

# Dual Variable-Reluctance Sensor Interface IC

## Description

The CS1124 is a monolithic integrated circuit designed primarily to condition signals used to monitor rotating parts.

The CS1124 is a dual channel device. Each channel interfaces to a Variable Reluctance Sensor, and monitors the signal produced when a metal object is moved past that sensor. An output is generated that is a comparison of the input voltage and the voltage pro-

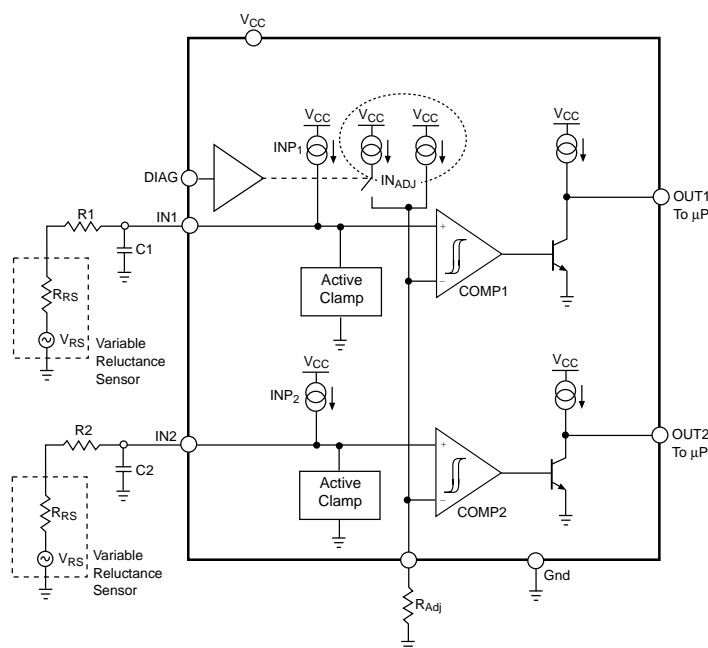
duced at the  $IN_{Adj}$  lead. The resulting square-wave is available at the OUT pin.

When the DIAG pin is high, the reference voltage at  $IN_{Adj}$  is increased. This then requires a larger signal at the input to trip the comparator, and provides for a procedure to test for an open sensor.

## Absolute Maximum Ratings

Storage Temperature Range .....	-65°C to 150°C
Ambient Operating Temperature .....	-40°C to 125°C
Supply Voltage Range (continuous) .....	-0.3V to 7V
Input Voltage Range (at any input, $R_1 = R_2 = 22k$ ) .....	-250V to 250V
Maximum Junction Temperature .....	150°C
ESD Capability (Human Body Model) .....	2 kV
Lead Temperature Soldering	
Reflow (SMD styles only) .....	60 sec. max above 183°C, 230°C peak

## Block Diagram

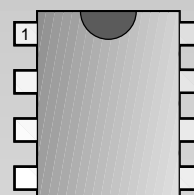


## Features

- Dual Channel Capability
- Built-In Test Mode
- On-Chip Input Voltage Clamping
- Works From 5V Supply
- Accurate Built-In Hysteresis

## Package Option

### 8 Lead SOIC



ON Semiconductor

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**Electrical Characteristics:  $4.5V < V_{CC} < 5.5V$ ;  $-40^{\circ}C < T_A < 125^{\circ}C$ ;  $V_{DIAG} = 0$ ; unless otherwise specified.**

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>■ V<sub>CC</sub> Supply</b>					
Operating Current Supply	$V_{CC} = 5V$			5	mA
<b>■ Sensor Inputs</b>					
Input Threshold – Positive	$V_{DIAG} = \text{low}$	135	160	185	mV
	$V_{DIAG} = \text{high}$	135	160	185	mV
Input Threshold – Negative	$V_{DIAG} = \text{low}$	–185	–160	–135	mV
	$V_{DIAG} = \text{high}$	135	160	185	mV
Input Bias Current (INP1, INP2)	$V_{IN} = 0.336V$	–16	–11	–6	μA
Input Bias Current (DIAG)	$V_{DIAG} = 0V$			1	μA
Input Bias Current Factor (K <sub>I</sub> ) ( $IN_{ADJ} = INP \times K_I$ )	$V_{IN} = 0.336V$ , $V_{DIAG} = \text{low}$		100		% INP
	$V_{IN} = 0.336V$ , $V_{DIAG} = \text{high}$	152	155	157	% INP
Bias Current Matching	INP1 or INP2 to $IN_{Adj}$ , $V_{IN} = 0.336V$	–1	0	1	μA
Input Clamp – Negative	$I_{IN} = -50\mu A$	–0.5	–0.25	0	V
	$I_{IN} = -12mA$	–0.5	–0.30	0	V
Input Clamp – Positive	$I_{IN} = +12mA$	5	7	9	V
Output Low Voltage	$I_{OUT} = 1.6mA$		0.2	0.4	V
Output High Voltage	$I_{OUT} = -1.6mA$	$V_{CC} - 0.5$	$V_{CC} - 0.2$		V
Mode Change Time Delay		0		20	μs
Input to Output Delay	$I_{OUT} = 1.0mA$		1	20	μs
Output Rise Time	$C_{LOAD} = 30pF$		0.5	2	μs
Output Fall Time	$C_{LOAD} = 30pF$		0.05	2	μs
Open-Sensor Positive Threshold	$V_{DIAG} = \text{high}$ , $R_{IN(Adj)} = 40k$ (Note 1)	29.4	54k	86.9	Ω
<b>■ Logic Inputs</b>					
DIAG Input Low Threshold				$0.2 \times V_{CC}$	V
DIAG Input High Threshold		$0.7 \times V_{CC}$			V
DIAG Input Resistance	$V_{IN} = 0.3 \times V_{CC}$ , $V_{CC} = 5.0V$	8k	22k	70k	Ω
	$V_{IN} = V_{CC}$ , $V_{CC} = 5.0V$	8k	22k	70k	Ω

Note 1: This parameter is guaranteed by design, but not parametrically tested in production.

**Package Pin Description**

PACKAGE PIN#	PIN SYMBOL	FUNCTION
<b>8 Lead So Narrow</b>		
1	$IN_{Adj}$	External resistor to ground that sets the trip levels of both channels. Functions for both diagnostic and normal mode.
2	IN1	Input to channel 1.
3	IN2	Input to channel 2.
4	Gnd	Ground.
5	DIAG	Diagnostic mode switch. Normal mode is low.
6	OUT2	Output of channel 2.
7	OUT1	Output of channel 1.
8	$V_{CC}$	Positive 5 volt supply input.



since  $R_{RS}$  is the only unknown variable we can solve for  $R_{RS}$ ,

$$R_{RS} = \frac{INP1 \times K_I \times R_{Adj} + V_{HYS}}{INP1} - R1 \quad (13)$$

Equation (13) shows that if the output switches states when entering the diag mode with  $V_{RS} = 0$ , the sensor impedance must be greater than the above calculated value. This can be very useful in diagnosing intermittent sensor.

#### Input Protection

As shown in Figure 1, an active clamp is provided on each input to limit the voltage on the input pin and prevent sub-

strate current injection. The clamp is specified to handle  $\pm 12\text{mA}$ . This puts an upper limit on the amplitude of the sensor output. For example,

if  $R1 = 20\text{k}$ ,

then  $V_{RS(\text{MAX})} = 20\text{k} \times 12\text{mA} = 240\text{V}$ .

Therefore, the  $V_{RS(\text{pk-pk})}$  voltage can be as high as 480V.

The CS1124 will *typically* run at a frequency up to 1.8MHz if the input signal does not activate the positive or negative input clamps. Frequency performance will be lower when the positive or negative clamps are active. *Typical* performance will be up to a frequency of 680kHz with the clamps active.

#### Circuit Description

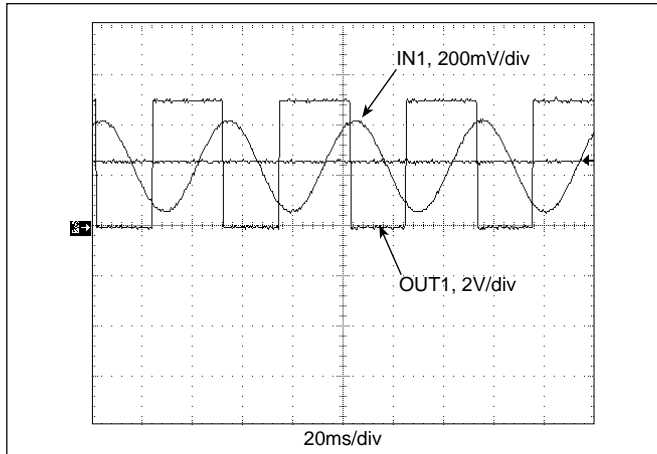


Figure 2: Minimum Threshold Operation.

Figure 2 shows the part operating near the minimum input thresholds. As the sin wave input threshold is increased, the low side clamps become active (Figure 3). Increasing the amplitude further (Figure 4), the high-side clamp becomes active. These internal clamps allow for voltages up to  $-250\text{V}$  and  $250\text{V}$  on the sensor side of the setup (with  $R1 = R2 = 22\text{k}$ ) (reference the diagram on the front page).

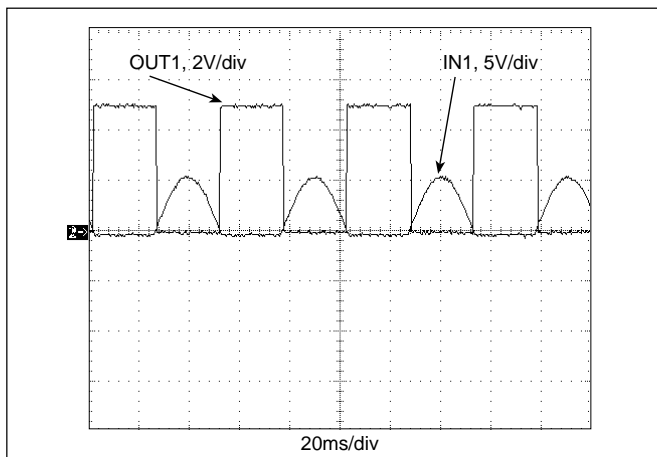


Figure 3: Low-Side Clamp.

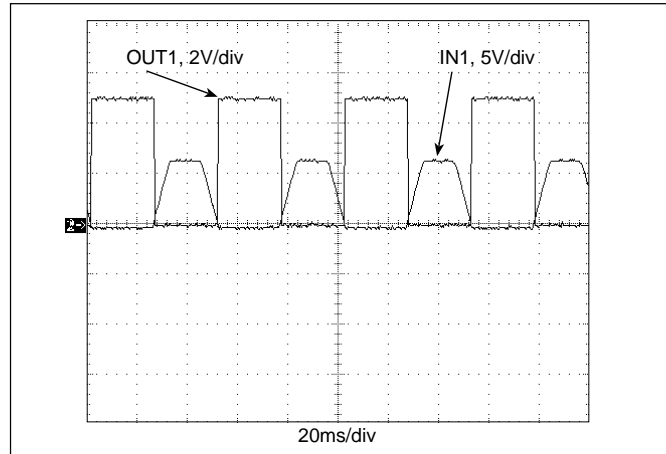


Figure 4: Low- and High-Side Clamps.

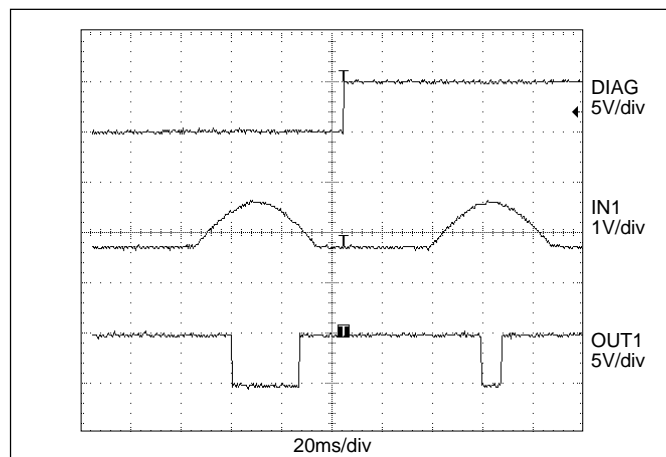


Figure 5: Diagnostic Operation.

Figure 5 shows the effect using the diagnostic (DIAG) function has on the circuit. The input threshold (negative) is switched from a threshold of  $-160\text{mV}$  to  $+160\text{mV}$  when DIAG goes from a low to a high. There is no hysteresis when DIAG is high.

Referring to Figure 1, the following will be a design example given these system requirements:

$$R_{RS} = 1.5k\Omega \text{ (>12k}\Omega \text{ is considered open)}$$

$$V_{RS(MAX)} = 120V_{pk}$$

$$V_{RS(MIN)} = 250mV_{pk}$$

$$F_{VRS} = 10kHz @ V_{RS(MIN)} = 40V_{pk-pk}$$

**1. Determine tradeoff between R1 value and power rating.**  
(use 1/2 watt package)

$$P_D = \frac{\left(\frac{120}{\sqrt{2}}\right)^2}{R1} < 1/2W$$

Set R1 = 15k

(the clamp current will then be  $120/15k = 8mA$ , which is less than the 12mA limit)

**2. Determine  $R_{Adj}$**

Set  $R_{Adj}$  as close to  $R1 + R_{RS}$  as possible.

Therefore,  $R_{Adj} = 17k$

**3. Determine  $V_{RS(+TRP)}$  using equation (7).**

$$V_{RS(+TRP)} = 11\mu A \times 17k - 11\mu A(15k + 1.5k) + 160mV$$

$V_{RS(+TRP)} = 166mV$  typical (easily meets 250mV minimum)

**4. Calculate worst case  $V_{RS(+TRP)}$**

Examination of equation (7) and the spec reveals the worst case trip voltage will occur when:

$$V_{HYS} = 180mV \quad R1 = 14.25k \text{ (5% low)}$$

$$IN_{Adj} = 16\mu A \quad R_{Adj} = 17.85k \text{ (5% High)}$$

$$INP1 = 15\mu A$$

$$V_{RS(+TRP)MAX} = 16\mu A(17.85k) - 15\mu A(14.25k + 1.5k) + 180mV = 229mV,$$

which is still less than the 250mV minimum amplitude of the input.

**5. Calculate C1 for low pass filtering**

Since the sensor guarantees  $40V_{pk-pk} @ 10kHz$ , a low pass filter using R1 and C1 can be used to eliminate high frequency noise without affecting system performance.

$$\text{Gain Reduction} = \frac{0.29V}{20V} = 0.0145 = -36.7dB$$

Therefore, a cut-off frequency,  $f_c$ , of 145Hz could be used.

$$C1 \leq \frac{1}{2\pi f_c R1} \leq 0.07\mu F$$

Set  $C1 = 0.047\mu F$

**6. Calculate the minimum  $R_{RS}$  that will be indicated as an open circuit. (DIAG = 5V)**

Rearranging equation (7) gives

$$R_{RS} = \frac{V_{HYS} + INP1 \times K_I \times R_{Adj} - V_{RS(+TRP)}}{INP1} - R1$$

But,  $V_{RS} = 0$  during this test, so it drops out.

Using the following as worst case Low and High:

	Worst Case Low ( $R_{RS}$ )	Worst Case High ( $R_{RS}$ )
$IN_{Adj}$	$23.6\mu A = 15\mu A \times 1.57$	$10.7\mu A = 7\mu A \times 1.53$
$R_{Adj}$	16.15k	17.85k
$V_{HYS}$	135mV	185mV
$INP1$	16 $\mu A$	6 $\mu A$
R1	15.75k	14.25k
$K_I$	1.57	1.53

$$R_{RS} = \frac{135mV + 23.6\mu A \times 16.15k}{16\mu A} - 15.75k = 16.5k$$

Therefore,

$$R_{RS(MIN)} = 16.5k \text{ (meets 12k system spec)}$$

and,

$$R_{RS(MAX)} = \frac{185mV + 10.7\mu A \times (17.85k)}{6\mu A} - 14.25k = 48.4k$$

# Package Specification

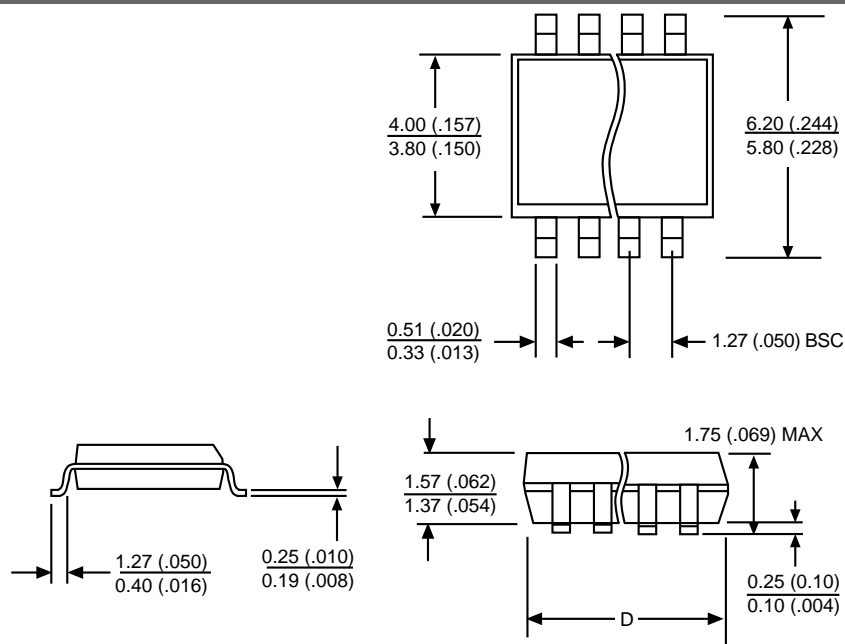
## PACKAGE DIMENSIONS IN mm (INCHES)

Lead Count	D			
	Metric		English	
	Max	Min	Max	Min
8 Lead SO Narrow	5.00	4.80	.197	.189

## PACKAGE THERMAL DATA

Thermal Data		8 Lead SO Narrow	
$R_{\theta JC}$	typ	45	$^{\circ}\text{C}/\text{W}$
$R_{\theta JA}$	typ	165	$^{\circ}\text{C}/\text{W}$

## Surface Mount Narrow Body (D); 150 mil wide



## Ordering Information

Part Number	Description
CS1124YD8	8 Lead SO Narrow
CS1124YDR8	8 Lead SO Narrow ( <i>tape &amp; reel</i> )

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