# iC-MZI
## 2-WIRE DIFFERENTIAL HALL SWITCH

preliminary



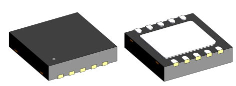
### FEATURES

- Simple electric connection possible as two-wire device
- High magnetic sensitivity with input frequency up to 30 kHz
- User-defined current levels preset by external resistors
- Automatic duty-cycle correction and operation point settings
- Reverse polarity protected supply voltage

### APPLICATIONS

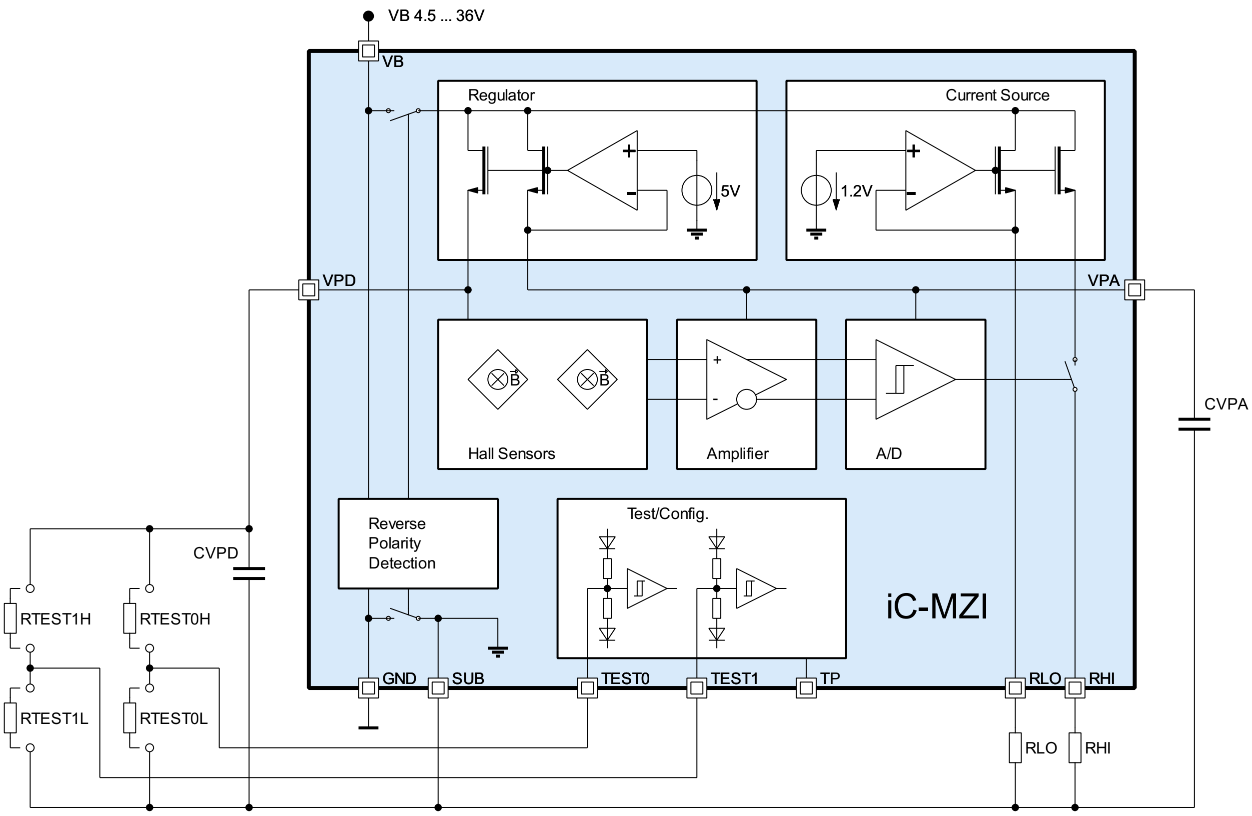
- Gear wheel sensing
- Magnetic position encoders
- Proximity switch

### PACKAGES



DFN10
4 mm x 4 mm x 0.9 mm
RoHS compliant

### BLOCK DIAGRAM

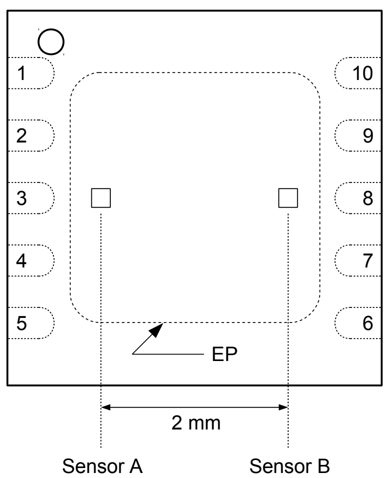


## DESCRIPTION

The iC-MZI is a differential Hall switch intended for sensing a magnetic target or, with the aid of an additional back-bias magnet, a ferromagnetic gear. The two Hall sensors are spaced 2 mm apart. Depending on the detected magnetic field difference, the supply current of the iC-MZI will vary between two levels (high, low) which are preset by two external resistors RHI and RLO respectively. With solenly using the supply pins VB and GND, thus the iC-MZI acts as a simple two-wire, reverse polarity protected magnetic sensor switch.

## PACKAGING INFORMATION

### PIN CONFIGURATION DFN10 4x4



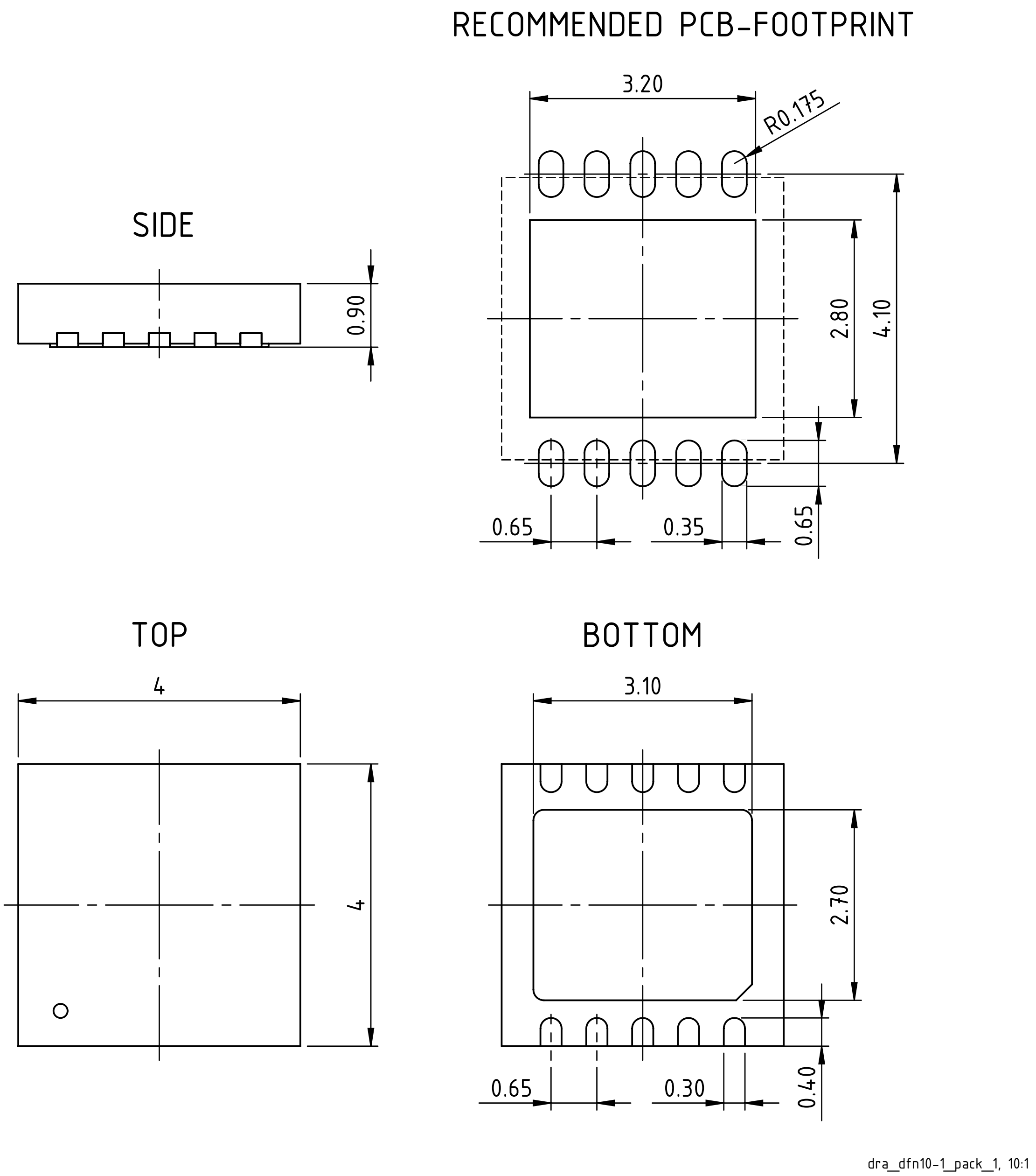

### PIN FUNCTIONS

| No. | Name | Function |
|---|---|---|
| 1 | VPD | Internal digital supply voltage |
| 2 | RLO | Low level current preset |
| 3 | TEST0 | Test pin 0 |
| 4 | RHI | High level current preset |
| 5 | GND | Supply Ground |
| 6 | VB | Supply voltage |
| 7 | TP | (iC-Haus use only - do not connect) |
| 8 | SUB | Substrate (internal Ground) |
| 9 | TEST1 | Test pin 1 |
| 10 | VPA | Internal analog supply voltage |
| | EP | Exposed Pad |

Connect the *Exposed Pad* EP to SUB pin. Use a large ground plane to improve thermal performance. EP is not intended as an electrical connection point. The pin TP is for iC-Haus test purpose and has to be left unconnected. Orientation of the logo (iC MZI CODE ...) is subject to alteration.

## PACKAGE DIMENSIONS DFN10 4 mm x 4 mm

All dimensions given in mm.



## ABSOLUTE MAXIMUM RATINGS

Beyond these values damage may occur; device operation is not guaranteed.

| Item No. | Symbol | Parameter | Conditions | Min. | Max. | Unit |
|---|---|---|---|---|---|---|
| G001 | VB | Voltage at VB | | -40 | 40 | V |
| G002 | I(VB) | Current in VB | | -40 | 40 | mA |
| G003 | Vd() | Susceptibility to ESD at all pins | HBM 100 pF discharged through 1.5 kΩ | | 2 | kV |
| G004 | V() | Voltage at all pins (exept VB) | versus SUB | -0.3 | 5.5 | V |
| G005 | I() | Current in TEST0, TEST1 | | -4 | 4 | mA |
| G006 | I() | Current in RLO, RHI, VPA, VPD, SUB | | -20 | 20 | mA |

## THERMAL DATA

| Item No. | Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| T01 | Ta | Operating ambient temperature range | | -40 | | +120 | °C |
| T02 | Tj | Junction Temperature | | -40 | | +125 | °C |
| T03 | Ts | Storage Temperature | | -55 | | +125 | °C |

All voltages are referenced to ground unless otherwise stated.
All currents flowing into the device pins are positive; all currents flowing out of the device pins are negative.

## ELECTRICAL CHARACTERISTICS

Operating Conditions: VB = 4.5...36 V, Tj = -40...125 °C

| Item No. | Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| **Supply data** | | | | | | | |
| 001 | VB | Permissible supply voltage | | 4.5 | | 36 | V |
| 002 | I(VB) | Supply current in VB | device only, with I(RHI, RLO) = 0 | 2.1 | 3.2 | 3.8 | mA |
| 003 | V()on | Turn-on threshold VB | versus SUB | 4.0 | | 4.4 | V |
| 004 | V()off | Turn-off threshold VB | versus SUB | 3.8 | | 4.2 | V |
| 005 | V()hys | Hysteresis VB | | 200 | | 300 | mV |
| 006 | V(VPA) | Internal analog supply | versus SUB | 4.2 | 5.0 | 5.5 | V |
| 007 | V(VPD) | Internal digital supply | versus SUB | 4.2 | 5.0 | 5.5 | V |
| 008 | V(SUB) | Substrat voltage | versus GND, I(GND) = 20 mA | | | 200 | mV |
| 009 | Vc()hi | Clamp voltage hi at pins RHI, RLO, TEST0, TEST1, TP | VCc()hi = V()−V(VPD), I() = 1 mA | 0.3 | | 1.6 | V |
| 010 | Vc()lo | Clamp voltage lo an pins RHI, RLO, TEST0, TEST1, TP, VPA, VPD | Vc()lo = V()−V(SUB), I() = -1 mA versus SUB | -1.6 | | -0.3 | V |
| 011 | Vc()hi | Clamp voltage hi an Pin VB | I() = 10 mA, versus GND, I(RHI, RLO) = 0 | 36 | | | V |
| 012 | Vc()lo | Clamp voltage lo an Pin VB | I() = -10 mA, versus GND | | | -36 | V |
| 013 | ton | Response time | From t(VB > V()on) until start of switching operation | | | 200 | µs |
| 014 | CVPA | Capacitance at VPA | versus SUB | | | 10 | nF |
| 015 | CVPD | Capacitance at VPD | versus SUB | | | 10 | nF |
| **Magnetic data** | | | | | | | |
| 101 | Hdc | Magnetic Field | DC value | -400 | | 400 | kA/m |
| 102 | Hth,hi | Magnetic switching threshold, high | TEST0, TEST1: open circuit | -2.6 | 1.2 | 5.4 | kA/m |
| 103 | Hth,lo | Magnetic switching threshold, low | TEST0, TEST1: open circuit | -5.4 | -1.2 | 2.6 | kA/m |
| 104 | Hth,hys | Hysteresis | | 2.0 | 2.4 | 2.8 | kA/m |
| 105 | \|ΔHmin\| | Differential field | switching | 3 | | | kA/m |
| 106 | fc | signal cut-off frequency | -3 dB roll off | 25 | 30 | | kHz |
| 107 | fmag | Magnetic input frequency | | 0 | | 30 | kHz |
| 108 | Hth,max | duty cycle correction range, max. magnetic field | | | | 9 | kA/m |
| 109 | Hth,min | duty cycle correction range, min. magnetic field | | -9 | | | kA/m |
| 110 | ΔHth | Step size of duty cycle-correction | | 0.1 | 0.15 | 0.2 | kA/m |
| **Pins RLO, RHI** | | | | | | | |
| 201 | V(RLO) | Voltage at RLO | I() ≤ -7 mA, versus SUB | 1.1 | 1.22 | 1.3 | V |
| 202 | V(RHI) | Voltage at RHI | I() ≤ -14 mA, versus SUB | 0 | 1.22 | 1.3 | V |
| 203 | I(RLO) | Current at RLO | versus SUB | | | 7 | mA |
| 204 | Isc(RLO) | Short-circuit current at RLO | versus SUB | 10 | | 25 | mA |
| 205 | I(RHI) | Current at RHI | versus SUB | | | 14 | mA |
| 206 | Isc(RHI) | Short-circuit current at RHI | versus SUB | 15 | | 35 | mA |
| 207 | Vt()hi | Input threshold voltage hi | in test mode, versus SUB | 3 | | | V |
| 208 | Vt()lo | Input threshold voltage lo | in test mode, versus SUB | | | 2 | V |
| **Inputs TEST0, TEST1** | | | | | | | |
| 401 | V()open | Open circuit voltage | pin not connected | 2.0 | 2.5 | 2.9 | V |
| 402 | I()pu | Pull-Up current | V() = 0 V | -40 | | -9 | µA |
| 403 | I()pd | Pull-Down current | V() = V(VPD) | 9 | | 40 | µA |
| 404 | Vt()hi,on | Input threshold voltage hi | Vt()hi = V(VPD)−V() | 0.7 | | 1.3 | V |
| 405 | Vt()hi,off | Input threshold voltage hi | Vt()hi = V(VPD)−V() | 1.0 | | 1.6 | V |
| 406 | Vt()lo,on | Input threshold voltage lo | versus SUB | 0.7 | | 1.2 | V |
| 407 | Vt()lo,off | Input threshold voltage lo | versus SUB | 0.9 | | 1.5 | V |

## Current level setting using external resistors

The voltages at pins RHI, RLO are regulated to 1.25 V typically. Therefore, attached resistors will cause additional current draw I = U/R depending on the resistor values. The quiescent current I(VB) of the iC-MZI (typ. 3.6 mA) has to be accounted for the total resulting current levels.

As an example, to set the supply current levels to I(VB,LO)= 7 mA and I(VB,HI) = 14 mA, the resulting preset currents must be I(LO) = I(VB,LO) - I(VB) = 7 mA − 3.6 mA = 3.4 mA and I(HI) = I(VB,HI) - I(VB,LO) = 7 mA, which leads to resistor values of R(RLO) = 1.25 V/3.4 mA = 370 Ω and R(RHI) = 1.25 V/7 mA = 180 Ω.

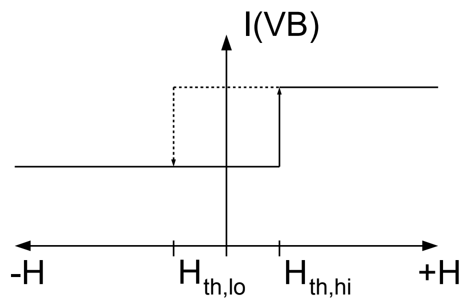



Figure 1: Current level switching vs. magnetic field difference

## Switching thresholds and hysteresis

In a typical gear sensing application, the iC-MZI is back-biased with an external magnet and the resulting variations in the magnetic field due to the modulation by the gear teeth is monitored. As the Hall sensors are spaced apart, the two sensor signals will differ and can be evaluated, thus eliminating the DC bias signal. Figure 2 shows the magnetic input signals for the two Hall sensors (green and red), from which the differential signal (blue) is extracted and, after further amplification, is fed to a comparator to toggle the two current levels.

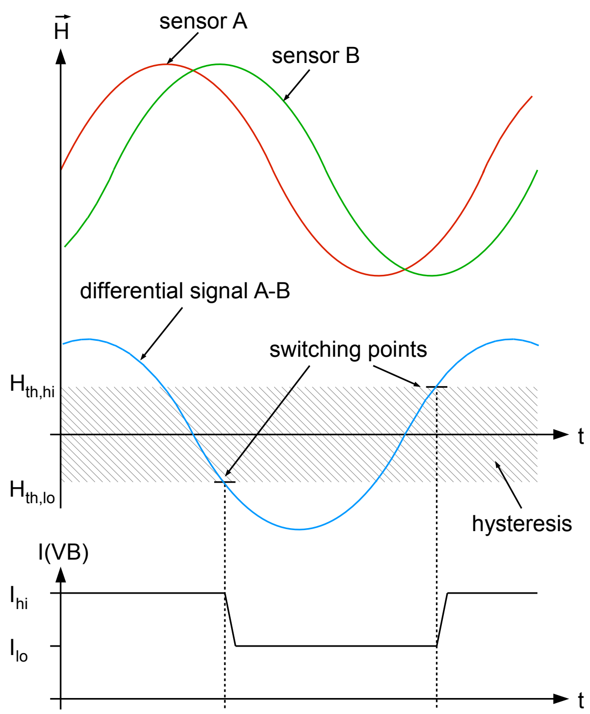



Figure 2: Übertragungsfunktion

## Effects of signal noise

In case of a moving gear with constant rotating speed, also a fixed frequency switching output signal with 50% duty-cycle is expected. Noise in the internal signal path of the device or external interference of electric or magnetic origin may have undesirable effect on switching operation.

Fig 3 shows the transfer function S(ΔH) (blue) of the iC-MZI with respect to the differencial magnetic field ΔH. R The additional noise and interferences as shown in the light blue area will also contribute to the time of switching, resulting in deviation of the nominal expected transisition known as jitter. Therefore, this jitter will lead to non-constant output duty-cycle as shown in Fig. 4.

Also note that the switching level associated with a given hysteresis, which makes the duty-cycle sensitve to the magnitude of the differential magnetic field. As shown in Fig. 5, the magnetic signal should be large compared to the hysteresis to maintain a 50% duty cycle. A weakdifferetial signal results in large deviations in duty-cycle or even non-switching operating behaviour.

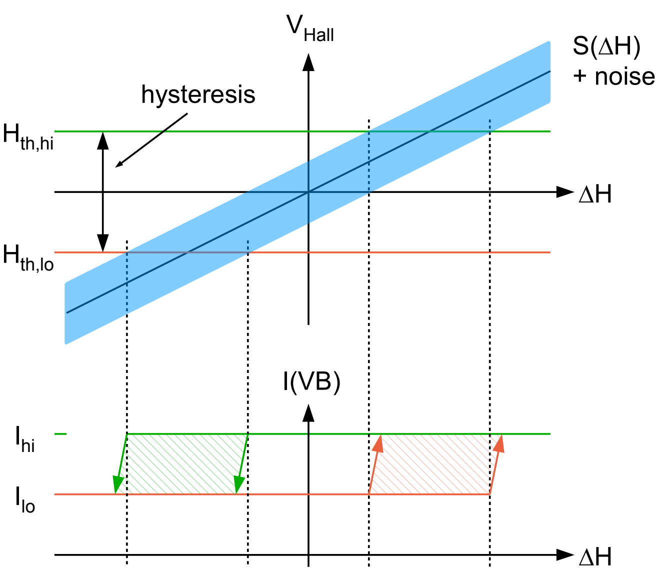



Figure 3: Switching behaviour vs. magnetic input signal

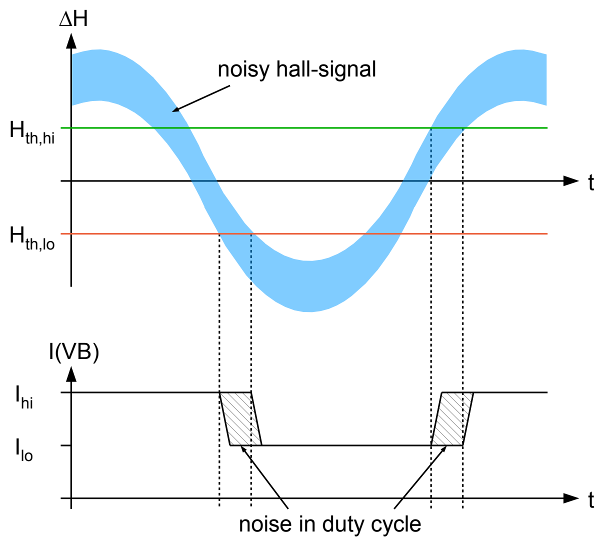



Figure 4: Effect of noise on output duty-cycle

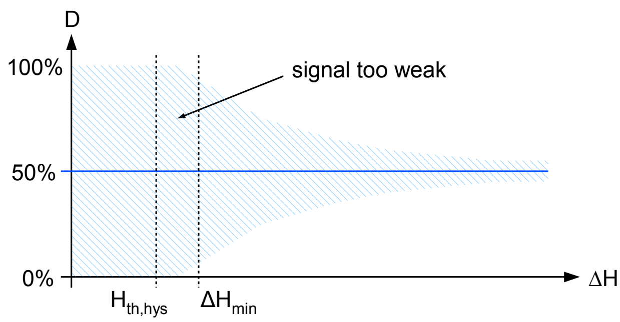



Figure 5: Duty-cycle as a function of ΔH

## Offset and duty-cycle correction

The iC-MZI allows for a duty-cylce correction provided the input signal frequency is in the range of 20 Hz to 25 kHz. This is done by offsetting the switching threshold toward the mean value of the input signal (see center bar in Fig. 6).

Table 4 shows the configuration of the offset depending on the logic state at the two pins TEST0 und TEST1.

The value PRESEL defines the threshold value of the comparator at the time of power-on to compensate for a given magntic offset. With setting AUTO an automatic offset correction is initiated.

| Nr. | TEST0 | TEST1 | Duty-Cycle Correction | PRESEL [kA/m] |
|---|---|---|---|---|
| 0 | Z | Z | OFF | 0 |
| 1 | | L | | -4,8 |
| 2 | | H | | +4,8 |
| 3 | L | Z | ON | 0 |
| 4 | | L | | -2,4 |
| 5 | | H | | -4,8 |
| 6 | H | Z | ON | AUTO |
| 7 | | L | | +2,4 |
| 8 | | H | | +4,8 |

Table 4: Parameters for Duty-Cycle Correction

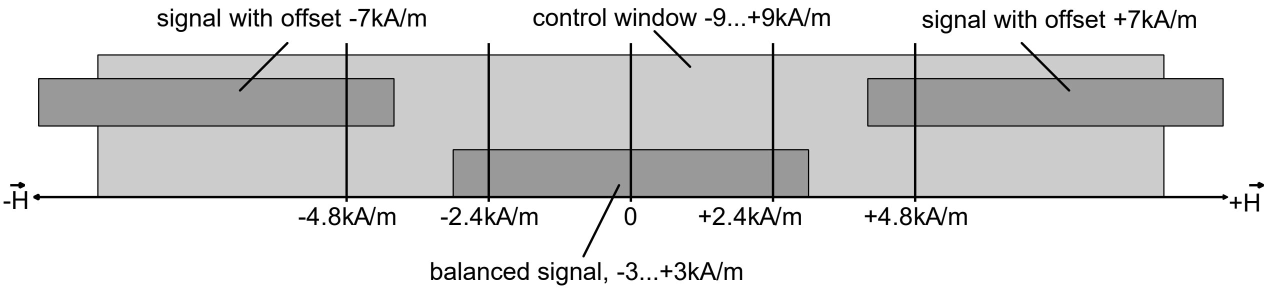



Figure 6: Adjustment range and starting values

Fig. 8 shows how the pins TEST0 and TEST1 can be configured using exterally connected resistors. The pin VPD should not be loaded with more than about 100 µA, therefore the resistors should be of no less value than about 25kΩ. Either a high or a low state at the input can be realized by connecting a resistor from the pin to VPD or SUB. Leaving the pin open results in the third logic state (mid-level, logic state Z). Fig. 7 shows how the internal signals TEST_LO and TEST_HI are related to the input voltage of the pin.

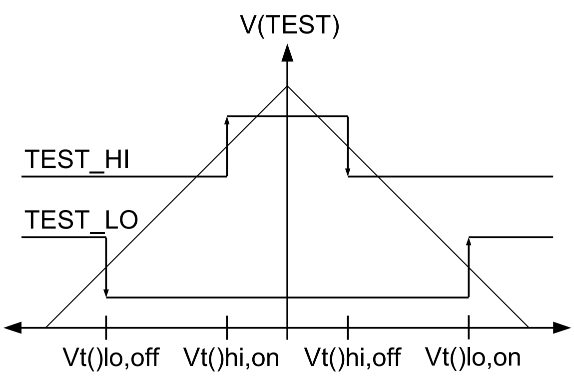



Figure 7: Three-level transfer function

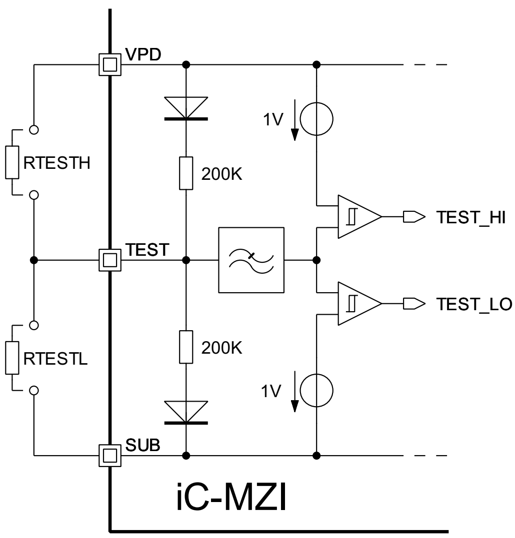



Figure 8: Schematic of the three-level inputs of TEST0 and TEST1 pins and optional preset circuitry

## Reverse polarity protection

The iC-MZI is reverse polarity protected with respect to the VB and GND pins. In case of wrong polarity the internal circuitry will be disconnected from the supply pins VB and GND.

## Substrate pin SUB

External compontents should be located as close as possible to the iC-MZI, with pin SUB as a common reference ground. During normal operation, the reverse polarity control connects SUB to the GND pin.

## Application Example

Figure 9 shows a typical arrangement of the iC-MZI together with a control unit. The latter one sources the iC-MZI with the supply voltage and shunts the supply current to convert it back to sensor voltages to be further evaluated.

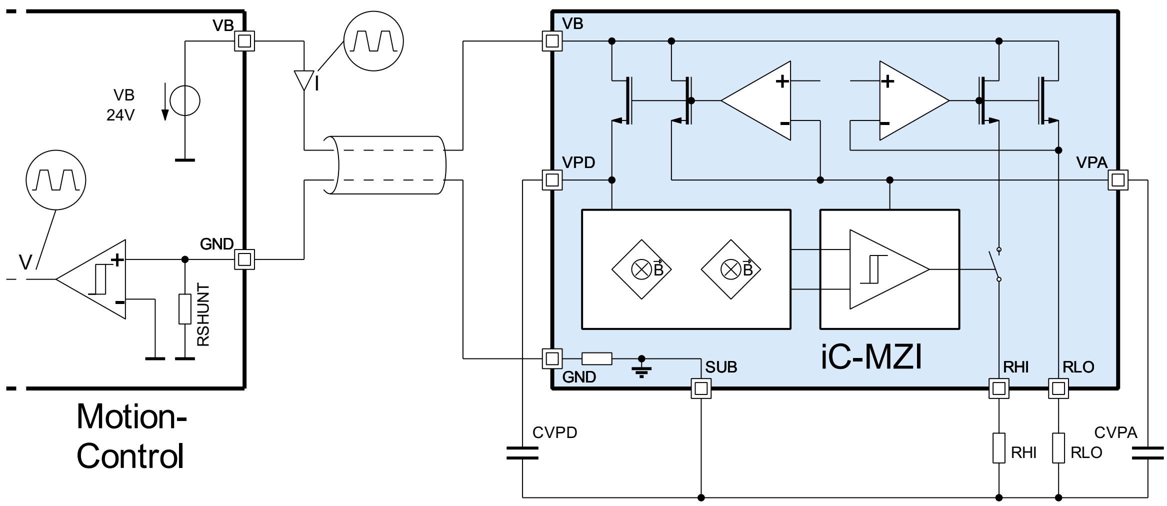



Figure 9: Sourcing and sensing the iC-MZI as a two-wire sensor

## REVISION HISTORY

| Rel. | Rel. Date* | Chapter | Modification | Page |
|---|---|---|---|---|
| A.1 | 2018-11-09 | | Preliminary Release | all |



* Release Date format: *YYYY-MM-DD*

## ORDERING INFORMATION

| Type | Package | Order Designation |
|---|---|---|
| iC-MZI | 10-pin DFN, 4 mm x 4 mm<br>0.9 mm thickness<br>RoHS compliant | iC-MZI DFN10-4x4 |

Please send your purchase orders to our order handling team:

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