Converter IC for Capacitive Signals CAN404

FEATURES

- **Wide Supply Voltage Range: 5...18V**
- **Wide Operating Temperature Range: –25°C...+85°C**
- **High Detection Sensivity of Relative Capacitive Changes: 5% – 100%**
- **Detection Frequency up to 2kHz**
- **Adjustable Voltage Output**
- **Adjustable Namur Current Output**
- **Low Power Dissipation: 5mW @ 5V**

APPLICATIONS

- Industrial Process Control
- Distance Measurement
- Pressure Measurement
- Humidity Measurement
- Level Control

GENERAL DESCRIPTION

The CAN404 is a universal multipurpose interface for capacitive sensors and contains the complete signal conditioning unit on chip. The CAN404 detects the relative capacitive change of a measuring capacity to a fixed reference capacity. The IC is optimized for capacities in the wide range of 10pF to 2nF with possible changes of capacity of 5% to 100% of the reference capacity. The CAN404 offers an output signal proportional to the change of the measuring capacity and can be adjusted by an active lowpass filter. Referring the output signal to an internal reference allows a temperature compensation. In addition to the voltage output, a voltage-to-current interface according to the Namur norm is implemented. With only a few external components, the CAN404 is suitable for a great variety of applications including a zero compensation.

BLOCK DIAGRAM

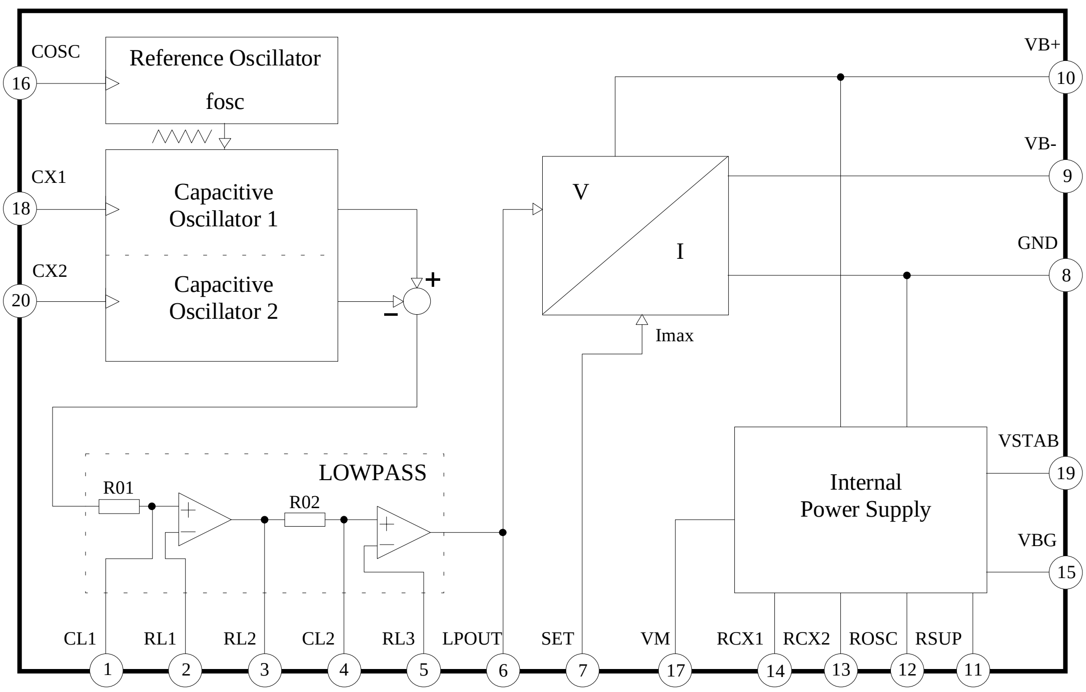

Figure 1

analog microelectronics

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ELECTRICAL SPECIFICATIONS

T_{amb} = 25°C, V_{CC} = 8.2V, R_I = 1kΩ (unless otherwise noted)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply Voltage Range	V_{CC}		5	8.2	18	V
Supply Current Range	$I_{CC,0}$	Namur: not active, $V_{SET} = V_M$		0.9	1.0	mA
	I_{CC}	Namur: active, see Application Notes			2.5	mA
Temperature Specifications						
Operating	T_{amb}		–25		85	°C
Storage	T_{st}		–55		125	°C
Junction	T_J				150	°C
Reference Voltage						
Reference Voltage 4.5V	V_{STAB}	for internal usage only	4.27	4.5	4.73	V
Temperature Coefficient V_{VSTAB}	TK_{VSTAB}	T_{amb} = –25 ... 85°C		±100		ppm/°C
Reference Voltage V_{BG}	V_{BG}	for internal usage only	1.23	1.30	1.37	V
Temperature Coefficient V_{BG}	TK_{VBG}	T_{amb} = –25 ... 85°C		±100		ppm/°C
Reference Voltage 2V	V_M		1.9	2	2.15	V
Temperature Coefficient V_M	TK_{VM}	T_{amb} = –25 ... 85°C		±100		ppm/°C
Reference Oscillator						
Oscillator Capacitor	C_{OSC}	$C_{OSC} = 2 \cdot C_{X1}$	20		2200	pF
Oscillator Frequency	f_{OSC}		1		150	kHz
Oscillator Current	I_{OSC}	R_{OSC} = 200kΩ	9.5	10	10.8	µA
Capacitive Oscillators 1 and 2						
Capacitor 1	C_{X1}		10		1000	pF
Capacitive Oscillator Current 1	I_{X1}	R_{CX1} = 400kΩ	4.75	5	5.38	µA
Capacitive Detection Sensitivity	ΔC_X	$\Delta C_X = (C_{X2} - C_{X1})/C_{X1}$	5		100	%
Capacitor 2	C_{X2}	$C_{X2} = C_{X1} \cdot (1 + \Delta C_X)$	10.5		2000	pF
Capacitive Oscillator Current 2	I_{X2}	R_{CX2} = 400kΩ	4.75	5	5.38	µA
Detection Frequency	f_{DET}	$C_{L1} = C_{L2}$ =1nF, C_{OSC} = 20pF			2	kHz
Lowpass						
Adjustable Gain 1	A_1	see Application Notes	1		10	
Adjustable Gain 2	A_2	see Application Notes	1		10	
Output Voltage	V_{LPOUT}		1.1		3.3	V
Load Capacitor at PIN *LPOUT*	C_{LPOUT}				50	pF
3dB Corner Frequency 1	f_{C1}	R_{01} = 20kΩ			8	kHz
3dB Corner Frequency 2	f_{C2}	R_{02} = 20kΩ			8	kHz
Temperature Coefficient V_{OUT} (with input stages)	TK_{VOUT}	$V_{OUT} = V_{LPOUT} - V_M$, T_{amb} = –25 ... 85°C		±200		ppm/°C
Internal Resistors 1 and 2	R_{01}, R_{02}			20		kΩ
Temperature Coefficient $R_{01,02}$	$TK_{R01,R02}$	T_{amb} = –25 ... 85°C		1.9		10^{-3}/°C
Power Supply Rejection Ratio	*PSRR*	V_{CC} = 8V → 18V; A_{GES} = 1		90		dB
Namur Output Stage						
Threshold Voltage	V_{SET}	see Application Notes			V_M	V
Output Resistance	Z_{OUT}	$Z_{OUT} = dV_{CC} / dI_{CC}$		850		kΩ
Temperature Coefficient I_{CC}	TK_{ICC}	T_{amb} = –25 ... 85°C, Namur: active		±200		ppm/°C

BOUNDARY CONDITIONS

Parameter	Symbol	Min.	Typ.	Max.	Unit
Current Sense Resistor	R_M			90	Ω
Gain 1 Resistor Sum	$R_{L1}+R_{L2}$	100		200	kΩ
Gain 2 Resistor Sum	$R_{L3}+R_{L4}$	100		200	kΩ
V_M Capacitor	C_{VM}	80	100	120	nF
V_{STAB} Capacitor	C_{BG1}	1.7	2.2	2.7	µF
V_{BG} Capacitor	C_{BG2}		100		pF
V_{CC} Capacitor	C_S		220		nF
Namur Resistor Sum	$R_{N1}+R_{N2}$	90	100	200	kΩ
Set Resistor 1 (Capacitive Oscillator 1)	R_{CX1}	396	400		kΩ
Set Resistor 2 (Capacitive Oscillator 2)	R_{CX2}	396	400		kΩ
Set Resistor 3 (Reference Oscillator)	R_{OSC}	198	200	202	kΩ
Set Resistor 4 (Internal Power Supply)	R_{SUP}	396	400	404	kΩ
Set Resistor 5 (Reference Voltage 4.5V)	R_{BG1}	246	249	252	kΩ
Set Resistor 6 (Internal Stabilized Voltage)	R_{BG2}	99	100	101	kΩ

For the performance of the entire system it is important that all *Set Resistors* have to have a small temperature coefficient. An offset compensation over temperature can only be achieved by choosing the resistors R_{CX1} and R_{CX2} with the same temperature coefficient and a very close placement of them in the entire circuit.

FUNCTIONAL DIAGRAM

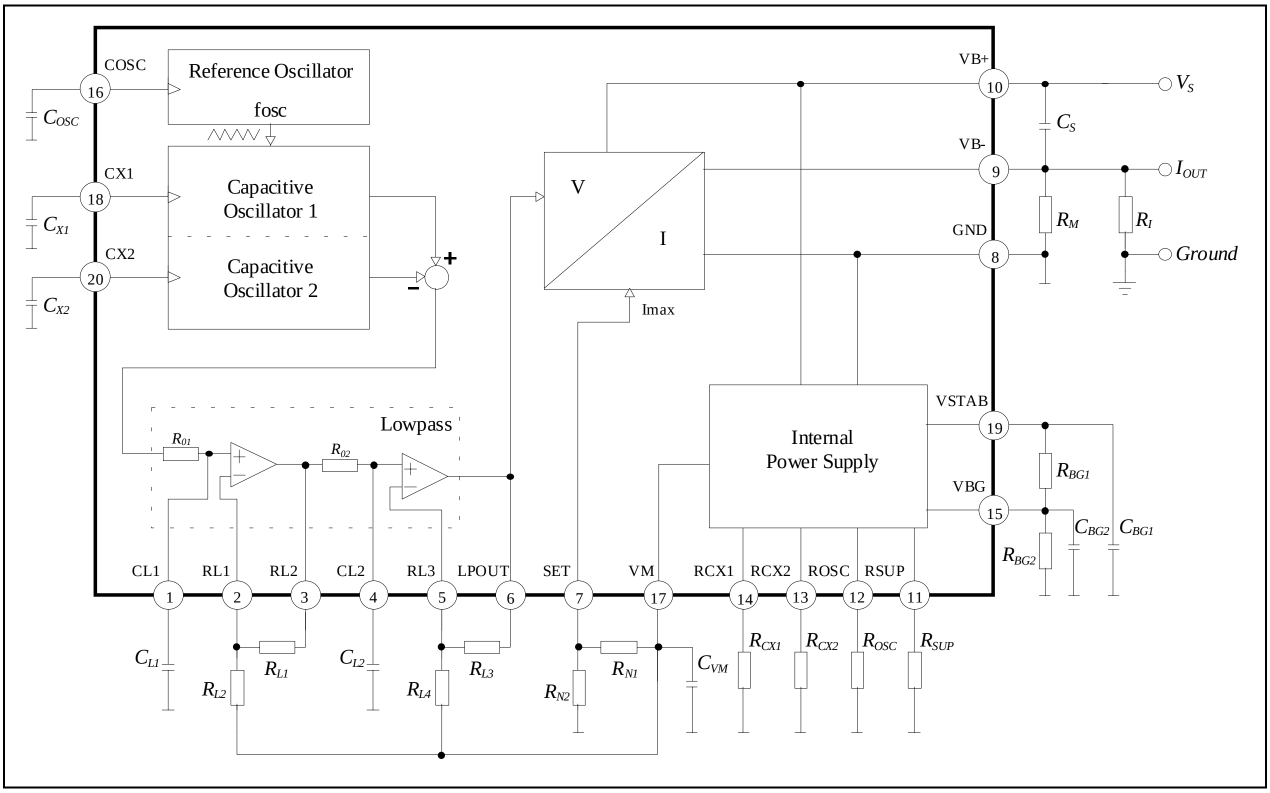

Figure 2

FUNCTIONAL DESCRIPTION

Basically the CAN404 is composed of two input stages, a signal processing unit and a voltage-to-current interface according to the Namur standard.

A reference oscillator with a frequency, adjusted by the capacity C_{OSC}, drives two symmetrically built oscillators synchronously to its clock and its phase. The capacitors C_{X1} and C_{X2} determine the amplitude of the two driven oscillators. The difference of the oscillator amplitudes gives the relative change of the capacities C_{X1} and C_{X2} to each other with high common mode rejection and high resolution. This difference signal is rectified by a lowpass filter. The corner frequency and gain of it can be adjusted with a few external components. The output of the lowpass filter is connected to a voltage-to-current interface (Namur output). The maximum current of the output is adjustable externally.

In Namur operation (Figure 2), the external reference point *Ground* is connected by the resistors R_M and R_I to the ground pin 10 of the IC (*GND*). The minimum supply voltage of the entire system V_S depends on the minimum supply voltage V_{CC} (5V) of the IC, the value of the input resistance R_I of the power supply and the current sense resistor R_M and has to fulfil the following relationship:

$$V_S \geq V_{CC,\min} + I_{OUT,max} \cdot (R_I + R_M)$$

The rated **Namur operation** is characterised by:

$$V_{S,n} = (8.2 \pm 0.1)\ \text{V}$$

$$R_{I,n} = (1000 \pm 10)\ \Omega$$

Adjustment of CAN404: The zero adjustment of the differential output signal

$$V_{OUT} = V_{LPOUT} - V_M$$

is made by the resistors R_{CX1} or R_{CX2} for the case that the two capacitors have nearly the same value $C_{X2} \approx C_{X1}$ (distance sensor without target). Therefore one of the resistors R_{CX1} or R_{CX2} is varied until the output voltage is zero:

$$V_{OUT} = 0$$

The greatest possible change of the capacitors $C_{X2} = C_{X1} \cdot (1 + \Delta C_X)$ (distance sensor with target) results in the maximum output signal that can be amplified by the lowpass. The maximum amplification is limited by the maximum allowed output voltage V_{LPOUT} (see *Electrical Specifications*).

In **Namur operation**, additional adjustments are required. The minimum output signal is

$$V_{LPOUT,min} = V_M \qquad (\text{for } C_{X1} = C_{X2} \text{ and } \Delta C_{X,\min} = 0)$$

The maximum output signal is amplified by the lowpass to a value of

$$V_{LPOUT,max} = 3.2\text{V} \qquad (\text{for } C_{X1} \neq C_{X2} \text{ and } \Delta C_{X,\max} = (C_{X2} - C_{X1}) / C_{X1})$$

The output current I_{CC} consists of the supply current $I_{CC,0}$ of the system and an additional component. The maximum output current at $V_{LPOUT,max}$ has to be adjusted to

$$I_{CC,max} = 2.5\text{mA}$$

For the minimum output current at $V_{LPOUT,min}$, a typical value which is greater than the value of the supply current is chosen. That means

$I_{CC,min}$ = 0.9mA

The transfer function of the Namur output is adjusted by the resistor R_M and the voltage V_{SET}. The resistor R_M is calculated by

$$R_M = \frac{V_{LPOUT,\max} - V_{LPOUT,\min}}{10 \cdot \left(I_{CC,\max} - I_{CC,\min}\right)}$$

The voltage V_{SET} it is given by

$$V_{SET} = \frac{1}{11} \cdot \left(V_{LPOUT,\min} - 10 \cdot R_M \cdot I_{CC,\min}\right)$$

The voltage V_{SET} has to be adjusted by the voltage divider R_{N1} and R_{N2}:

$$\frac{R_{N1}}{R_{N2}} = \frac{V_M}{V_{SET}} - 1$$

Sample calculations and typical values for the external components are listed in separate available *Application Notes.*

PINOUT

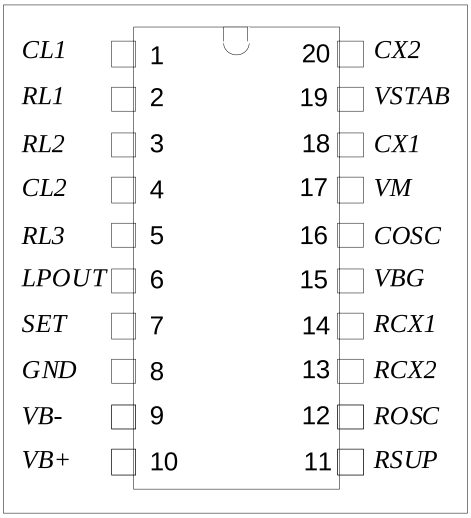

Figure 3

PIN	NAME	BESCHREIBUNG
1	*CL*1	Corner Frequency of Lowpass 1
2	*RL*1	Gain Adjustment Lowpass 1
3	*RL*2	Gain Adjustment Lowpass 1
4	*CL*2	Corner Frequency of Lowpass 2
5	*RL*3	Gain Adjustment Lowpass 2
6	*LPOUT*	Output Lowpass
7	*SET*	Voltage Setting of Namur Current Output
8	*GND*	IC Ground
9	*VB–*	Power Supply (negative connection)
10	*VB+*	Power Supply (positive connection)
11	*RSUP*	Current Definition of Internal Power Supply
12	*ROSC*	Current Definition of Reference Oscillator
13	*RCX*2	Current Adjustment of Capacitive Oscillator 2
14	*RCX*1	Current Adjustment of Capacitive Oscillator 1
15	*VBG*	Internal Stabilised Voltage
16	*COSC*	Capacitor of Reference Oscillator
17	*VM*	Reference Voltage 2V
18	*CX*1	Oscillator Capacitor 1
19	*VSTAB*	Reference Voltage 4.5V
20	*CX*2	Oscillator Capacitor 2

DELIVERY

The CAN404 is available in version:

- 20 pin DIL packages
- SO20 (w) packages
- Dice on 5“ blue foil