °C junction temperature

– operates from 4.5 V up to 5.5 V supply voltage in specification and functions up to 8.5 V

– operates with static magnetic fields and dynamic magnetic fields up to 1 kHz

– overvoltage and reverse-voltage protection at all pins

– magnetic characteristics extremely robust against mechanical stress

– short-circuit protected push-pull output

– EMC and ESD optimized design

1.2. Marking Code

The CUR 3105 has a marking on the package surface (branded side). This marking includes the name of the IC and the temperature range.

Type	Temperature Range			
	A	K	I	C
CUR 3105	3105A	3105K	3105I	3105C

1.3. Operating Junction Temperature Range (T_J)

The ICs 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

I: T_J = –20 °C to +125 °C

C: T_J = 0 °C to +85°C

The relationship between ambient temperature (T_A) and junction temperature is explained in Section 4.3. on page 25.

1.4. IC Package Codes

CURXXXXPA-T

- Temperature Range: A, K, I, C
- Package: UT for TO92UT-1/-2
  DJ for SOIC8-1
- Type: 3105

Example: **CUR3105DJ-K**

→ Type: 3105
→ Package: SOIC8-1
→ Temperature Range: T_J = –40 °C to +140 °C

The ICs 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

Soldering

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

Welding (for TO92UT package only)

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 and Short Descriptions

1.6.1. TO92UT Package

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

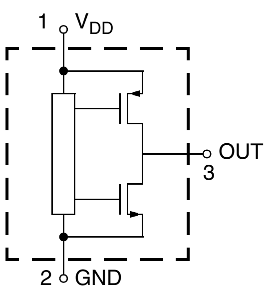


Fig. 1–1: Pin configuration TO92UT

1.6.2. SOIC8 Package

Pin No.	Pin Name	Type	Short Description
1	V_{DD}	IN	Supply Voltage and Programming Pin
2,5,6,7,8	GND		Ground
3	NC		Not Connected
4	OUT	OUT	Push-Pull Output and Selection Pin

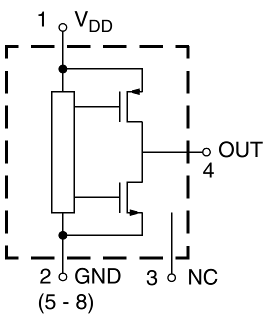


Fig. 1–2: Pin configuration SOIC8

Note: Note: Pins number 2, 5, 6, 7, and 8 must be connected to GND.

2. Functional Description

2.1. General Function

The CUR3105 is a monolithic integrated circuit which provides an output voltage proportional to the magnetic flux through the Hall plate and proportional to the supply voltage (ratiometric behavior).

The external magnetic field component perpendicular to the branded side of the package generates a Hall voltage proportional to the magnetic field. 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 an analog voltage with ratiometric behavior, and stabilized by a push-pull output transistor stage. The function and the parameters for the DSP are explained in Section 2.2. on page 9.

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). In the supply voltage range from 4.5 V up to 5.5 V, the transducer generates an analog output voltage. After detecting a command, the transducer reads or writes the memory and answers with a digital signal on the output pin. The analog output is switched off during the communication. Several ICs in parallel to the same supply and ground line can be programmed individually. The selection of each IC is done via its output pin.

The open-circuit detection provides a defined output voltage if the V_{DD} or GND line is broken. 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 and non-redundant EEPROM cells. The non-redundant EEPROM cells are only used to store production information inside the IC. In addition, the IC is equipped with devices for overvoltage and reverse-voltage protection at all pins.

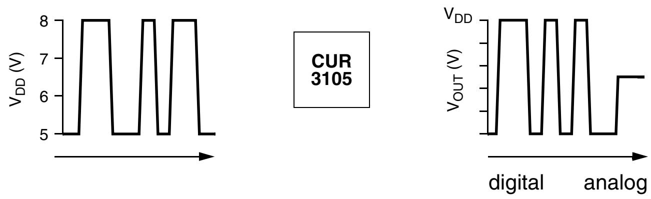


Fig. 2–1: Programming with V_{DD} modulation

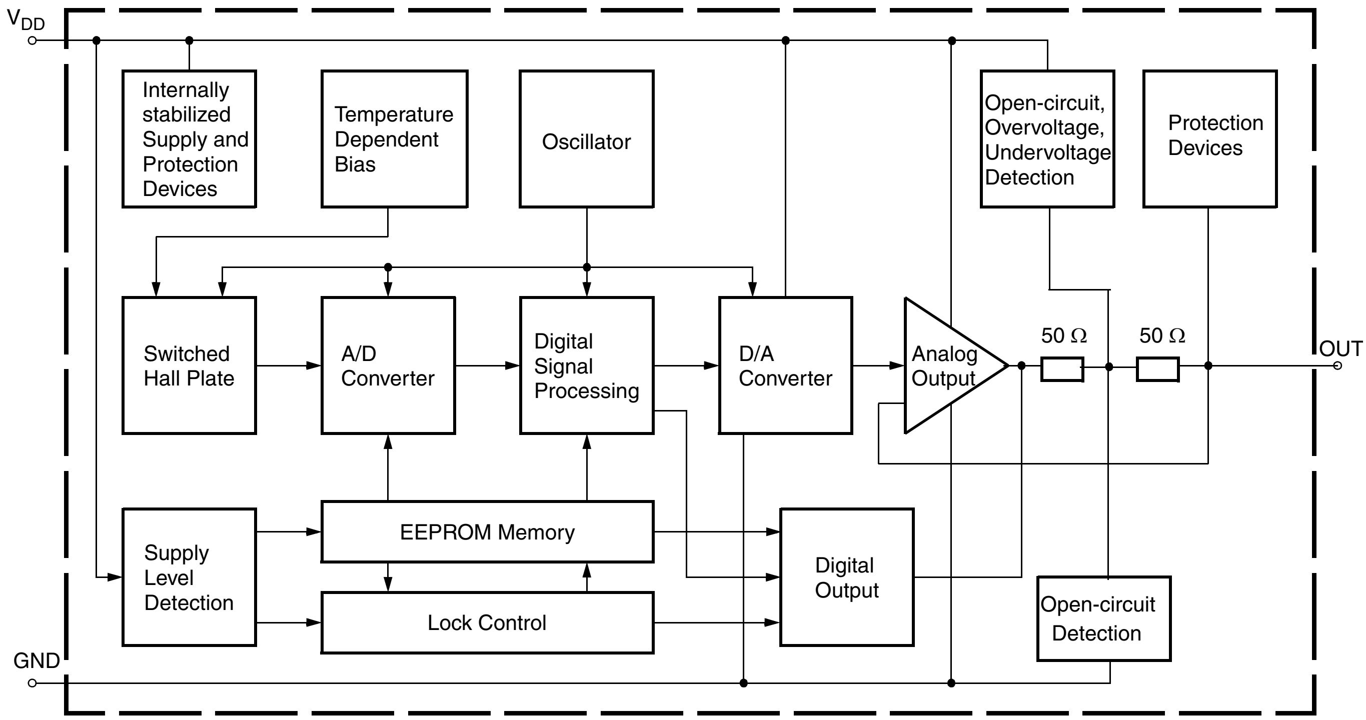


Fig. 2–2: CUR3105 block diagram

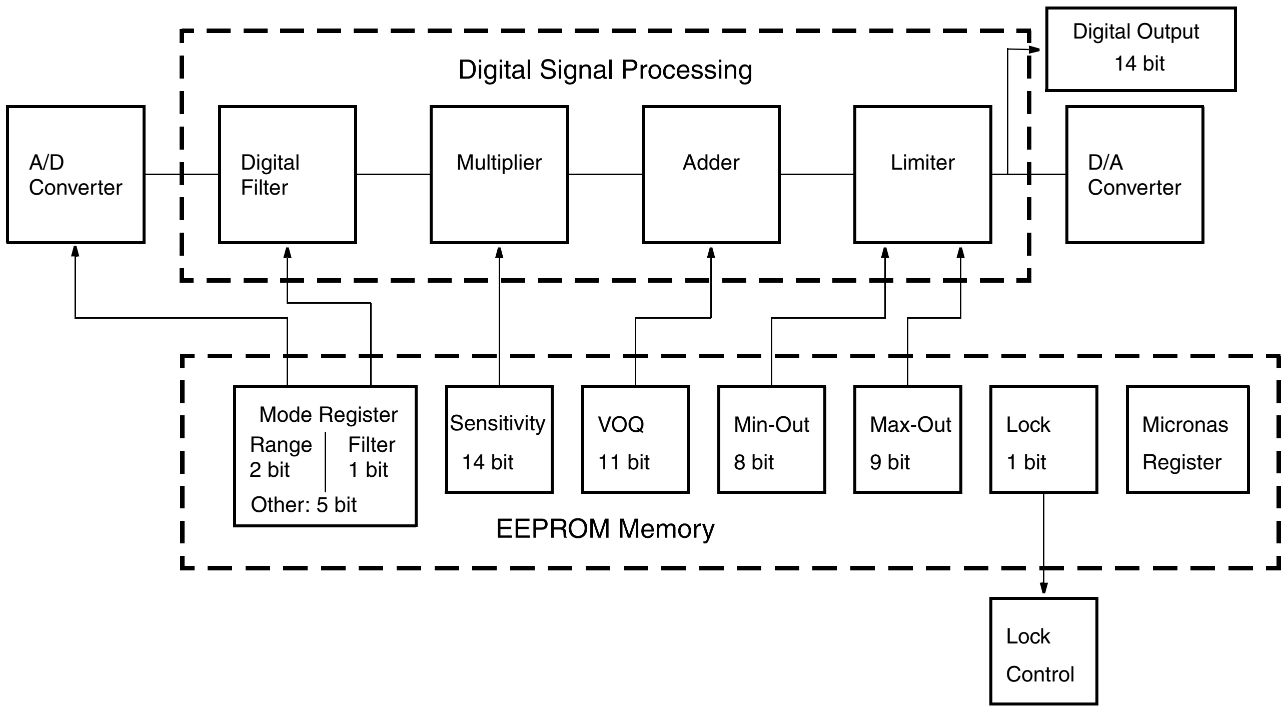


Fig. 2–3: Details of EEPROM and digital signal processing

2.2. Digital Signal Processing and EEPROM

The DSP is the main part of this transducer and performs the signal conditioning. The parameters for the DSP are stored in the EEPROM registers. The details are shown in Fig. 2–3.

Terminology:

SENSITIVITY: name of the register or register value

Sensitivity: name of the parameter

The EEPROM registers consist of four groups:

Group 1 contains the registers for the adaption of the transducer to the magnetic field generated by the current to be measured: MODE for selecting the magnetic field range and filter frequency to select the bandwidth of the transducer.

Group 2 contains the registers for defining the output characteristics: SENSITIVITY, VOQ, CLAMP-LOW, and CLAMP-HIGH. The output characteristic of the transducer is defined by these 4 parameters.

– The parameter V_{OQ} (Output Quiescent Voltage) corresponds to the output voltage at B = 0 mT.

– The parameter Sensitivity defines the magnetic sensitivity:

$$Sensitivity = \frac{\Delta V_{OUT}}{\Delta B}$$

– The output voltage can be calculated as:

$$V_{OUT} \sim Sensitivity \times B + V_{OQ}$$

The output voltage range can be clamped by setting the registers CLAMP-LOW and CLAMP-HIGH in order to enable failure detection (such as short-circuits to V_{DD} or GND and open connections).

Group 3 contains the general purpose register GP. The GP Register can be used to store customer information, like a serial number after manufacturing. Micronas will use this GP REGISTER to store informations like, Lot number, wafer number, x and y position of the die on the wafer, etc. This information can be readout by the customer and stored in it's on data base or it can stay in the IC as is.

Group 4 contains the Micronas registers and LOCK for the locking of all registers. The Micronas registers are programmed and locked during production. These registers are used for oscillator frequency trimming, A/D converter offset compensation, and several other special settings.

An external magnetic field generates a Hall voltage on the Hall plate. The ADC converts the amplified positive or negative Hall voltage 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 D/A-READOUT register. Depending on the programmable magnetic range of the transducer IC, the operating range of the A/D converter is from –30 mT...+30 mT up to –100 mT...+100 mT.

During further processing, the digital signal is multiplied with the sensitivity factor, added to the quiescent output voltage and limited according to the clamping voltage. The result is converted to an analog signal and stabilized by a push-pull output transistor stage.

The D/A-READOUT at any given magnetic field depends on the programmed magnetic field range, the low-pass filter, TC values and CLAMP-LOW and CLAMP-HIGH. The D/A-READOUT range is min. 0 and max. 16383.

Note: During application design, it should be taken into consideration that the maximum and minimum D/A-READOUT should not saturate in the operational range of the specific application.

Range

The RANGE bits are bit 2 and 3 of the MODE register; they define the magnetic field range of the A/D converter.

Magnetic Field Range	RANGE
–30mT...30 mT	0
–60 mT...60 mT	1
–80 mT...80 mT	2
–100 mT...100 mT	3

Filter

The FILTER bit is bit number 4 of the MODE register; it defines the –3 dB frequency of the digital low pass filter.

–3 dB Frequency	FILTER
500 Hz	0
1 kHz	1

Bit Time

The BITTIME bit is bit number 5 of the MODE register; It defines the protocol bit time for the communication between the IC and the programmer board.

Bit Time	BITTIME
1:64 (Typ. 1.75 ms)	0
1:128 (Typ. 3.5 ms)	1

Output Format

The OUTPUTMODE bits are the bits number 6 to 7 of the MODE register; They define the different output modes.

Output Format	OUTPUTMODE
Analog Output (12 bit)	0
Internal Burn-In Mode	2
Multiplex Analog Output (external trigger)	–

In Analog Output mode, the transducer provides an ratiometric 12-bit analog output voltage between 0 V and 5 V.

In Multiplex Analog Output mode, the IC transmits the LSN and MSN of the output value separately. This enables the IC to transmit a 14-bit signal. In external trigger mode the ECU can switch the output of the IC between LSN and MSN by changing current flow direction through IC output. In case the output is pulled up by a 10 kΩ resistor the IC sends the MSN. If the output is pulled down the IC will send the LSN. Maximum refresh rate is about 500 Hz (2 ms). Three pins are sufficient.

Note: Please contact Micronas for further information about Multiplex Analog Output Mode.

In Burn-In Mode, the signal path of the transducer DSP is stimulated internally without applied magnetic field. In this mode, the transducer provides a “saw tooth” shape output signal. Shape and frequency of the saw tooth signal depends on the programming of the transducer. This mode can be used for Burn-In test in the customers production line.

Sensitivity

The SENSITIVITY register contains the parameter for the multiplier in the DSP. The Sensitivity is programmable between –4 and 4. For V_{DD} = 5 V, the register can be changed in steps of 0.00049.

For all calculations, the digital value from the magnetic field of the D/A converter is used. This digital information is readable from the D/A-READOUT register.

$$\text{SENSITIVITY} = \frac{\Delta V_{out} \times 16383}{2 \cdot \Delta\text{DA-Readout} \cdot V_{DD}}$$

VOQ

The VOQ register contains the parameter for the adder in the DSP. V_{OQ} is the output voltage without external magnetic field (B = 0 mT) and programmable from $-V_{DD}$ up to V_{DD}. For V_{DD} = 5 V, the register can be changed in steps of 4.9 mV.

Note: If V_{OQ} is programmed to a negative voltage, the maximum output voltage is limited to:

$$V_{OUTmax} = V_{OQ} + V_{DD}$$

Clamping Voltage

The output voltage range can be clamped in order to detect failures like shorts to V_{DD} or GND or an open circuit.

The CLAMP-LOW register contains the parameter for the lower limit. The lower clamping voltage is programmable between 0 V and V_{DD}/2. For V_{DD} = 5 V, the register can be changed in steps of 9.77 mV.

The CLAMP-HIGH register contains the parameter for the upper limit. The upper clamping voltage is programmable between 0 V and V_{DD}. For V_{DD} = 5 V, in steps of 9.77 mV.

GP Register

This register can be used to store some information, like production date or customer serial number. Micronas will store production Lot number, wafer number and x,y coordinates in three blocks of this registers. The total register contains of four blocks with a length of 13 bit each. The customer can read out this information and store it in his own production data base for reference or he can change them and store own production information.

Note: To enable programming of the GP register bit 0 of the MODE register has to be set to 1. This register is not a guarantee for trace-ability.

LOCKR

By setting the first bit of this 2-bit register, all registers will be locked, and the IC 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!

D/A-READOUT

This 14-bit register delivers the actual digital value of the applied magnetic field after the signal processing. This register can be read out and is the basis for the calibration procedure of the IC in the system environment.

Note: The MSB and LSB are reversed compared with all the other registers. Please reverse this register after readout.

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 (PC3105) for the input of the register values.

For the individual calibration of each transducer in the customer application, a two point adjustment is recommended. The calibration shall be done as follows:

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

The magnetic range (depending on the maximum field strength generated by the current), the filter frequency, the output mode and the GP Register value are given for this application. Therefore, the values of the following registers should be identical for all transducers of the customer application.

– FILTER
(according to the maximum signal frequency)
– RANGE
(according to the maximum magnetic field at the IC position)
– OUTPUTMODE
– GP
(if the customer wants to store own production information. It is not necessary to change this register)

As the clamping voltages are given. They have an influence on the D/A-Readout value and have to be set therefore after the adjustment process.

Write the appropriate settings into the CUR3105 registers.

Step 2: Initialize DSP

As the D/A-READOUT register value depends on the settings of SENSITIVITY, VOQ and CLAMP-LOW/HIGH, these registers have to be initialized with defined values, first:

– $VOQ_{INITIAL}$ = 2.5 V
– $Sensitivity_{INITIAL}$ = 0.5
– Clamp-Low = 0 V
– Clamp-High = 4.999 V

Note: For inverted output characteristics it is necessary to change $Sensitivity_{INITIAL}$ to -0.5.
Please contact your application support team for further details.

Step 3: Define Calibration Points

The calibration points 1 and 2 can be set inside the specified range. The corresponding values for V_{OUT1} and V_{OUT2} result from the application requirements.

$$Lowclampingvoltage \le V_{OUT1,2} \le Highclampingvoltage$$

For highest accuracy of the transducer, calibration points near the minimum and maximum input signal are recommended. The difference of the output voltage between calibration point 1 and calibration point 2 should be more than 3.5 V.

Step 4: Calculation of V_{OQ} and Sensitivity

Set the system to calibration point 1 and read the register D/A-READOUT. The result is the value D/A-READOUT1.

Now, set the system to calibration point 2, read the register D/A-READOUT again, and get the value D/A-READOUT2.

With these values and the target values V_{OUT1} and V_{OUT2}, for the calibration points 1 and 2, respectively, the values for Sensitivity and V_{OQ} are calculated as:

$$Sensitivity = \frac{1}{2} \times \frac{(Vout2 - Vout1)}{(\text{D/A-Readout2} - \text{D/A-Readout1})} \times \frac{16384}{5}$$

$$V_{OQ} = \frac{1}{16} \times \left[\frac{Vout2 \times 16384}{5} - [(\text{D/A-Readout2} - 8192) \times Sensitivity \times 2]\right] \times \frac{5}{1024}$$

This calculation has to be done individually for each IC.

Next, write the calculated values for Sensitivity and V_{OQ} into the IC for adjusting the transducer. At that time it is also possible to store the application specific values for Clamp-Low and Clamp-High into the ICs EEPROM.

The transducer is now calibrated for the customer application. However, the programming can be changed again and again if necessary.

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 from step 1 are overwritten in step 4.

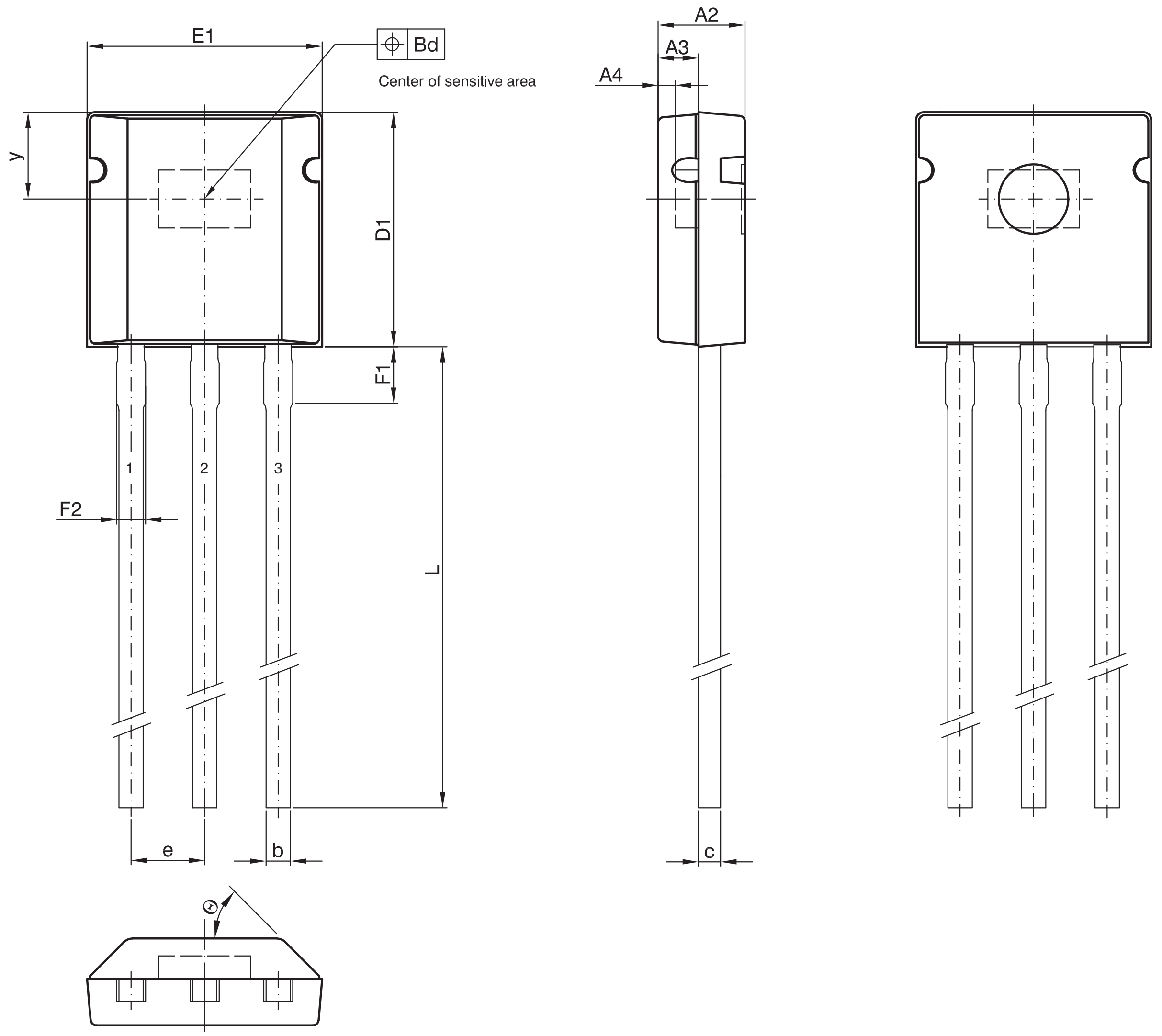
Step 5: Locking the Transducer

The last step is activating the LOCK function by programming the LOCK bit. Please note that the LOCK function becomes effective after power-down and power-up of the Hall IC. The IC is now locked and does not respond to any programming or reading commands.

Warning: This register can not 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.

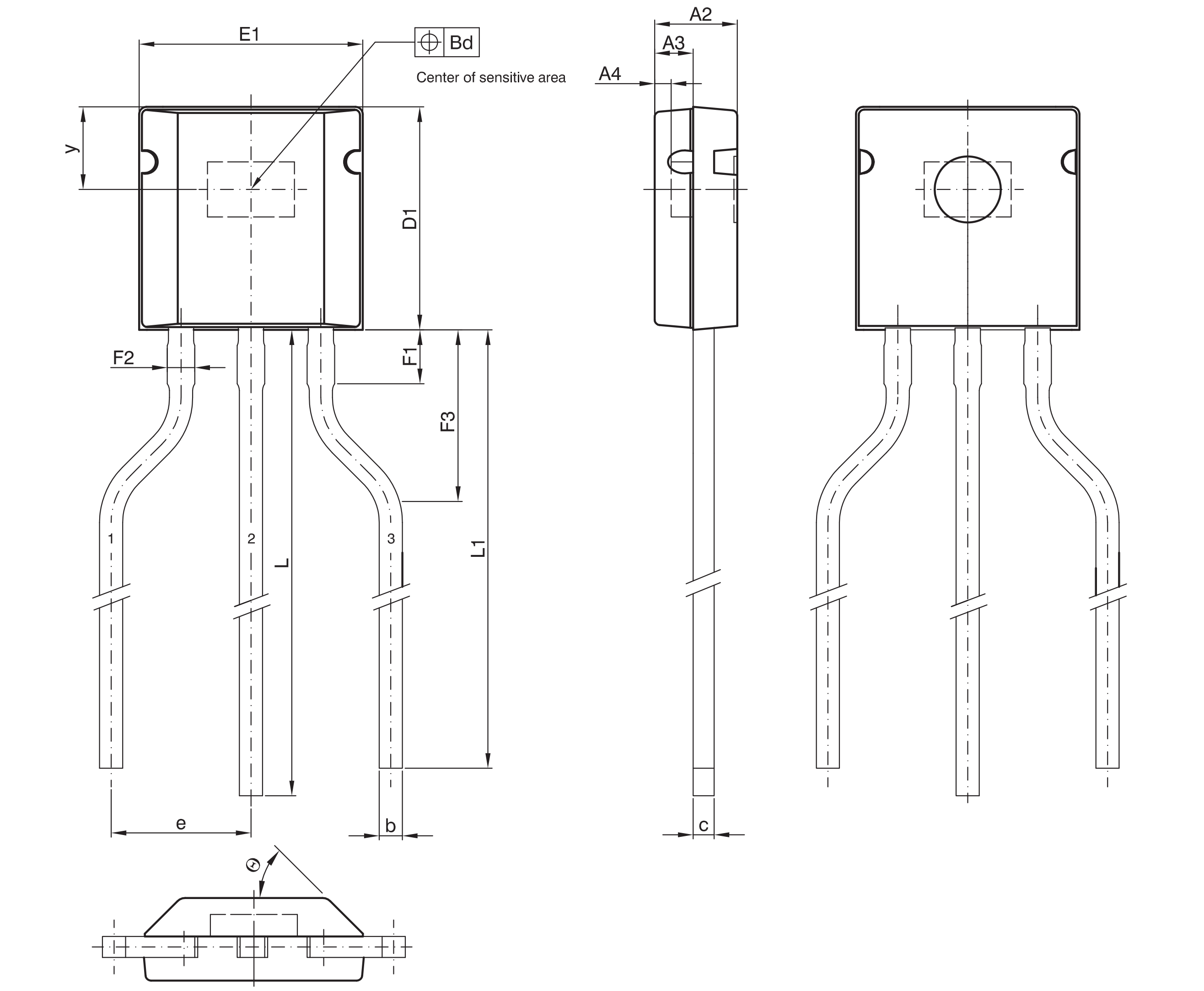
min/max of D1 are specified in the datasheet.

0 2.5 5 mm
scale

UNIT	A2	A3	b	c	D1	e	E1	F1	F2	L	Θ
mm	1.55 1.45	0.7	0.42	0.36	4.05	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.				
-	-		10-04-29	06615.0001.4	ZG001015_Ver.06

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

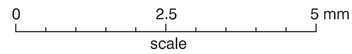


physical dimensions do not include moldflash.

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.

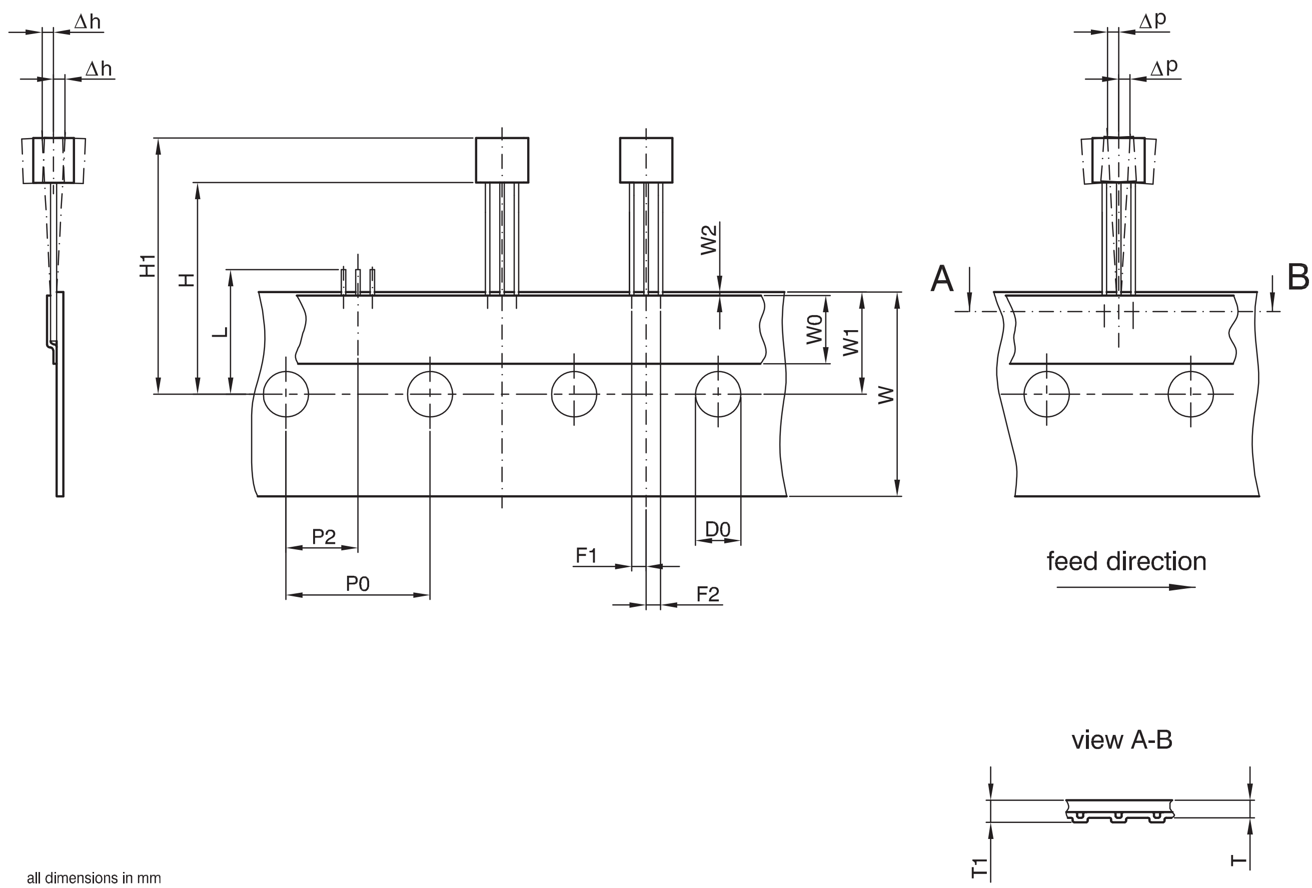
min/max of D1 are specified in the datasheet.



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	4.05	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°

JEDEC STANDARD		ANSI	ISSUE DATE YY-MM-DD	DRAWING-NO.	ZG-NO.
ISSUE	ITEM NO.				
-	-		10-04-29	06609.0001.4	ZG001009_Ver.06

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

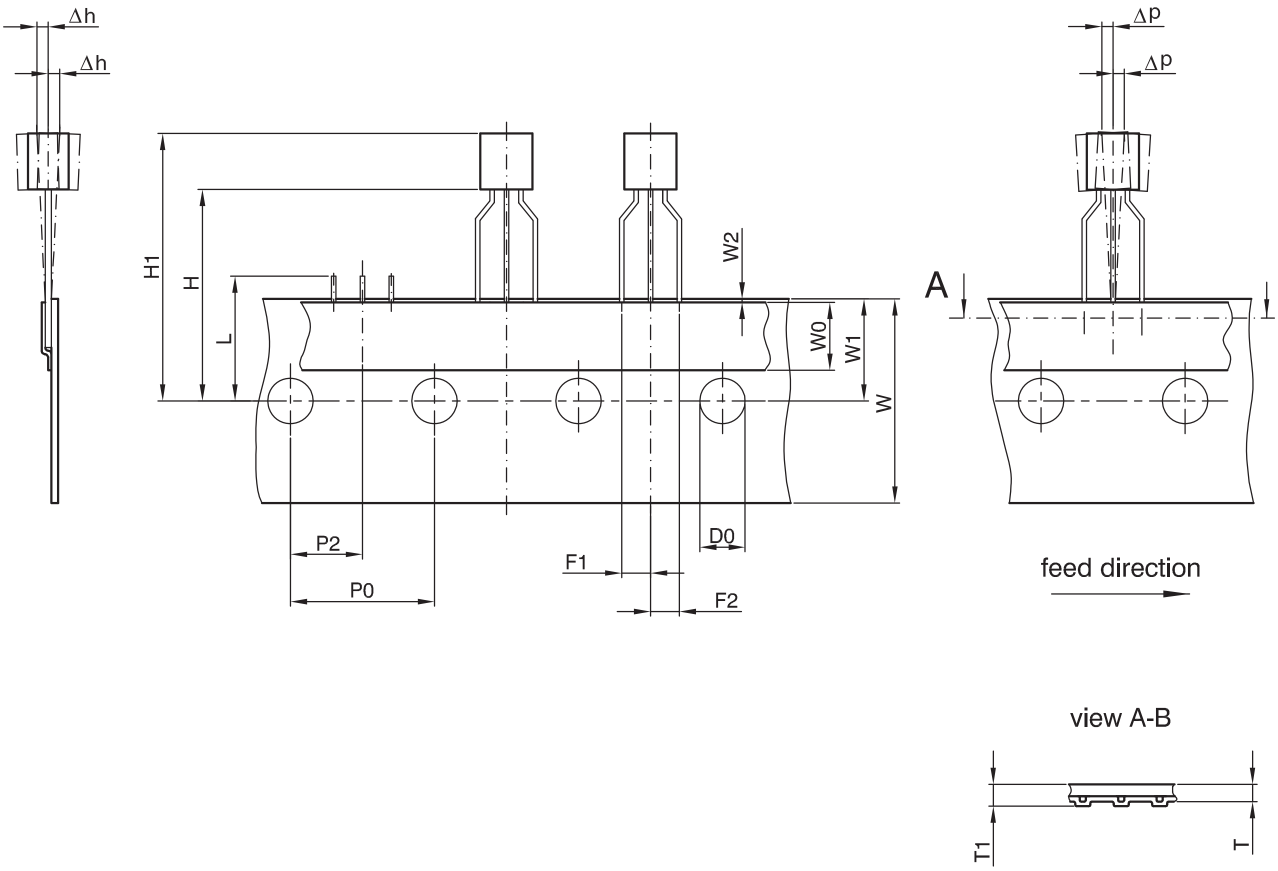


all dimensions in mm
other dimensions see drawing of bulk
max. allowed tolerance over 20 hole spacings ±1.0
H1= this dimension is different for each sensor type and is specified in the data sheet

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:
TO92UA/UT-2: Dimensions ammopack inline, not spread

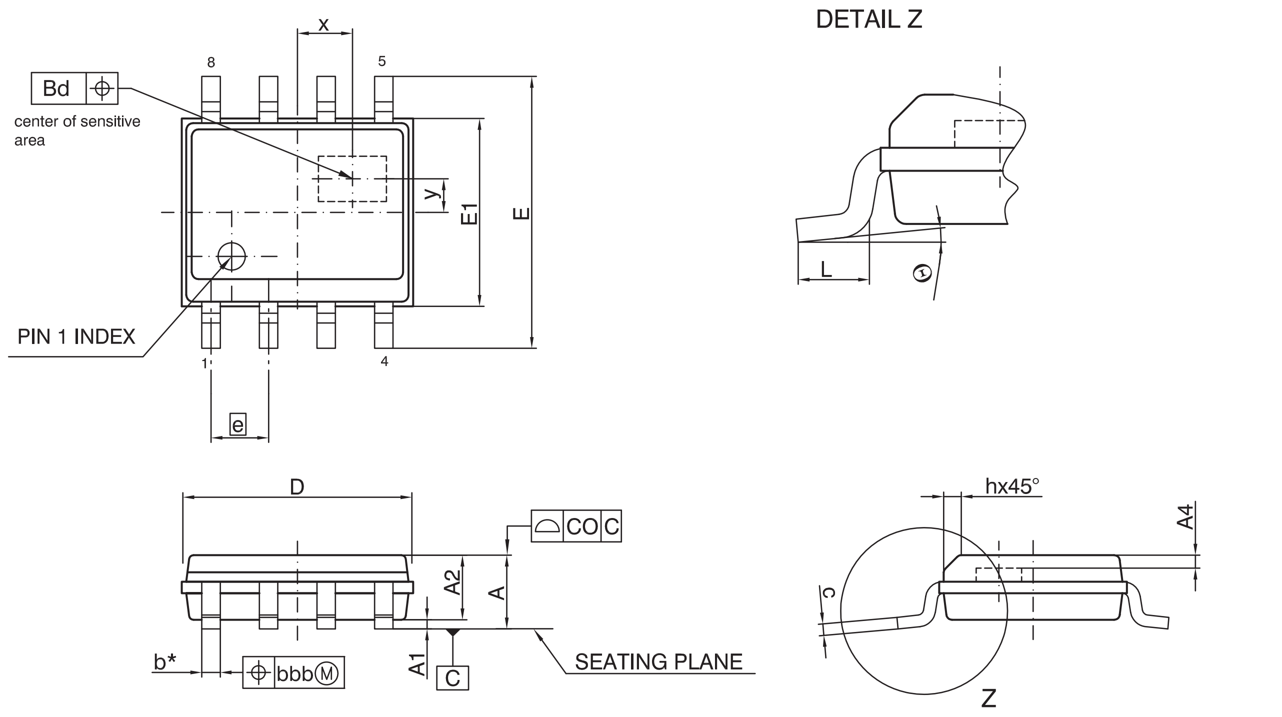


all dimensions in mm
other dimensions see drawing of bulk
max. allowed tolerance over 20 hole spacings ±1.0
H1 = this dimension is different for each sensor type and is specified in the data sheet

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

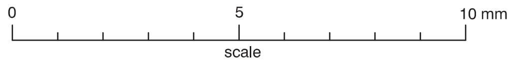
Fig. 3–4:
TO92UA/UT: Dimensions ammopack inline, spread



"D" and "E1" are reference data and do not include mold flash or protrusion.
Mold flash or protrusion shall not exceed 150 µm per side.

* does not include dambar protrusion of 0.1 max. per side

A4, Bd, x, y=these dimensions are different for each sensor type and are specified in the data sheet



UNIT	A	A1	A2	b	bbb	c	CO	D	E	E1	e	h	L	Θ
mm	1.65	0.25 0.1	1.45	0.4	0.25	0.22	0.1	5.0 4.8	6.0	4.0 3.8	1.27	0.3	0.41 min.	8° max.

JEDEC STANDARD		ANSI	ISSUE DATE YY-MM-DD	DRAWING-NO.	ZG-NO.
ISSUE	ITEM NO.				
F	MS-012		09-07-21	06690.0001.4	ZG001090_Ver.03

Fig. 3–5:
SOIC8-1: Plastic **S**mall **O**utline **IC** package, 8 leads, gullwing bent, 150 mil
Ordering code: DJ
Weight approximately 0.084 g

3.2. Dimensions of Sensitive Area

0.25 mm x 0.25 mm

3.3. Positions of Sensitive Areas

	TO92UT-1/-2	SOIC8-1
x	n.a.	0 mm nominal
y	1.5 mm nominal	0.197 mm nominal
A4	0.3 mm nominal	0.38 mm nominal
Bd	0.3 mm	0.3 mm
D1	4.05 ±0.05 mm	n.a.
H1	min. 22.0 mm, max. 24.1 mm	n.a.

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 circuit.

All voltages listed are referenced to ground (GND).

Symbol	Parameter	Pin No.	Min.	Max.	Unit	Condition
V_{DD}	Supply Voltage	1	–8.5	8.5	V	t < 96 h not additive
V_{DD}	Supply Voltage	1	–16	16	V	1) not additive t < 1 h
$-I_{DD}$	Reverse Supply Current	1	–	50 1)	mA	
V_{OUT}	Output Voltage	3 or 4	–5 3) –5 3)	8.5 2) 16 1)	V	not additive t < 1 h, not additive
$V_{OUT} - V_{DD}$	Excess of Output Voltage over Supply Voltage	3 or 4 ,1	–	2	V	
I_{OUT}	Continuous Output Current	3 or 4	–10	10	mA	
t_{Sh}	Output Short Circuit Duration	3 or 4	–	10	min	

1) as long as T_{Jmax} is not exceeded
2) as long as T_{Jmax} is not exceeded, output is not protected to external –16 V)
5) internal protection resistor = 50 Ω

3.4.1. Storage and Shelf Life for TO92UT Package

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.

3.4.2. Storage and Shelf Life for SOIC8 Package

The SOIC8 package is a moisture-sensitive Surface Mount Device. The Moisture Sensitivity Level (MSL) is defined according to JEDEC J-STD-020 (Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices). The device is packed acc. to IPC/JEDEC J-STD-033: Handling, Packing, Shipping and Use of Moisture/Reflow Sensitive Surface Mount Devices. By using these procedures, safe and damage-free reflow can be achieved.

Please follow the instructions printed on each Moisture Barrier Bag. These instructions contain information about the Moisture Sensitivity Level “MSL”, the maximum reflow temperature “Peak Package Body Temp.” and the time frame “Time for Mounting after opening the MBB”. The dry-bag shelf life capability of sealed dry-bags is minimum 12 months starting from the “Bag seal date” printed on each bag.

If moisture-sensitive components have been exposed to ambient air for longer than the specified time according to their MSL, or the humidity indicator card indicates too much moisture after opening a Moisture Barrier Bag (MBB), the components have to be baked prior to the assembly process. Please refer to IPC/JEDEC J-STD-033 for details. Please be aware that packing materials may not withstand higher baking temperatures.

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, reduce reliability and lifetime of the device.

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	
I_{OUT}	Continuous Output Current	3 or 4	–1.2	–	1.2	mA	
R_L	Load Resistor	3 or 4	5.0	10	–	kΩ	Can be pull-up or pull-down resistor
C_L	Load Capacitance	3 or 4	0.33	10	1000	nF	
N_{PRG}	Number of EEPROM Programming Cycles	–	–	–	100	Cycles	0°C < T_{amb} < 55°C
T_J	Junction Operating Temperature [1)]	–	–40 –40 –40	– – –	125 150 170	°C	for 8000 h (not additive) for 2000 h (not additive) <1000 h (not additive)

[1)] Depends on the temperature profile of the application. Please contact Micronas for life time calculations

3.6. Characteristics

at T_J = –40 °C to +170 °C (for temperature type A), V_{DD} = 4.5 V to 5.5 V, GND = 0 V after programming and locking, 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
I_{DD}	Supply Current over Temperature Range	1	–	7	10	mA	
	Resolution	3 or 4	–	12	–	bit	ratiometric to V_{DD} [1]
DNL	Differential Non-Linearity of D/A Converter	3 or 4	–2.0	0	2.0	LSB	Only at 25 °C ambient temperature Production test limit
INL	Non-Linearity of Output Voltage over Temperature	3 or 4	–0.5	0	0.5	%	% of supply voltage[2)] For V_{out} = 0.35 V ... 4.65 V; V_{DD} = 5 V
E_R	Ratiometric Error of Output over Temperature (Error in V_{OUT} / V_{DD})	3 or 4	–0.5	0	0.5	%	$\lvert V_{OUT1} - V_{OUT2} \rvert > 2\ V$ during calibration procedure
Voffset	Offset Drift over Temperature Range $\lvert V_{OUT}(B = 0\ mT)_{25°C} - V_{OUT}(B = 0\ mT)_{max} \rvert$	3 or 4	0	0.15	0.25	% V_{DD}	V_{DD} = 5 V; 60 mT range, 3 dB frequency = 500 Hz, –0.6 < sensitivity < 0.6
T_K	Temperature Coefficient of Sensitivity	3 or 4	–	0	–	ppm/k	Variation see parameter ES
ES	Error in Magnetic Sensitivity over Temperature Range	3 or 4	–2	0	2	%	V_{DD} = 5 V; 60 mT range, 3 db frequency = 500 Hz (see Section 3.6.1. on page 22)
ΔV_{OUTCL}	Accuracy of Output Voltage at Clamping Low Voltage over Temperature Range	3 or 4	–45	0	45	mV	R_L = 5 kΩ, V_{DD} = 5 V
ΔV_{OUTCH}	Accuracy of Output Voltage at Clamping High Voltage over Temperature Range	3 or 4	–45	0	45	mV	R_L = 5 kΩ, V_{DD} = 5 V
V_{OUTH}	Upper Limit of Signal Band[3)]	3 or 4	4.65	4.8	–	V	V_{DD} = 5 V, –1 mA ≤ I_{OUT} ≤ 1mA
V_{OUTL}	Lower Limit of Signal Band[3)]	3 or 4	–	0.2	0.35	V	V_{DD} = 5 V, –1 mA ≤ I_{OUT} ≤ 1mA
f_{ADC}	Internal ADC Frequency over Temperature Range	–	–	128	–	kHz	
$t_{r(O)}$	Step Response Time of Output	3 or 4	–	2 1	3 2	ms ms	3 dB Filter frequency = 500 Hz 3 dB Filter frequency = 1 kHz C_L = 10 nF, time from 10% to 90% of final output voltage for a step like signal B_{step} from 0 mT to B_{max}
$t_{d(O)}$	Delay Time of Output	3 or 4	–	0.1	0.5	ms	C_L = 10 nF
t_{POD}	Power-Up Time (Time to Reach Stabilized Output Voltage)	–	1.5	1.7	1.9	ms	C_L = 10 nF, 90% of V_{OUT}
BW	Small Signal Bandwidth (–3 dB)	3 or 4	–	1	–	kHz	B_{AC} < 10 mT; 3 dB Filter frequency = 1 kHz
V_{OUTn}	RMS Noise on Output Voltage	3 or 4	–	6	15	mV	magnetic range = 60 mT 3 dB Filter frequency = 500 Hz Sensitivity ≤ 0.7; C = 4.7 nF (V_{DD} & V_{OUT} to GND)
R_{OUT}	Output Resistance over Recommended Operating Range	3 or 4	–	1	10	Ω	$V_{OUTLmax}$ ≤ V_{OUT} ≤ $V_{OUTHmin}$

1) Output DAC full scale = 5 V ratiometric, Output DAC offset = 0 V, Output DAC LSB = V_{DD}/4096
2) if more than 50% of the selected magnetic field range is used and the temperature compensation is suitable
3) Signal Band Area with full accuracy is located between V_{OUTL} and V_{OUTH}. The sensor accuracy is reduced below V_{OUTL} and above V_{OUTH}

Symbol	Parameter	Pin No.	Min.	Typ.	Max.	Unit	Conditions
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
SOIC8 Package							
	Thermal Resistance						
R_{thja}	Junction to Air	–	–	–	180	K/W	Measured with a 1s0p board
		–	–	–	113	K/W	Measured with a 1s1p board
R_{thjc}	Junction to Case	–	–	–	73	K/W	Measured with a 1s0p board
		–	–	–	46	K/W	Measured with a 1s1p board

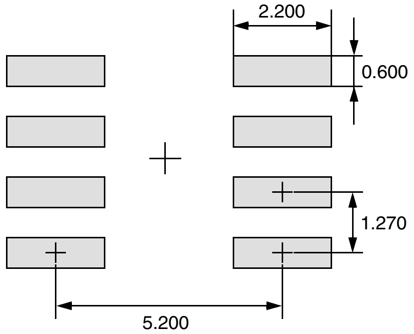


Fig. 3–1: Recommended pad size SOIC8 package

3.6.1. Definition of Sensitivity Error ES

ES is the maximum of the absolute value of 1 minus the quotient of the normalized measured value[1)] over the normalized ideal linear[2)] value:

$$ES = \max\left(\mathrm{abs}\left(\frac{\mathrm{meas}}{\mathrm{ideal}} - 1\right)\right)\Big|_{[Tmin,\ Tmax]}$$

In the below example, the maximum error occurs at −10 °C:

$$ES = \frac{1.001}{0.993} - 1 = 0.8\%$$

1) normalized to achieve a least-square-fit straight-line that has a value of 1 at 25 °C

2) normalized to achieve a value of 1 at 25 °C

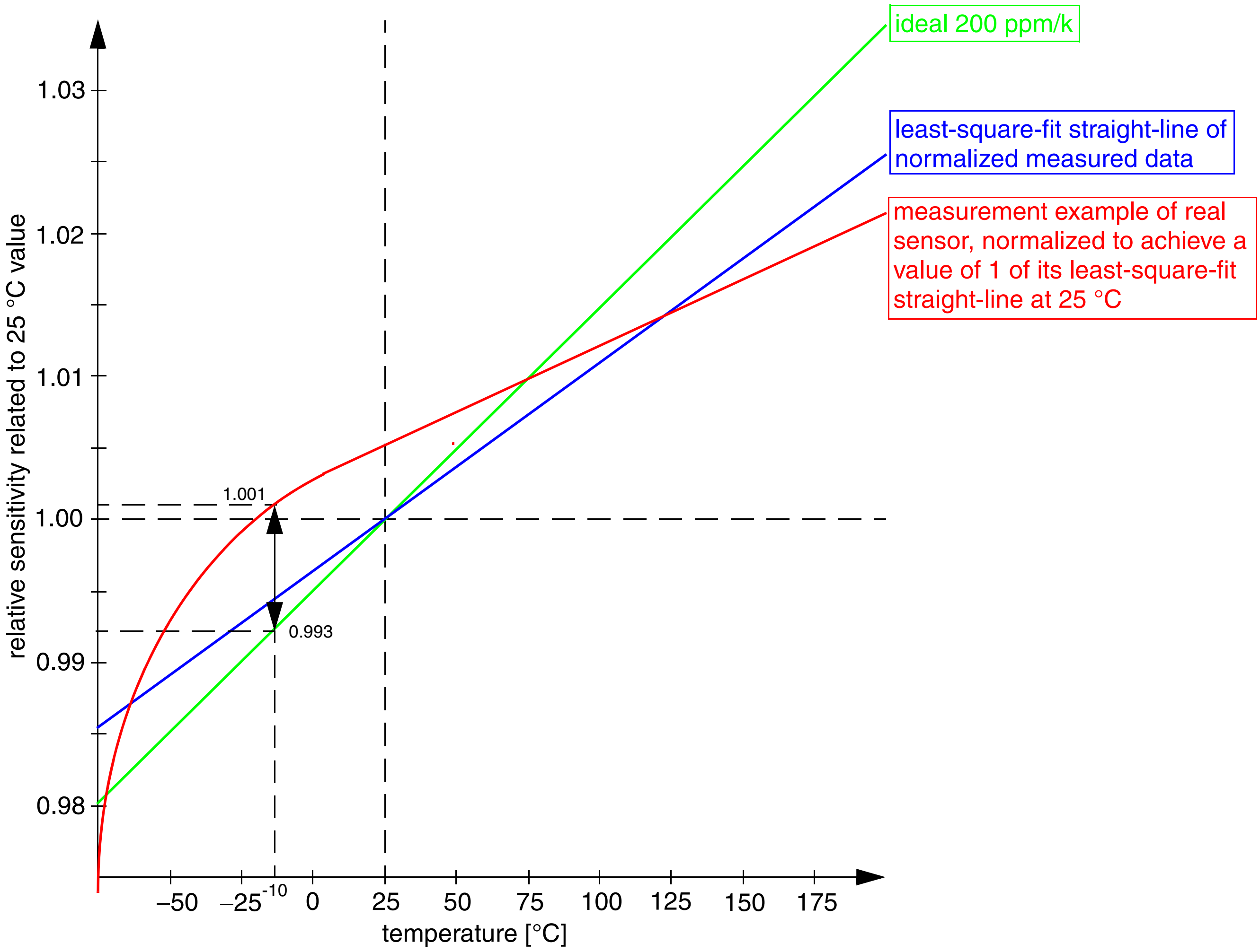


Fig. 3–2: ES definition example

3.7. Open-Circuit Detection

at T_J = –40 °C to +170 °C (A-Type), Typical Characteristics for T_J = 25 °C, after locking the sensor.
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	Comment
V_{OUT}	Output Voltage at Open V_{DD} Line	3 or 4	0	0	0.15	V	V_{DD} = 5 V R_L = 10 kΩ to 200 kΩ
			0	0	0.2	V	V_{DD} = 5 V R_L = 5 kΩ to 10 kΩ
V_{OUT}	Output Voltage at Open GND Line	3 or 4	4.85	4.9	5.0	V	V_{DD} = 5 V 10 kΩ ≥R_L ≤ 200 kΩ
			4.8	4.9	5.0	V	V_{DD} = 5 V 5 kΩ ≥ R_L < 10 kΩ
R_L: Can be pull-up or pull-down resistor							

3.8. Power-On Operation

at T_J = –40 °C to +170 °C (A-Type), after programming and locking. Typical Characteristics for T_J = 25 °C
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	Min.	Typ.	Max.	Unit
POR_{UP}	Power-On Reset Voltage (UP)	–	3.4	–	V
POR_{DOWN}	Power-On Reset Voltage (DOWN)	–	3.0	–	V

3.9. Overvoltage and Undervoltage Detection

at T_J = –40 °C to +170 °C (A-Type), Typical Characteristics for T_J = 25 °C, after programming and locking
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	Test Conditions
$V_{DD,UV}$	Undervoltage Detection Level	1	–	4.2	4.3	V	[1]
$V_{DD,OV}$	Overvoltage Detection Level	1	8.5	8.9	10.0	V	[1]

[1] If the supply voltage drops below $V_{DD,UV}$ or rises above $V_{DD,OV}$, the output voltage is switched to V_{DD} (≥97% of V_{DD} at R_L = 10 kΩ to GND). The CLAMP-LOW register has to be set to a voltage ≥ 200 mV.

Note: The over- and undervoltage detection is activated only after locking the sensor!

3.10. Magnetic Characteristics

at T_J = –40 °C to +170 °C (A-Type), V_{DD} = 4.5 V to 5.5 V, GND = 0 V after programming and locking,
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	Test Conditions
B_{Offset}	Magnetic Offset	3 or 4	–0.5	0	0.5	mT	B = 0 mT, I_{OUT} = 0 mA, T_J = 25 °C, unadjusted sensor
$\Delta B_{Offset}/\Delta T$	Magnetic Offset Change due to T_J	3 or 4	–10	0	10	µT/K	B = 0 mT, I_{OUT} = 0 mA

4. Application Notes

4.1. Application Circuit

For EMC protection, it is recommended to connect one ceramic 100 nF capacitor each between ground and the supply voltage, respectively the output voltage pin. In addition, the input of the controller unit should be pulled-down with a 10 kΩ resistor and a ceramic 4.7 nF capacitor.

Please note that during programming, the sensor will be supplied repeatedly with the programming voltage of 12.5 V for 100 ms. All components connected to the V_{DD} line at this time must be able to resist this voltage.

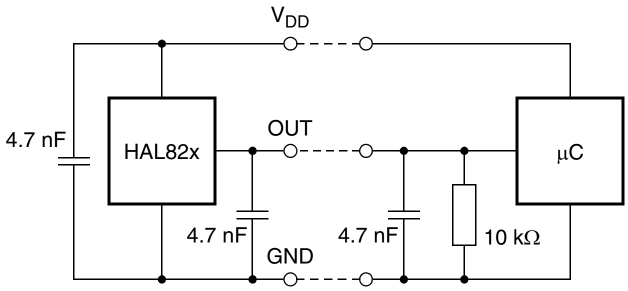


Fig. 4–1: Recommended application circuit

4.2. Use of two CUR3105 in Parallel

Two different CUR3105 current transducers which are operated in parallel to the same supply and ground line can be programmed individually. In order to select the IC which should be programmed, both ICs are inactivated by the “Deactivate” command on the common supply line. Then, the appropriate IC is activated by an “Activate” pulse on its output. Only the activated sensor will react to all following read, write, and program commands. If the second IC has to be programmed, the “Deactivate” command is sent again, and the second IC can be selected.

Note: The multi-programming of two transducers works only if the outputs of the two IC’s are pulled to GND with a 10 kΩ pull-down resistor.

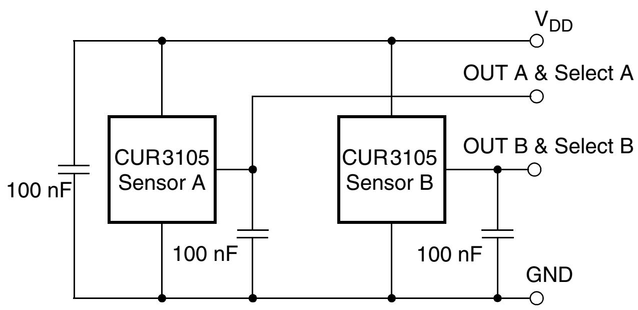


Fig. 4–2: Parallel operation of two CUR3105

4.3. 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:

$$\Delta T = I_{DD} \times V_{DD} \times R_{thJ}$$

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

For V_{DD} = 5.5 V, R_{thjA} = 235 K/W, and I_{DD} = 10 mA, the temperature difference ΔT = 12.93 K.

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

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

4.4. EMC and ESD

The CUR3105 is designed for a stabilized 5 V supply. Interferences and disturbances conducted along the 12 V on board system (product standard ISO 7637 part 1) are not relevant for these applications.

For applications with disturbances by capacitive or inductive coupling on the supply line or radiated disturbances, the application circuit shown in Fig. 4–1 is recommended.