

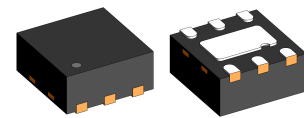
### FEATURES

- Configurable high-side, low-side and push-pull operation
- Current limited output (< 450 mA)
- Reverse polarity protection
- 150 mA output current
- 5  $\mu$ s input filter for spike suppression
- Wide supply voltage range from 8 to 30 V
- Driver shut-down with over temperature
- Integrated free-wheeling diode for inductive loads
- Sensor supply voltage output of 5 V, 10 mA

### APPLICATIONS

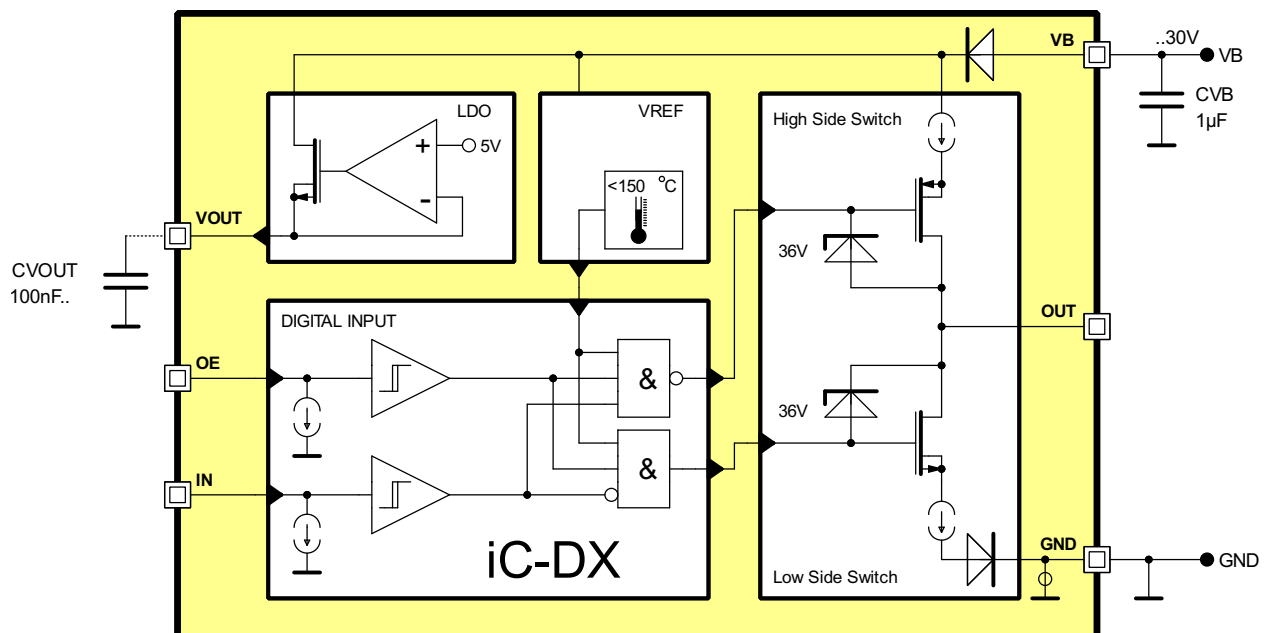
- Digital sensors
- Light barriers
- Proximity switches

### PACKAGES



DFN6 2x2mm

### BLOCK DIAGRAM



### DESCRIPTION

The iC-DX is a monolithic switch capable of driving ohmic, inductive and capacitive loads and features integrated reverse polarity protection. The supply voltage  $V_B$  of the device can range from 8 to 30 V.

Output source/sink-current is at least 150 mA, with saturation voltages of typically 2 V.

With input OE on high level state, the output works as a push-pull stage under control of pin IN. If pin IN is set either to high or low level, the output acts as

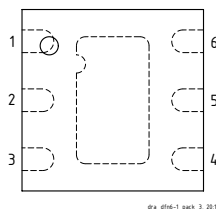
a high-side (PNP) or low-side (NPN) driver which is activated by a high logic level on input OE.

Output transitions are slew-rate limited to minimize interference on lines. The output is current limited to 450 mA maximum and short circuit protected by shutting down the device with excessive temperature.

A regulated 5 V supply which can be loaded up to 10 mA is available at pin VOUT.

### PACKAGES DFN6 2x2

#### PIN CONFIGURATION



#### PIN FUNCTIONS

##### No. Name Function

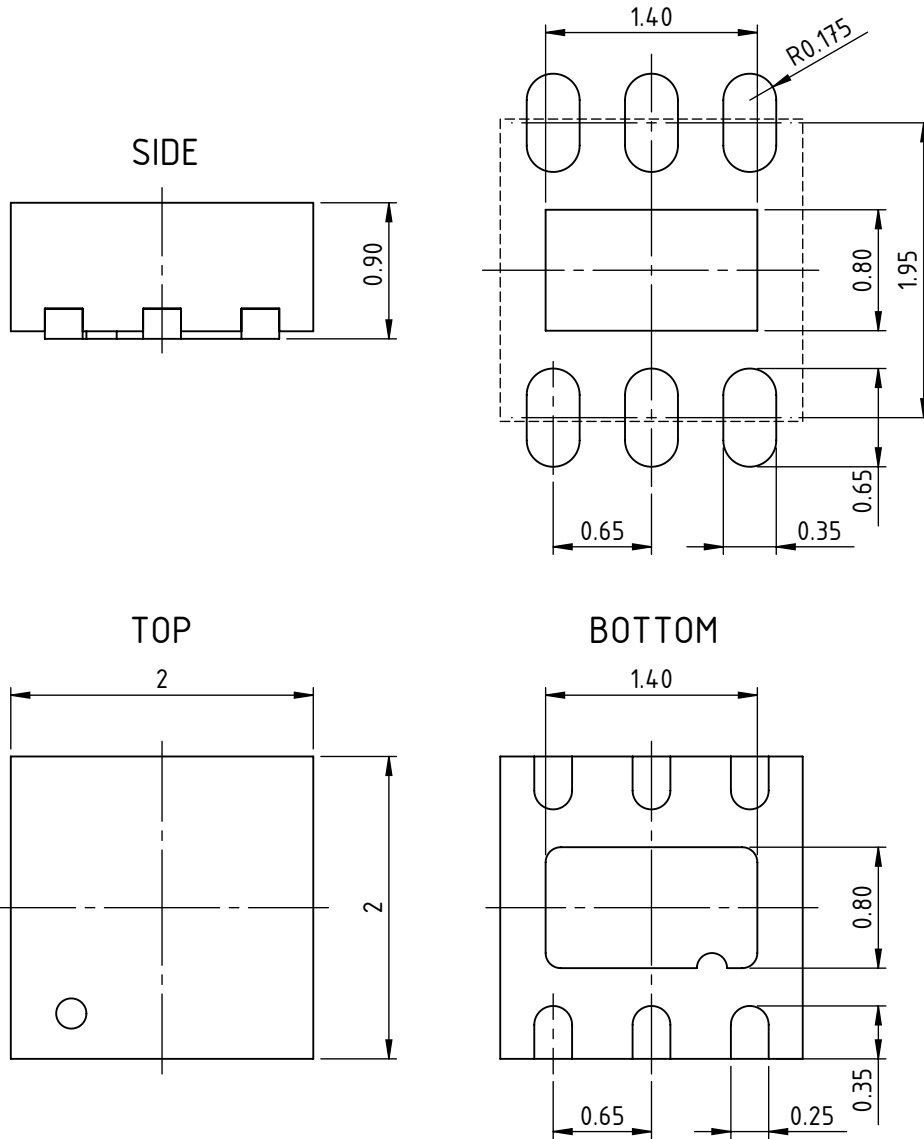
|   |      |                        |
|---|------|------------------------|
| 1 | VOUT | Regulated +5 V Voltage |
| 2 | GND  | Ground                 |
| 3 | IN   | Input                  |
| 4 | OE   | Output Enabled         |
| 5 | OUT  | Driver Output          |
| 6 | VB   | Supply Voltage         |

The *Thermal Pad* is to be connected to a Ground Plane (GND) on the PCB.

**Only pin 1 marking on top or bottom defines the package orientation (top label and coding is subject to change).**

### PACKAGE DIMENSIONS DFN6 2x2

#### RECOMMENDED PCB-FOOTPRINT



dra\_dfn6-1\_pack\_5, 20:1

**ABSOLUTE MAXIMUM RATINGS**

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

| Item No. | Symbol         | Parameter            | Conditions                               |      |      | Unit |
|----------|----------------|----------------------|--|------|------|------|
|          |                |                      |  | Min. | Max. |      |
| G001     | VB             | Supply Voltage       | Referenced to lowest voltage of GND, OUT | -36  | 36   | V    |
| G002     | OUT            | OUT Voltage          | Referenced to lowest voltage of VB, GND  | -36  | 36   | V    |
| G003     | GND            | GND Voltage          | Referenced to lowest voltage of VB, OUT  | -36  | 36   | V    |
| G004     | V()            | Voltage at IN, OE    |  | -0.3 | 7    | V    |
| G005     | T <sub>j</sub> | Junction Temperature |  | -40  | 150  | °C   |
| G006     | T <sub>s</sub> | Storage Temperature  |  | -40  | 150  | °C   |
| G007     | Vd()           | ESD Susceptibility   | HBM, 100 pF discharged through 1.5 kΩ    | 2    |      | kV   |

**THERMAL DATA**

Operating Conditions: VB = 8..30 V

| Item No. | Symbol         | Parameter                           | Conditions          |      |      |      | Unit |
|----------|----------------|-------------------------------------|---------------------|------|------|------|------|
|          |                |                                     |                     | Min. | Typ. | Max. |      |
| T01      | T <sub>a</sub> | Operating Ambient Temperature Range | no thermal shutdown | -40  |      | +150 | °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:  $V_B = 8..30\text{ V}$ ,  $T_j = -40..120^\circ\text{C}$ , unless otherwise stated

| Item No.                            | Symbol     | Parameter                                     | Conditions  |                  |      |                   | Unit           |
|-------------------------------------|------------|---|---|------------------|------|-------------------|----------------|
|                                     |            |   |   | Min.             | Typ. | Max.              |                |
| <b>General</b>                      |            |   |   |                  |      |                   |                |
| 001                                 | Vc()lo     | Clamp Voltage lo at IN, OE, VOUT              | I() = -1 mA   | -1.4             |      |                   | V              |
| 002                                 | VB         | Permissible Supply Voltage                    | Referenced to GND   | 8                | 24   | 30                | V              |
| 003                                 | I(VB)      | Supply Current in VB                          | no load,<br>IN = lo, OE = lo<br>IN = lo, OE = hi<br>IN = hi, OE = hi            |                  |      | 0.9<br>1.2<br>1.5 | mA<br>mA<br>mA |
| 004                                 | V(VB)on    | Turn-on threshold                             | increasing VB   | 6                |      | 8                 | V              |
| 005                                 | Ilk(GND)rp | Reverse Polarity Leakage Current              | V(VB) = 0; V(OUT) = 0; V(GND) = 0...30 V  |                  |      | 300               | uA             |
| 006                                 | Ilk(OUT)rp | Reverse Polarity Leakage Current              | V(VB)=0;V(GND)=0; V(OUT)= 0...30 V  |                  |      | 300               | uA             |
| 007                                 | Ilk(VB)rp  | Reverse Polarity Leakage Current              | V(OUT) = 0 ; GND open; ; V(VB)= 0...30 V  |                  |      | 300               | uA             |
| <b>Output characteristics</b>       |            |   |   |                  |      |                   |                |
| 101                                 | Vs(IOUT)lo | Saturation voltage Low-Side driver            | IN = lo, OE = hi<br>I(OUT) = 100 mA<br>I(OUT) = 150 mA                          |                  |      | 1.5<br>2          | V<br>V         |
| 102                                 | Vs(IOUT)hi | Saturation voltage High-Side driver           | IN = hi, OE = hi<br>I(OUT) = -100 mA<br>I(OUT) = -150 mA                        | -1.5<br>-2       |      |                   | V<br>V         |
| 103                                 | Isc()lo    | Short-Circuit Current lo in OUT               | V(OUT) = 3 V...VB   | 150              |      | 450               | mA             |
| 104                                 | Isc()hi    | Short-Circuit Current Hi in OUT               | V() = 0...VB - 3 V  | -450             |      | -150              | mA             |
| 105                                 | Ilk()      | Leakage Current at OUT                        | OUTPUT Disabled<br>V(OUT) = -6...0 V<br>V(OUT) = 0 V...VB<br>V(OUT) > VB...30 V | -100<br>-40<br>0 |      | 0<br>40<br>100    | uA<br>uA<br>uA |
| 106                                 | SR()       | Slew Rate (switch off → on, switch on → off ) | VB = 30 V, CI = 2.2 nF, I(OUT) = 0  |                  |      | 40                | V/μs           |
| 107                                 | Vfw(OUT)lo | Freewheeling Voltage                          | I(OUT) = -1 mA,<br>with reference to VB   | -50              |      | -36               | V              |
| 108                                 | Vfw(OUT)hi | Freewheeling Voltage                          | I(OUT) = 1 mA,<br>with reference to GND   | 36               |      | 50                | V              |
| <b>Temperature monitor</b>          |            |   |   |                  |      |                   |                |
| 201                                 | Toff       | Overtemperature shutdown                      | increasing Tj   | 150              |      | 198               | °C             |
| <b>Inputs OE, IN</b>                |            |   |   |                  |      |                   |                |
| 301                                 | Vt()hi     | Input Threshold Voltage hi at IN, OE          |   |                  |      | 2                 | V              |
| 302                                 | Vt()lo     | Input Threshold Voltage lo at IN, OE          |   | 0.8              |      |                   | V              |
| 303                                 | Vt()hys    | Hysteresis at IN, OE                          | Vt()hys = Vt()hi - Vt()lo   | 200              |      |                   | mV             |
| 304                                 | Ipd()      | Pull-Down Current at IN, OE                   | V() > 0.4 V   | 2                |      | 150               | uA             |
| 305                                 | tpio       | Propagation Delay<br>IN, OE → OUT             |   | 2.1              |      | 6.5               | μs             |
| 306                                 | tsup()     | Permissible Spurious Pulse Width at IN, OE    |   |                  |      | 1.6               | μs             |
| 307                                 | ttrig()    | Required Pulse Width at IN, OE                |   | 4                |      |                   | μs             |
| <b>Series regulator output VOUT</b> |            |   |   |                  |      |                   |                |
| 401                                 | V(VOUT)    | Regulated output voltage                      | VB = 9..30 V, I(VOUT) = 10 .. 0 mA<br>VB = 8..9 V, I(VOUT) = 10 .. 0 mA         | 4.7<br>4.5       |      | 5.3<br>5.3        | V<br>V         |
| 402                                 | C(VOUT)    | Capacitor at VOUT                             | I(VOUT) = 0<br>I(VOUT) > 0  | 0<br>0.1         |      | 10<br>10          | μF<br>μF       |
| 403                                 | Isc(VOUT)  | Short circuit current at VOUT                 | VOUT connected to GND   |                  |      | -125              | mA             |

**DESCRIPTION OF FUNCTIONS**

iC-DX is a current limited switching channel which enables digital sensors to drive peripheral elements. They are designed to cope with high driver currents. The switches are reverse-polarity protected, feature a free-wheeling circuit for inductive loads, and a current limited output.

**Reverse polarity protection**

The pins VB, OUT and GND on the *line side* of the chip are reverse polarity protected. As far as the maximum voltage ratings are not exceeded, no possible supply combination at the *line side* pins can damage the chip.

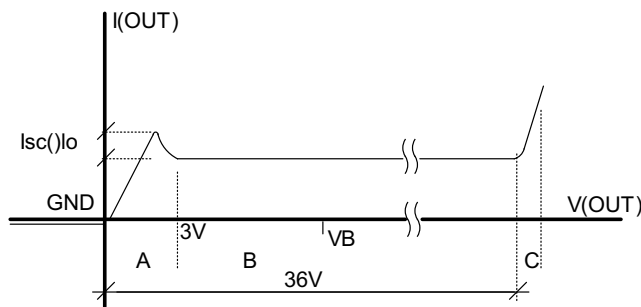


Figure 1: OUT characteristic when Low side active

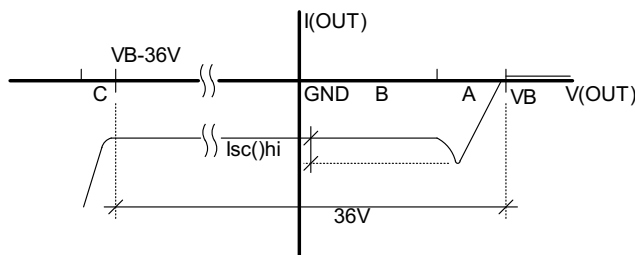


Figure 2: OUT characteristic when high side active

**Output characteristics of OUT**

The switching channel is current limited to a value between 150mA and 450mA. (cf. Electrical Characteristics Nos. 103, 104). The current limitation works only for voltages higher than 3V at OUT resp. lower than  $V_{BO} - 3V$ . For smaller output voltages the current limitation is reduced in order to minimise the saturation voltages without increasing the power dissipation. Figures 1 and 2 show the characteristic of the switching channels when activated. Region "A" is the saturation range, where the current limitation is not fully active yet and region "B" is the current limited range. Region "C" corresponds to the free-wheeling circuit activated. The switching channel is designed so that the low side can only sink current and high side can only source current (no reverse current).

**Free-wheeling circuit for inductive loads**

The free-wheeling circuit is always present and does not depend on the current output status. It is activated by voltages higher than 36 V at OUT referenced to GND or lower than -36 V at OUT referenced to VB. In that case the correspondent channel will switch on without current limitation (see Figure 3).

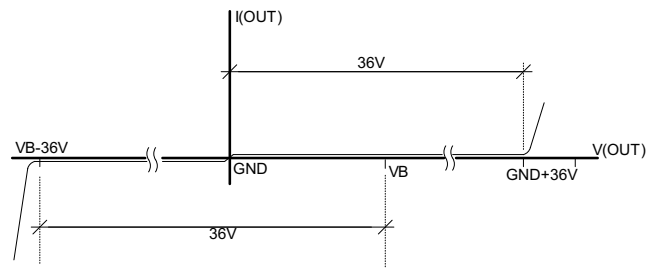


Figure 3: Free-wheeling characteristic

### OPERATION MODES

The iC-DX can be operated in High-Side (PNP-Switch), Low-Side (NPN-Switch) and Push-Pull switch mode. Figure 4 shows the high-side operation where IN pin must be kept high and the OE pin controls the switch. Figure 5 shows the low-side operation where IN pin must be kept low and the OE pin controls the switch. Figure 6 shows the push-pull operation where OE pin must be kept high and the IN pin controls the switch.

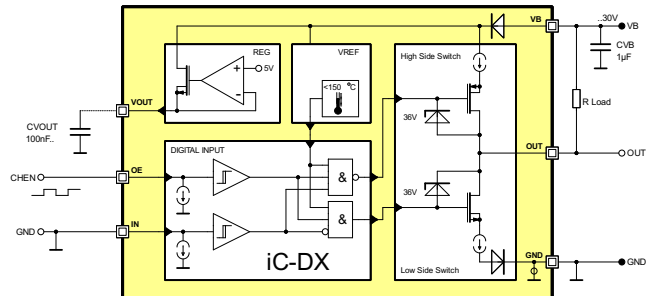


Figure 5: Configuration as Low-Side (NPN-Switch)

| Output Table. Low-side mode (NPN-Switch) |    |       |                            |
|--|----|-------|----------------------------|
| OE                                       | IN | OUT   | Mode                       |
| L  | L  | Z (H) | Low-Side, passive pull up  |
| H  | L  | L     | Low-Side, active pull down |

Table 5: Output Function table Fig. 5. Low-side mode (NPN-Switch) with external pull-up.

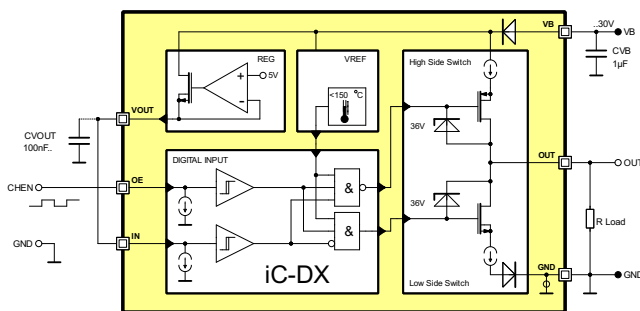


Figure 4: Configuration as High-Side (PNP-Switch)

| Output Table. High-side mode (PNP-Switch) |    |       |                              |
|---|----|-------|------------------------------|
| OE  | IN | OUT   | Mode                         |
| L   | H  | Z (L) | High-Side, passive pull down |
| H   | H  | H     | High-Side, active pull up    |

Table 4: Output Function table Fig. 4. High-side mode (PNP-Switch) with external pull-down.

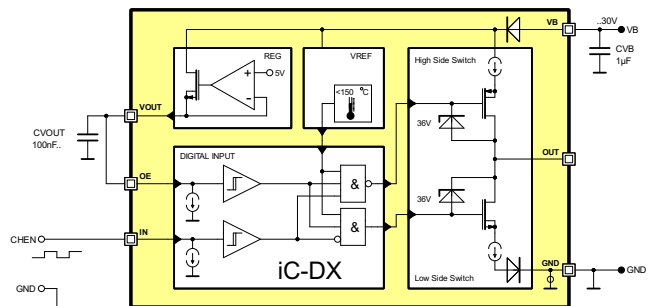


Figure 6: Configuration as Push-Pull

| Output Table. Push-Pull mode |    |     |                             |
|------------------------------|----|-----|-----------------------------|
| OE                           | IN | OUT | Mode                        |
| H                            | L  | L   | Push-Pull, active pull down |
| H                            | H  | H   | Push-Pull, active pull up   |

Table 6: Output Function table Fig. 6. Push-Pull mode

### TIMING DESCRIPTION

The iC-DX has a built-in spurious pulse suppression that prevents short (undesired) pulses at the input pins from reaching the output. Every pulse at OE or IN pins shorter than 1.6  $\mu\text{s}$  (cf. Electrical Characteristics No. 306) will be ignored and the output will not react. The minimum required pulse length to be sure that the output reacts is 4  $\mu\text{s}$  (cf. Electrical Characteristics No. 307). That means that every pulse longer than

4  $\mu\text{s}$  will be propagated to the output but with an additional propagation delay of 1.2  $\mu\text{s}$  maximum. The resulting maximum propagation delay is 5.2  $\mu\text{s}$  (cf. Electrical Characteristics No. 305).

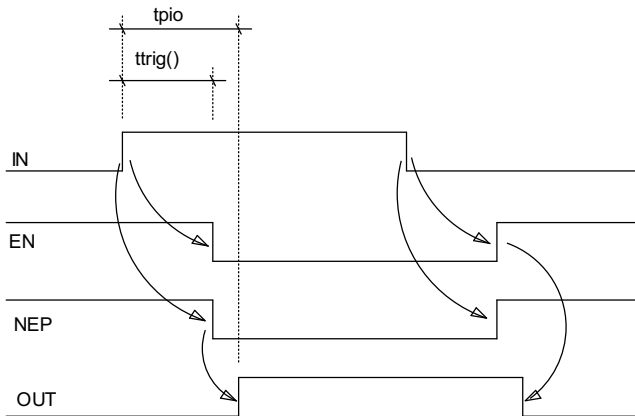


Figure 7: Timing diagram in push-pull operation mode

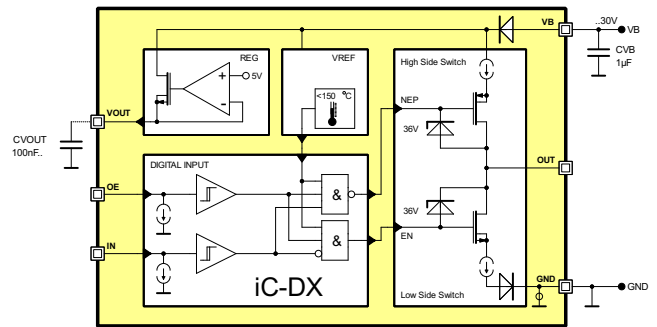


Figure 8: Block diagram with EN and NEP internal signals

### CIRCUIT PROTECTION

The iC-DX is reverse polarity protected via internal circuitry. As far as the maximum voltage ratings are not exceeded, no possible supply combination at the line side pins (VB, GND and OUT) can damage the chip.

Since the chip current consumption is relatively low, discharging of the backup capacitor C1 can be very slow, and injected charge through disturbances may in general result in capacitor voltage exceeding maximum ratings, leading to malfunction or destruction of circuitry and associated parts. Thus EMC requirements will afford more external circuitry. Figure 9 shows the iC-DX with the additional protective device D1, D2 and D3.

For over-voltage protection, the suppressor diodes D1, D2 and D3 absorb transients on supply line injected externally on the cable. Clamp voltage of the diodes should be rated slightly above maximum specified supply voltage.

These currents can be passed to ground or to VB by the internal ESD diodes of the iC-DX. Whereas negative current injection will simply be drained off to ground, positive current injection will charge capacitor C1 further to higher voltages. If not suppressor diodes nor any other over-voltage protection is implemented, the backup capacitor C1 should be kept small. A typical 100nF value is normally OK.

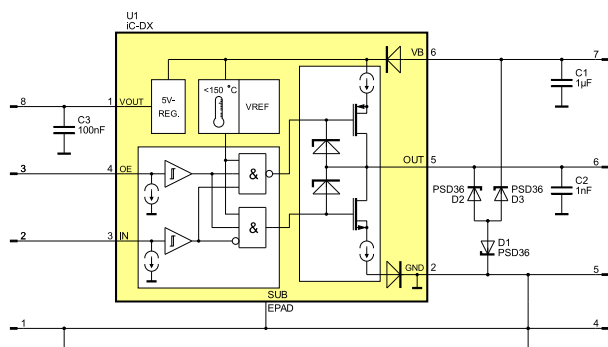


Figure 9: Circuit schematic showing protective devices

### Suggested protective devices

At  $V_{B_{max}}$  of 36V, suppressor diodes with a breakdown voltage from 36V has to be chosen in order to minimize the energy in iC-DX for higher voltages. For example Diode type like Vishay GSOT36C or PJS36W from Pan Jit should be enough as protection.



# iC-DX

## UNIVERSAL DIGITAL SENSOR OUTPUT DRIVER

preliminary



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We understand suitable application of our published designs to be state-of-the-art technology which can no longer be classed as inventive under the stipulations of patent law. Our explicit application notes are to be treated only as mere examples of the many possible and extremely advantageous uses our products can be put to.

**iC-DX**

UNIVERSAL DIGITAL SENSOR OUTPUT DRIVER

preliminary



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**ORDERING INFORMATION**

| Type  | Package | Order Designation |
|-------|---------|-------------------|
| iC-DX | DFN6    | iC-DX DFN6        |

For technical support, information about prices and terms of delivery please contact:

**iC-Haus GmbH**  
**Am Kuemmerling 18**  
**D-55294 Bodenheim**  
**GERMANY**

**Tel.: +49 (61 35) 92 92-0**  
**Fax: +49 (61 35) 92 92-192**  
**Web: <http://www.ichaus.com>**  
**E-Mail: [sales@ichaus.com](mailto:sales@ichaus.com)**

**Appointed local distributors: [http://www.ichaus.com/sales\\_partners](http://www.ichaus.com/sales_partners)**