Converter IC for Capacitive Signals CAV414

FEATURES

- **Wide Supply Voltage Range: 6...35V**
- **Wide Operating Temperature Range: –40°C...+85°C**
- **High Detection Sensitivity of Relative Capacitive Changes: 5% – 100%**
- **Detection Frequency up to 2kHz**
- **Adjustable Voltage Range: 0...5/10V, other**
- **Reference Voltage Source: 5V**
- **Protection against Reverse Polarity**
- **Output Current Limitation**
- **Adjustable with only two Resistors**

APPLICATIONS

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

GENERAL DESCRIPTION

The CAV414 is an universal multipurpose interface for capacitive sensors and contains the complete signal processing unit on chip. The CAV414 detects the relative capacitive change of a measuring capacity to a fixed reference capacity. The IC is optimised for capacities in the wide range of 10pF to 2nF with possible changes of capacity of 5% to 100% of the reference capacity.
The voltage output is formed by a high accuracy instrumentation amplifier in combination with an operational amplifier.
With only a few external components, the CAV414 is suitable for a great variety of applications including a zero compensation.

DELIVERY

- DIL16 packages (samples)
- SO16(n) packages
- Dice on 5“ blue foil

BLOCK DIAGRAM

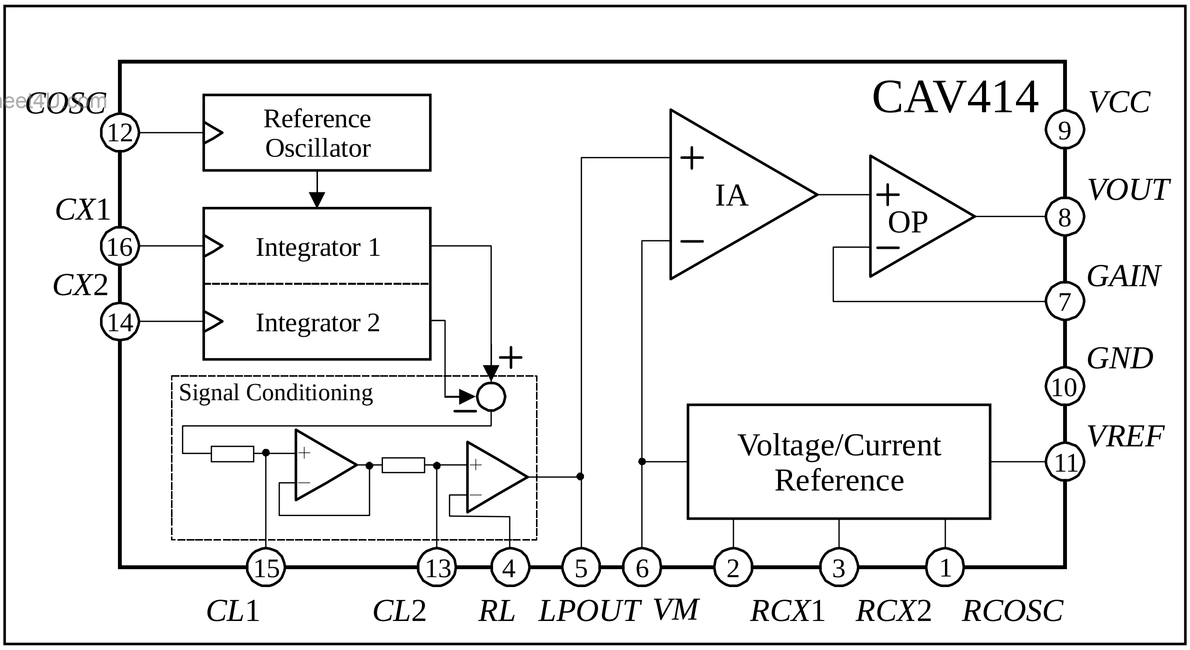

Figure 1

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ELECTRICAL SPECIFICATIONS

T_{amb} = 25°C, V_{CC} = 24V, I_{REF} = 1mA (unless otherwise noted)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply						
Supply Voltage	V_{CC}		6		35	V
Quiescent Current	I_{CC}	T_{amb} = –40 ... 85°C, I_{REF} = 0mA		1.55	2.7	mA
Temperature Specifications						
Operating	T_{amb}		–40		85	°C
Storage	T_{st}		–55		125	°C
Junction	T_j				150	°C
Thermal Resistance	Θ_{ja}	DIL16 plastic package		70		°C/W
	Θ_{ja}	SO16 (n) plastic package		140		°C/W
Reference Oscillator						
Oscillator Capacitor Range	C_{OSC}	$C_{OSC} = 1.6 \cdot C_{X1}$	14		1800	pF
Oscillator Frequency Range	f_{OSC}		1		130	kHz
Oscillator Current	I_{OSC}	R_{OSC} = 200kΩ	9.5	10	10.75	µA
Capacitive Integrator 1 and 2						
Capacitor Range 1	C_{X1}		10		1000	pF
Capacitive Integrator Current 1	I_{X1}	R_{CX1} = 400kΩ	4.75	5	5.38	µA
Capacitor Detection Sensitivity	ΔC_X	$\Delta C_X = (C_{X2} - C_{X1})/C_{X1}$	5		100	%
Capacitor Range 2	C_{X2}	$C_{X2} = C_{X1} \cdot (1 + \Delta C_X)$	10.5		2000	pF
Capacitive Integrator Current 2	I_{X2}	R_{CX2} = 400kΩ	4.75	5	5.38	µA
Detection Frequency	f_{DET}	$C_{L1} = C_{L2}$ =1nF			2	kHz
Lowpass						
Adjustable Gain	G_{LP}		1		10	
Output Voltage	V_{LPOUT}		V_M –0.4		V_M +0.4	V
Corner Frequency 1	f_{C1}	R_{01} = 20kΩ, C_{L1} =1nF			10	kHz
Corner Frequency 2	f_{C2}	R_{02} = 20kΩ, C_{L2} =1nF			10	kHz
Resistive Load at PIN *LPOUT*	R_{LOAD}		200			kΩ
Capacitive Load at PIN *LPOUT*	C_{LOAD}				50	pF
Temperature Coefficient V_{DIFF} (together with Input Stages)	dV_{DIFF}/dT	$V_{DIFF} = V_{LPOUT} - V_M$, T_{amb} = –40 ... 85°C		±100		ppm/°C
Internal Resistor 1 and 2	R_{01}, R_{02}			20		kΩ
Temperature Coefficient $R_{01,02}$	$dR_{01,02}/dT$	T_{amb} = –40 ... 85°C		1.9		10^{-3}/°C
Power Supply Rejection Ratio (together with Input Stages)	*PSRR*	$I_{OUT} \leq$ 1mA	80	90		dB
Voltage Reference V_{REF}						
Voltage	V_{REF}		4.75	5	5.25	V
Current	I_{REF}		0		9	mA
V_{REF} vs. Temperature	dV_{REF}/dT	T_{amb} = –40...+85°C		±90	±140	ppm/°C
Line Regulation	dV_{REF}/dV	Vcc = 6V...35V		30	80	ppm/V
	dV_{REF}/dV	Vcc = 6V...35V, $I_{REF} \approx$ 4mA		60	150	ppm/V
Load Regulation	dV_{REF}/dI			0.05	0.10	%/mA
	dV_{REF}/dI	$I_{REF} \approx$ 4mA		0.06	0.15	%/mA
Load Capacitance	C_{REF}		1.9	2.2	5.0	µF

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Voltage Reference V_M						
Voltage	V_M		1.90	2	2.15	V
V_M vs. Temperature	dV_M/dT	T_{amb} = –40...+85°C		±90		ppm/°C
Current	I_{VM}	Source			5	µA
	I_{VM}	Sink			-5	µA
Load Capacitance	C_{VM}		80	100	120	nF
Instrumentation Amplifier Input Stage						
Internal Gain	G_{IA}		4.9	5	5.1	
Differential Range	V_{IN}		0		400	mV
Common Mode Input Range	*CMIR*	$V_{CC} < 9V$, $I_{CV} < 2mA$	1.5		V_{CC} - 3	V
	CMIR	$V_{CC} \geq 9V$, $I_{CV} < 2mA$	1.5		6.0	V
Common Mode Rejection Ratio	*CMRR*		80	90		dB
Power Supply Rejection Ratio	*PSRR*	$I_{OUT} \leq 1mA$	80	90		dB
Offset Voltage	V_{OS}			±1.5	±6	mV
V_{OS} vs. Temperature	dV_{OS}/dT			±5		µV/°C
Output Stage						
Adjustable Gain	G_{OP}		1			
Input Range	*IR*	$V_{CC} < 11V$	0		V_{CC} - 5	V
	IR	$V_{CC} \geq 11V$	0		6	V
Power Supply Rejection Ratio	*PSRR*	$I_{OUT} \leq 1mA$	80	90		dB
Offset Voltage	V_{OS}			±0.5	±2	mV
V_{OS} vs. Temperature	dV_{OS}/dT			±3	±7	µV/°C
Input Bias Current	I_B			10	25	nA
I_B vs. Temperature	dI_B/dT			7	20	pA/°C
Output Voltage Range	V_{OUT}	$V_{CC} < 19V$	0		V_{CC} - 5	V
	V_{OUT}	$V_{CC} \geq 19V$	0		14	V
Output Current Limitation	I_{LIM}	$V_{CC} \geq 10V$	5	7	10	mA
Output Current	I_{OUT}		0		I_{LIM}	mA
Load Resistance	R_L		2			kΩ
Load Capacitance	C_L				500	nF
Protection Functions						
Protection Against Reverse Polarity		*Ground* vs. V_{CC} vs. V_{OUT}			35	V

Note:

1) The oscillator capacity has to be chosen in the following way: $C_{OSC} = 1.6 \cdot C_{X1}$
2) The capacitor range of C_{X1} and C_{X2} can be extended whereby the system performance is reduced and the electrical limits are exceeded.
3) Currents flowing into the IC, are negative.

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BOUNDARY CONDITIONS

Parameter	Symbol	Min.	Typ.	Max.	Unit
Current Definition of Ref. Oscillator	R_{COSC}	190	200	210	kΩ
Current Adjustment of Cap. Integrator 1	R_{CX1}	350	400	450	kΩ
Current Adjustment of Cap. Integrator 2	R_{CX2}	350	400	450	kΩ
Lowpass Stage Resistor Sum	$R_{L1} + R_{L2}$	90		200	kΩ
Output Stage Resistor Sum	$R_1 + R_2$	90		200	kΩ
Reference Voltage 5V	C_{REF}	1.9	2.2	5	µF
Reference Voltage 2V (only for internal use)	C_{VM}	80	100	120	nF
Lowpass Capacitance 1	C_{L1}	$100 \cdot C_{X1}$	$200 \cdot C_{X1}$		
Lowpass Capacitance 2	C_{L2}	$100 \cdot C_{X1}$	$200 \cdot C_{X1}$		
Oscillator Capacitance	C_{OSC}	$C_{OSC} = 1.55 \cdot C_{X1}$	$C_{OSC} = 1.60 \cdot C_{X1}$	$C_{OSC} = 1.65 \cdot C_{X1}$	

Note: The system performance over temperature forces that the resistors R_{CX1}, R_{CX2} and R_{OSC} have the same temperature coefficient and a very close placement of them in the circuit. The capacities C_{X1}, C_{X2} and C_{OSC} are also forced to have the same temperature coefficient and a very close placement of them in the circuit.

FUNCTIONAL DIAGRAM

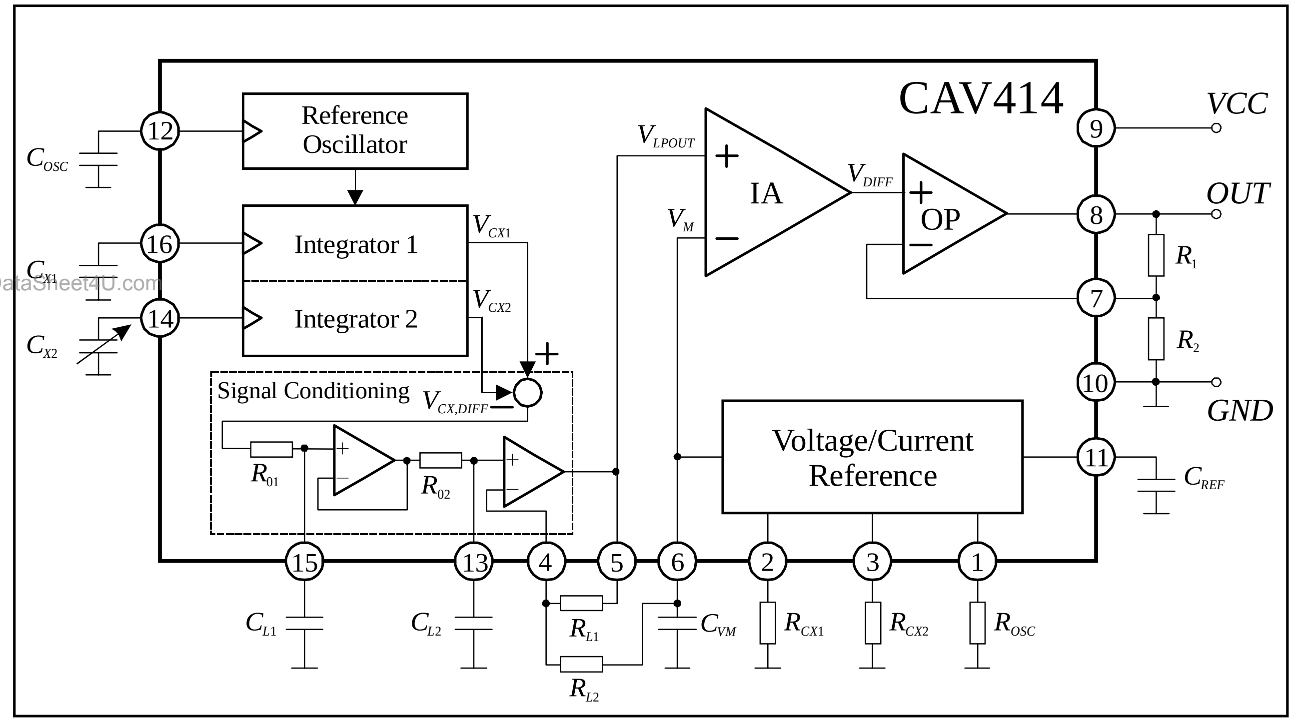

Figure 2

FUNCTIONAL DESCRIPTION

A reference oscillator with a frequency adjusted by the capacity C_{OSC} drives two symmetrically built integrators synchronously to its clock and its phase. The capacitors C_{X1} and C_{X2} determine the amplitude of the two driven integrators. The difference of the integrator amplitudes gives the relative change of the capacities C_{X1} and C_{X2} to each other with high common mode rejection and high resolution. The difference signal is conditioned 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 an instrumentation amplifier and an output stage. These two stages transform the signal into an adjustable voltage.

Adjustment:

The zero-adjustment is made by the resistors R_{CX1} or R_{CX2} for the case that the varying capacitance C_{X2} has nearly the same (and its smallest) value as the fixed capacitance C_{X1} (reference capacitance). Therefore one of this resistors is varied until the differential voltage

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

is zero:

$$V_{DIFF} = 0$$

Application Example:

The following values are given:

- fixed capacitance C_{X1}: 50pF
- varying capacitance C_{X2}: 50 ... 100pF

Calculation:

With the equations given in the boundary conditions, the following values for the devices can be calculated:

- C_{OSC}: 80pF
- C_{L1}: 10nF
- C_{L2}: 10nF

If the signal V_{DIFF} is amplified, it has to fulfil the unequation:

$V_{DIFF} \leq 400\text{mV}$

Detailed calculations are shown in a separately available *Application Note*.

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PINOUT

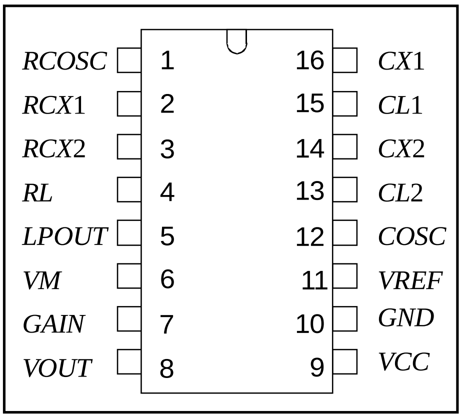

Figure 3

PIN	NAME	DESIGNATION
1	*RCOSC*	Current Definition of Ref. Oscillator
2	*RCX*1	Current Adjustment of Cap. Integrator 1
3	*RCX*2	Current Adjustment of Cap. Integrator 2
4	*RL*	Gain Adjustment of Lowpass Filter
5	*LPOUT*	Output of Lowpass Filter
6	*VM*	Reference Voltage 2V
7	*GAIN*	Gain Adjustment
8	*VOUT*	Voltage Output
9	*VCC*	Supply Voltage
10	*GND*	IC Ground
11	*VREF*	Reference Voltage 5V
12	*COSC*	Capacitor of Reference Oscillator
13	*CL*2	Corner Frequency of Lowpass 2
14	*CX*2	Integrator Capacitor 2
15	*CL*1	Corner Frequency of Lowpass 1
16	*CX*1	Integrator Capacitor 1

DELIVERY

The CAV414 is available in version:

- 16–Pin–DIL (samples)
- SO 16 (n) (Maximum Power Dissipation P_D = 300mW)
- Dice on 5“ blue foil

PACKAGE DIMENSIONS SO16 (n)

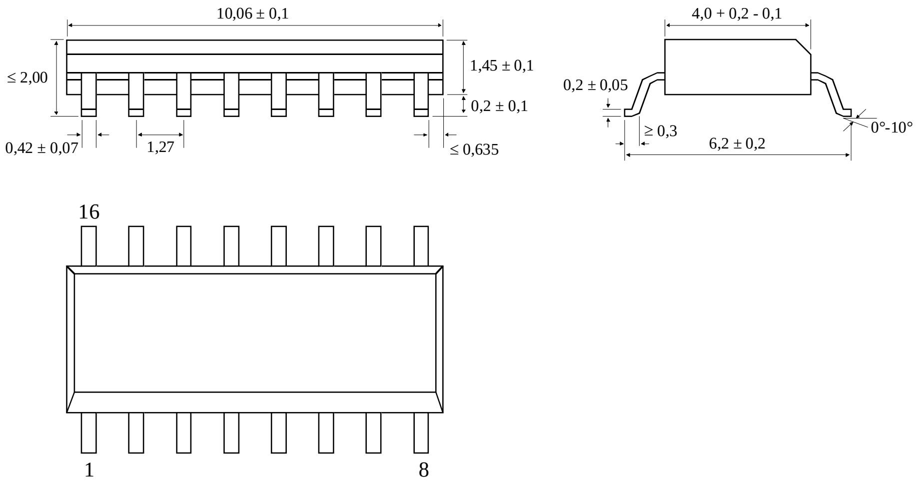

Figure 4