

## CAN Transceiver

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### Description

The device B10011S is a transceiver for CAN bus systems with high transmission levels according to ISO WD 11992-1 (point-to-point interface between trucks and trailers). The special features of a circuit containing this device allow transmission which is insensitive to electromagnetic interference that can appear particularly in truck applications, where, due to the length of the wires, high common-mode voltages (e.g., 50 V) can be coupled into the lines.

This device contains a fault recognition circuit for faults on one of the two wires which are normally used for transmission. If a fault occurs on one of the wires, the operation can be switched from double-wire to single-wire mode, thus allowing proper operation even if one wire is broken, has a short-cut or a high series resistance.

### Features

The CAN driver B10011S is a low-speed, high-level interface for 24-V (27-V) operation. It is developed for signal levels of 8/16 V and a speed of up to 250 kbits/s. Special features are:

- Especially suited for truck and van applications
- Interface between truck and trailer
- Interface between dashboard and engine
- High reliability

### Benefits

Systems which employ this device have the following benefits in comparison with solutions using discrete components:

- Capability of single-wire operation
- Hardware fault recognition
- Inputs with high common-mode and differential-mode interference rejection above 100 V<sub>PP</sub> due to external filters at the receiver input
- Immunity against electromagnetic interference
- Low cost
- Immunity against ground-voltage offsets < 6 V
- Ruggedized against ESD by MIL-STD-883C, method 3015

## Block Diagram (Simplified Schematic)

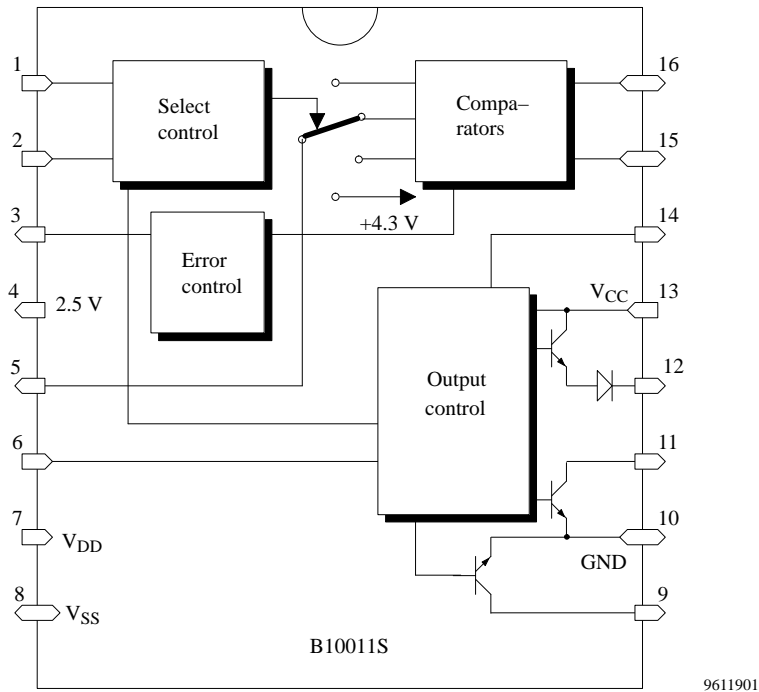


Figure 1. Block diagram

## Pin Description

16-lead SOIC (SO16), small outline gull-wing

Pin	Symbol	Function
1	A <sub>sel</sub>	Select control input
2	B <sub>sel</sub>	Select control input
3	$\overline{ER}$	Error signal output
4	R <sub>x1</sub>	Reference voltage 2.5 V
5	R <sub>x0</sub>	Receiver output
6	T <sub>x0</sub>	Transmitter input
7	V <sub>DD</sub>	Controller supply voltage 5 V
8	V <sub>SS</sub>	Controller supply voltage 0 V
9	S-	Collector of internal npn switch
10	GND	Vehicle ground 0 V
11	L'	Data out driver
12	H'	Data out driver
13	V <sub>CC</sub>	Vehicle power supply 24 V
14	S+	Control output for external pnp
15	F <sub>0</sub>	Receiver input
16	F <sub>1</sub>	Receiver input

## Absolute Maximum Ratings

Parameters	Symbol	Value	Unit
Supply voltage	$V_{CC}$	-0.5 to +36	V
Controller supply voltage	$V_{DD}$	-0.5 to +5.5	V
Input voltage at any input	$V_{in}$	-0.5 to $V_{DD}$	V
Junction temperature	$T_j$	150	°C
Storage temperature range	$T_{stg}$	-55 to +150	°C
Soldering temperature	$T_{sld}$	260	°C for 10 sec. maximum

## Operating Conditions

Parameters	Symbol	Value	Unit
Supply voltage car battery	$V_{CC}$	7 to 32	V
Controller supply voltage	$V_{DD}$	4.75 to 5.25	V
Control input voltage	$A_{sel}, B_{sel}$	0 to $V_{DD}$	V
Input voltage	$T_{x0}$	0 to $V_{DD}$	V
Operating temperature	$T_{amb}$	-40 to 105	°C

## Operating Modes

0 = 0 V, 1 = 5 V

$A_{sel}$	$B_{sel}$	$R_{x0}$	
0	0	3.8 V	H, L drivers disabled, L load disabled, S-, S+ disabled station not in operation, but consuming current
1	0	From $\bar{H}$	Single-wire H, L driver, L load, S-, S+ disabled
0	1	From L	Single-wire L, H driver disabled
1	1	From L-H	Two-wire operation, normal mode

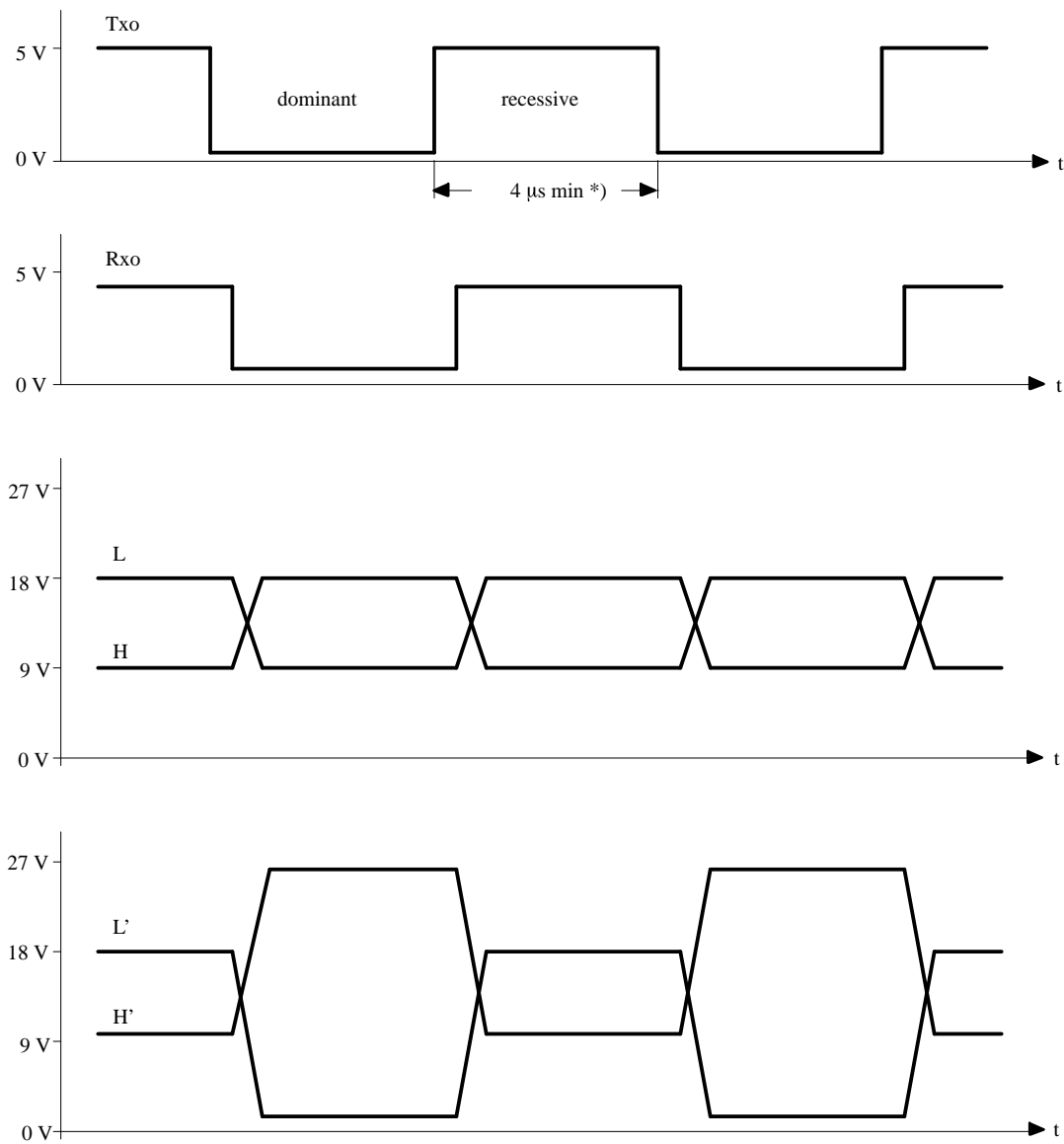
ER (error signal) is low when normal operation is disturbed by line faults (interruption, short to ground or to  $V_{CC}$ , H to L short disturbance by high voltage transients). After a waiting period due to transient delays, the controller is asked to test if single-wire operation is

possible by changing the  $A_{sel}$  and  $B_{sel}$  state.

$A_{sel}$  and  $B_{sel}$  have an internal pull-up resistor. Therefore to no-connect state is 1, but connection to  $V_{DD}$  is recommended when not in use.

## Pulse Diagram

The pulse diagram for two connected, identical stations is shown below. The resistor levels have to be kept when additional stations are connected.



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\*) Filter has to be changed if short distances are to be allowed.

## Electrical Characteristics

$V_{CC} = 27\text{ V}$ ,  $V_{DD} = 5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_{amb} = -40\text{ to }+105^{\circ}\text{C}$ , unless otherwise specified

Test condition: test circuit (see figure 2)

0 = 0 V, 1 = 5 V

Parameters	Test Conditions / Pins	Symbol	Min.	Typ.	Max.	Unit
Supply current	$T_{x0} = 0, A_{sel} = 1, B_{sel} = 1$	$I_{CC}$			15	mA
	$T_{x0} = 0, A_{sel} = 0, B_{sel} = 0$	$I_{DD}$			18	mA
	$T_{x0} = 1, A_{sel} = 1, B_{sel} = 1$	$I_{CC}$			26	mA
	$T_{x0} = 1, A_{sel} = 1, B_{sel} = 1$	$I_{DD}$			16	mA
Input current	$T_{x0} = 1, A_{sel} = 1, B_{sel} = 1$	$I(T_{x0})$			650	$\mu\text{A}$
	$T_{x0} = 1, A_{sel} = 1, B_{sel} = 1$	$I(A_{sel}, B_{sel})$			150	$\mu\text{A}$
Output voltage	$T_{x0} = 0, A_{sel} = 1, B_{sel} = 0$ $V_{IL}(F_0) = 1.9\text{ V}, V_{IH}(F_1) = 2.7\text{ V}$	$R_{x0}$			1.0	V
	$T_{x0} = 1, A_{sel} = 1, B_{sel} = 1$ $V_{IL}(F_1) = 1.9\text{ V}, V_{IH}(F_0) = 2.7\text{ V}$	$R_{x0}$	3.8			V
	$T_{x0} = 0, A_{sel} = 1, B_{sel} = 1$	$U(H')$	24.5			V
	$T_{x0} = 1, A_{sel} = 1, B_{sel} = 1$	$U(H')$			1.0	V
	$T_{x0} = 1, A_{sel} = 1, B_{sel} = 1$	$U(L')$	26			V
	$T_{x0} = 0, A_{sel} = 1, B_{sel} = 1$	$U(L')$			1.0	V
	No fault	$\overline{ER}$	4.7			V
	Fault on line	$\overline{ER}$				100

## Electrical Characteristics

$V_{CC} = 7\text{ C}$ ,  $V_{DD} = 4.75\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_{amb} = 25^{\circ}\text{C}$ , unless otherwise specified

Test condition: test circuit (see figure 2)

0 = 0 V, 1 = 5 V

Parameters	Test Conditions / Pins	Symbol	Min.	Typ.	Max.	Unit
Output voltage	$T_{x0} = 0, A_{sel} = 1, B_{sel} = 1$	$U(H')$	4.5			V
	$T_{x0} = 1, A_{sel} = 1, B_{sel} = 1$	$U(H')$			100	mV
	$T_{x0} = 1, A_{sel} = 1, B_{sel} = 0$	$U(L')$	6.5			V
	$T_{x0} = 0, A_{sel} = 1, B_{sel} = 1$	$U(L')$			1.0	V
	$T_{x0} = 1, A_{sel} = 1, B_{sel} = 0$ $V_{IL}(F_1) = 1.0\text{ V}, V_{IH}(F_0) = 1.15\text{ V}$	$R_{x0}$	3.3			V
	$T_{x0} = 0, A_{sel} = 1, B_{sel} = 0$ $V_{IL}(F_0) = 1.0\text{ V}, V_{IH}(F_1) = 1.15\text{ V}$	$R_{x0}$			1.0	V

## Electrical Characteristics

$V_{CC} = 32\text{ V}$ ,  $V_{DD} = 5.25\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_{amb} = 25^\circ\text{C}$ , unless otherwise specified

Test condition: test circuit (see figure 2)

0 = 0 V, 1 = 5 V

Parameters	Test Conditions / Pins	Symbol	Min.	Typ.	Max.	Unit
Output voltage	$T_{x0} = 0, A_{sel} = 1, B_{sel} = 1$	$U(H')$	29			V
	$T_{x0} = 1, A_{sel} = 1, B_{sel} = 1$	$U(H')$			500	mV
	$T_{x0} = 1, A_{sel} = 1, B_{sel} = 0$	$U(L')$	31.5			V
	$T_{x0} = 0, A_{sel} = 1, B_{sel} = 1$	$U(L')$			1.0	V
	$T_{x0} = 1, A_{sel} = 1, B_{sel} = 0$ $V_{IL}(F_1) = 1.6\text{ V}, V_{IH}(F_0) = 2.7\text{ V}$	$R_{x0}$	4.0			V
	$T_{x0} = 0, A_{sel} = 1, B_{sel} = 0$ $V_{IL}(F_0) = 1.6\text{ V}, V_{IH}(F_1) = 2.7\text{ V}$	$R_{x0}$			1.0	V

## Test Circuit

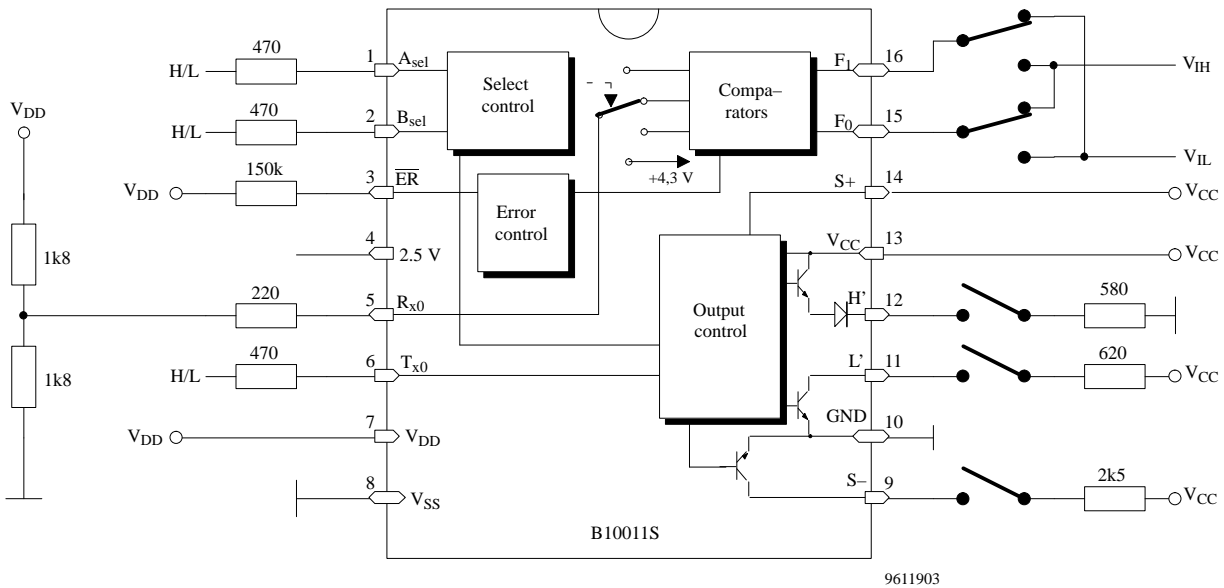


Figure 2.

**Applications Information**

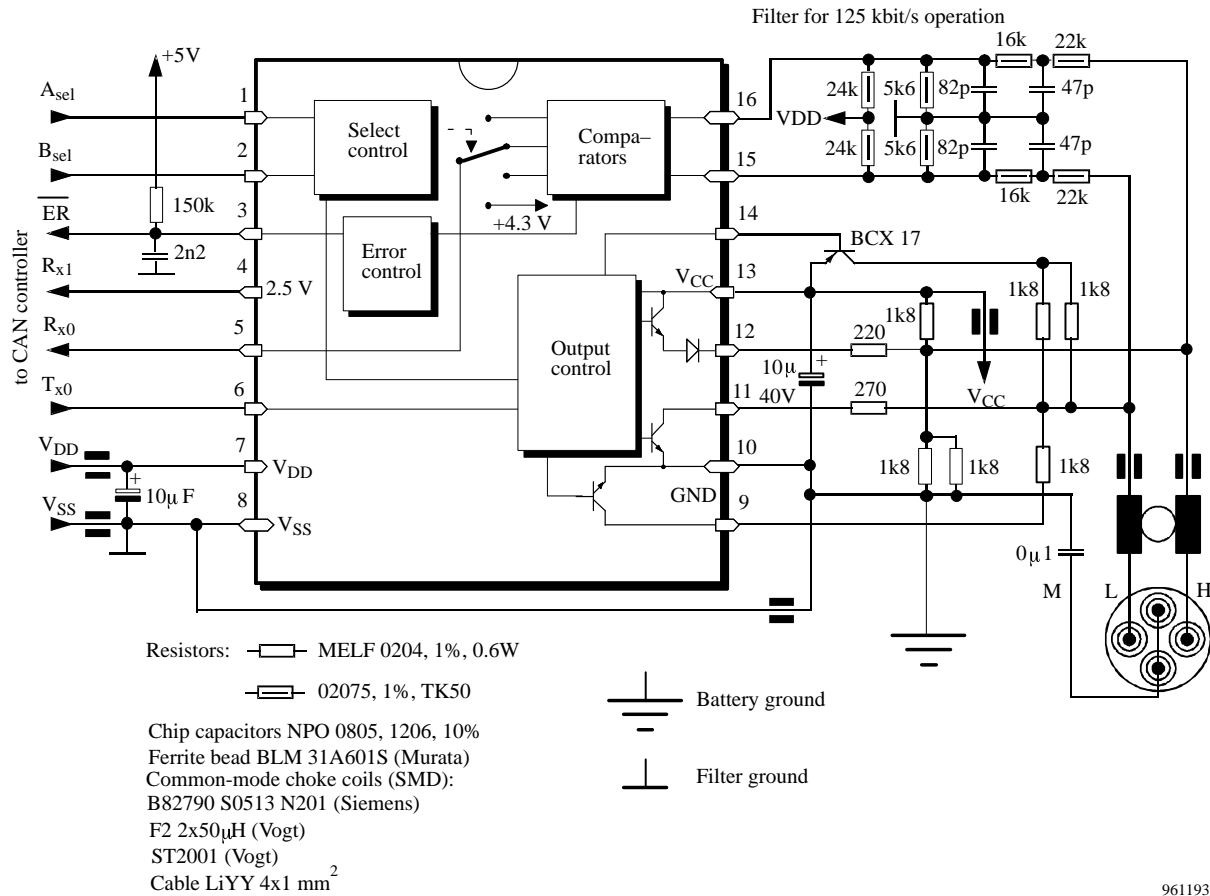
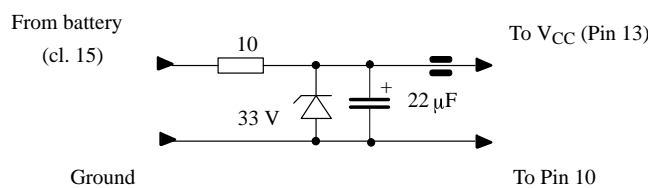


Figure 3.

The implementation of a power filter and overvoltage clamp as follows is highly recommended:



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**Application Hints**

As an interface between CAN controllers and a two-wire data-bus system for serial data interchange, this device is adapted to a special high-level, low-speed transmission system which is useful in harsh environments. High immunity against ground offset and interference voltages on the bus have been the design goals for this device, rather than low power consumption or a minimum of

external components. An error detection scheme is implemented in the receiver part to give quick information to the controller in case of faults occurring on the bus. Thus, the controller is able to start a search cycle in order to look for the possibility of single-wire operation or to disable the station from the bus.

An automatic error-signal end is not feasible because parts of the system are disabled during single-wire operation. Therefore the controller has to carry out short tests by switching to the two-wire state and checking whether the error signal is still present or not. Errors due to dirty contacts, shorts between high and low line, or interruptions may not be recognized at all, because this device does not contain a complete fault computer.

Two control inputs  $A_{sel}$  and  $B_{sel}$  enable four operation modes (see table "operation modes"). Depending on the nature of the error, the error signal  $\overline{ER}$  is internally generated partly in the recessive or partly in the dominant transmission state. In order to avoid watching the error bits bitwise, an open-collector output driver (with a 1-k $\Omega$  series resistor) discharges a storage capacitor, which is charged by a time constant, long enough to hold the 0 state for e.g., 200  $\mu$ s, thus giving the controller enough time to recognize this status during idle times. Only the charging resistor may be changed and not the 2.2-nF capacitor. In order to perform a faster error-end test, the charging resistor may be shorted by an npn emitter follower or by tri-state output high for approximately 1 to 2  $\mu$ s.

The pinout of the device shows a controller side (pins 1 to 8) and a bus side (pins 9 to 16). The application circuit utilizes an input filter section which is necessary for every station and a bias section which is needed in two master stations only. Additional slave stations only contain the driving resistors at pins 11 and 12 (270  $\Omega$  and 220  $\Omega$ ), the choke coil, and capacitor between pins 13 and 10.

A power filter and overvoltage clamp is highly recommended in order to avoid transmission errors due to spikes on the 24-V battery voltage.

The input filter is designed as a 2-RC filter for 125 kbit/s and may be changed to 250 kbit/s. Its good pulse response and good suppression of high frequencies should not be weakened by omitting one of the capacitors.

All the logical and sensing functions in the device are powered by  $V_{DD} = 5$  V. Therefore the filter section also acts as a level shifter to the input comparator range (approximately 1 to 3.3 V). The diagram (comparator thresholds) shows how the battery voltage,  $V_{CC}$ , influences the comparator input voltages,  $F_0$  and  $F_1$ , in relation to the internal reference voltage,  $U_{ref}$ , in the

recessive state. The lower  $V_{CC}$ , the lower the bus level. Taking this into account the comparator input levels are  $F_1 - U_{ref}$  for single-wire H respectively  $F_1 - F_0$  for two-wire operation. The comparator's offset voltage is  $\leq 10$  mV. Matching the filter biasing to the internal reference is essentially for safe operation down to low battery voltages during motor start.

The level investigations and tests described in the following description have been carried out within the temperature range of  $-40$  to  $+105^\circ\text{C}$  with two B10011S on a bus line, one of them always in the recessive state. See test circuit equivalents.

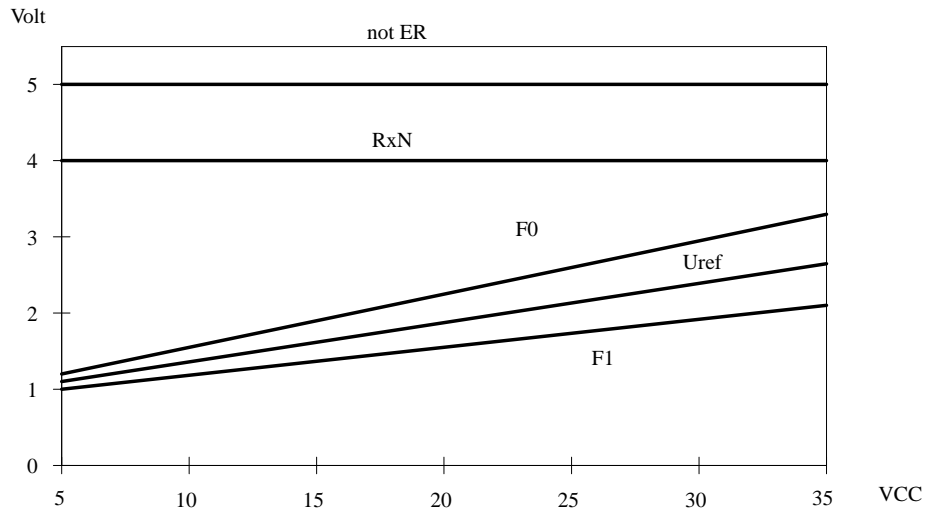
In case of line shorts to  $V_{CC}$  or to ground or in case of H to L shorts all participants on the bus are intended to switch to single-wire operation and to disable their drivers not in use.

The dynamic behavior of the circuit depends on the line capacitances to ground. Approximately 200 pF/m and a maximum of 6 nF have to be taken into account. The transition from the dominant to the recessive state enables the bias network to recharge the line through a driving resistor of approximately 300  $\Omega$ . The transition from the recessive to the dominant state is approximately twice as fast. This is probably the source of emitted radiation having no capacitance on the line. The choke coil enables for the suppression of this radiation in the frequency range above 5 to 7 MHz. Care should be taken not to feed noise from  $V_{DD}$  or  $V_{CC}$  to the line. Therefore, they should be properly blocked by low-inductance capacitors.

Data loss by externally induced interference is avoided by careful PCB layout and EMC design for this circuit as well as by providing appropriate overvoltage protection. It is very essential to separate battery ground and filter ground as indicated in the application circuit (figure 3). Especially the filter ground must be connected to pin 8 by a short connection not subject to disturbing currents from external sources. The ground wire of the "starquad" cable may introduce such currents and should be connected to battery ground via a 0.1- $\mu$ F capacitor on a way as short as possible, perhaps to the metal housing.

In order to avoid thermal problems, the voltage divider and driving resistors should be kept away from the IC. Otherwise they would heat up the environment of the small IC and might reduce its life expectancy.

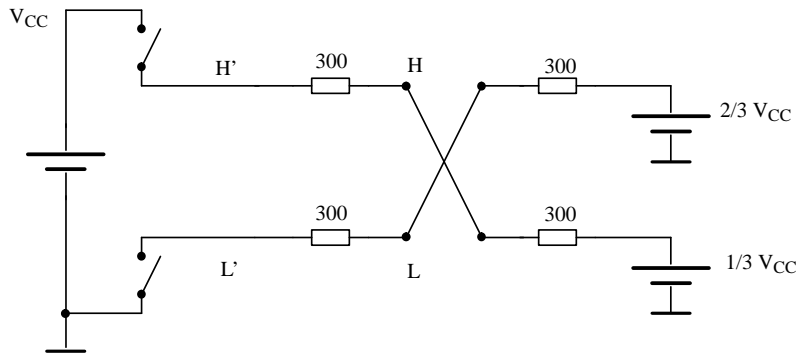




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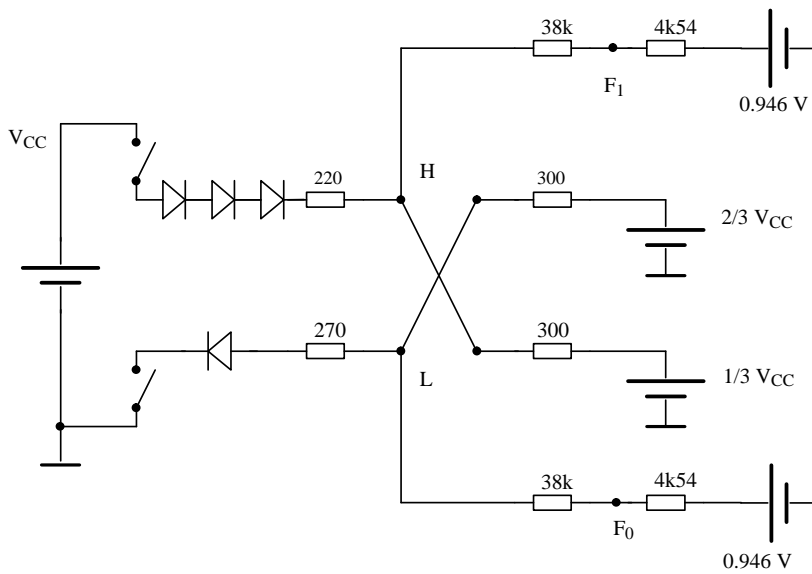
Figure 4. Comparator thresholds

## Test Circuit Equivalents



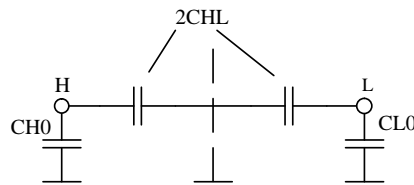
Ideal test circuit equivalent

Switches are closed in the dominant state



Real test circuit equivalent

Switches are closed in the dominant state



Capacitance H:  $CH_{\text{gnd}} = CH0 + 2 \text{ CHL} \leq 200 \text{ pF/m}$

Capacitance L:  $CL_{\text{gnd}} = CL0 + 2 \text{ CHL} \leq 200 \text{ pF/m}$

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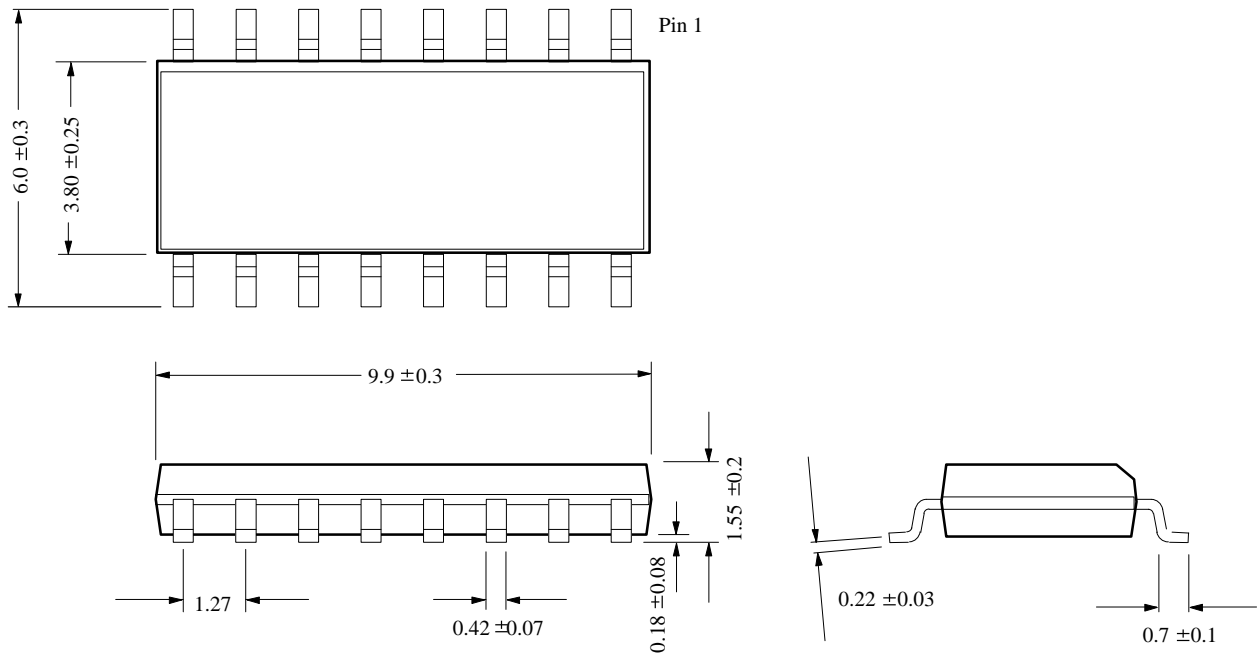
Figure 5.

**Ordering Information**

Package	Part Number
SO16 in tubes	B10011S
SO16, tape and reel, 1000 units/reel	B10011S-G1
SO16, tape and reel, 4000 units/reel	B10011S-G3

**Dimensions in mm**

Package: SO16



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2. Regularly and continuously improve the performance of our products, processes, distribution and operating systems with respect to their impact on the health and safety of our employees and the public, as well as their impact on the environment.

It is particular concern to control or eliminate releases of those substances into the atmosphere which are known as ozone depleting substances (ODSs).

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2. Class I and II ozone depleting substances in the Clean Air Act Amendments of 1990 by the Environmental Protection Agency (EPA) in the USA
3. Council Decision 88/540/EEC and 91/690/EEC Annex A, B and C (transitional substances) respectively.

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