

ON Semiconductor

Is Now

onsemi™

To learn more about onsemi™, please visit our website at
www.onsemi.com

onsemi and **onsemi** and other names, marks, and brands are registered and/or common law trademarks of Semiconductor Components Industries, LLC dba "**onsemi**" or its affiliates and/or subsidiaries in the United States and/or other countries. **onsemi** owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of **onsemi** product/patent coverage may be accessed at www.onsemi.com/site/pdf/Patent-Marking.pdf. **onsemi** reserves the right to make changes at any time to any products or information herein, without notice. The information herein is provided "as-is" and **onsemi** makes no warranty, representation or guarantee regarding the accuracy of the information, product features, availability, functionality, or suitability of its products for any particular purpose, nor does **onsemi** assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using **onsemi** products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by **onsemi**. "Typical" parameters which may be provided in **onsemi** data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. **onsemi** does not convey any license under any of its intellectual property rights nor the rights of others. **onsemi** products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use **onsemi** products for any such unintended or unauthorized application, Buyer shall indemnify and hold **onsemi** and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that **onsemi** was negligent regarding the design or manufacture of the part. **onsemi** is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner. Other names and brands may be claimed as the property of others.

20mA Air-Core Tachometer Drive Circuit

Description

The CS289 is specifically designed for use with air-core meter movements. The IC has charge pump circuitry for frequency-to-voltage conversion, a shunt regulator for stable

operation, a function generator, and sine and cosine amplifiers. The buffered sine and cosine outputs will typically sink or source 20mA.

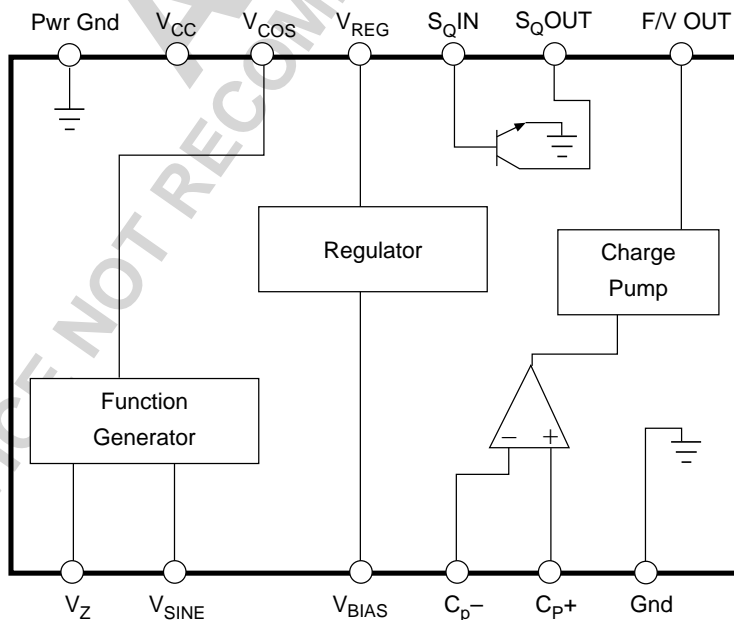
Features

- **Single Supply Operation**
- **On-Chip Regulation**
- **20mA Output Drive Capability**

Absolute Maximum Ratings

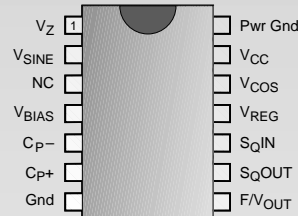
Supply Voltage (V_{CC}).....	20V
Operating Temperature.....	-40°C to +100°C
Junction Temperature.....	-40°C to 150°C
Storage Temperature.....	-65°C to +150°C
Lead Temperature Soldering	
Wave Solder (through hole styles only).....	10 sec. max, 260°C peak
Reflow (SMD styles only).....	60 sec. max above 183°C, 230°C peak

Block Diagram

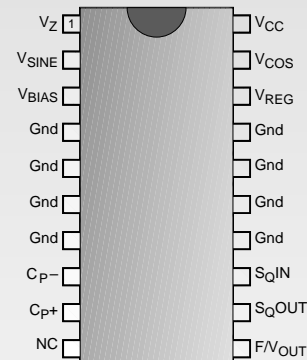


Package Options

14L PDIP



20L SOIC Wide



Electrical Characteristics: ($V_{CC} = 13.1V$, $-30^{\circ}C \leq T_A \leq 85^{\circ}C$)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Supply Current (Note 2)	$V_{CC} = 15.0V$		54		mA
	$V_{CC} = 13.1V$		60	65	mA
	$V_{CC} = 11.3V$		60	65	mA
Regulated Voltage	$I_{REG} = 4.3mA$	7.7	8.5	9.3	V
Regulation	$I_{REG} = 0$ to 5mA		0.10	0.20	V
Signal Input Current	$T = 25^{\circ}C$	0.1	2.0	4.0	mA
Saturation Voltage	$I_{SQ OUT} = 5mA$, $I_{SQ IN} = 500\mu A$		0.20	0.55	V
Leakage Current	$I_{SQ OUT} = 16V$, $V_{SQ IN} = 0V$			10	μA
Input Current	$C_{P+} = 0$, $T = 25^{\circ}C$		1	15	nA
F to V Output	$V_{SQ IN} = 0$ (zero input), $\emptyset = 0^{\circ}$	1.8	2.1	2.4	
	$V_{COS} = 0$ (Note 1), $\emptyset = 270^{\circ}$	6.3	7.1	7.9	V
Linearity	E_O vs. Frequency				
	$V_{COS} = 0$ (Note 1), $\emptyset = 270^{\circ}$, $T = 25^{\circ}C$	-1.5		1.5	%
V_{sine} at $\emptyset = 0^{\circ}$	$V_{SQ IN} = 0$ (zero input), $\emptyset = 0^{\circ}$	-0.55	0.00	0.55	V
MAX V_{sine+}	$V_{COS} = 0$ (Note 1), $\emptyset = 90^{\circ}$	3.8	4.5	5.8	V
MAX V_{sine-}	$V_{COS} = 0$ (Note 1), $\emptyset = 270^{\circ}$	-3.8	-4.5	-5.8	V
Coil Drive Current	$V_{COS} = 0$ (Note 1), $\emptyset = 90^{\circ}$, $T = 25^{\circ}C$		20	25	mA
	$V_{COS} = 0$ (Note 1), $\emptyset = 270^{\circ}$		20	25	mA
MAX V_{COS+}	$V_{SQ IN} = 0$ (zero input), $\emptyset = 0^{\circ}$	3.8	4.5	5.8	V
MAX V_{COS-}	$V_{sine} = 0$ (Note 1), $\emptyset = 180^{\circ}$	-3.8	-4.5	-5.8	V
Coil Drive Current	$V_{SQ IN} = 0$ (zero input), $\emptyset = 0^{\circ}$		20	25	mA
	$V_{sine} = 0$ (Note 1), $\emptyset = 180^{\circ}$		20	25	mA
External Voltage Ref.		4.98	5.40	5.85	V

Note 1: V_{sine} measured V_{sine} to V_Z . V_{COS} measured V_{COS} to V_Z . All other voltages specified are measured to ground.

Note 2: Max PWR dissipation $\leq V_{CC} \times I_{CC} - (V_Z I_{sine} + V_{I2} I_{COS})$.

Package Pin Description

PACKAGE PIN #		PIN SYMBOL	FUNCTION
20L SO	14L PDIP		
1	1	V_Z	External Zener reference.
2	2	V_{sine}	Sine output signal.
3	4	V_{BIAS}	Test pin or "0" calibration pin.
4, 5, 6, 7, 14, 15, 16, 17	7	Gnd	Analog Ground connection.
8	5	C_{P-}	Negative input to charge pump.
9	6	C_{P+}	Positive input to charge pump.
10	3	NC	No Connection
11	8	F/ V_{OUT}	Output voltage proportional to input signal frequency.

Package Pin Description: continued

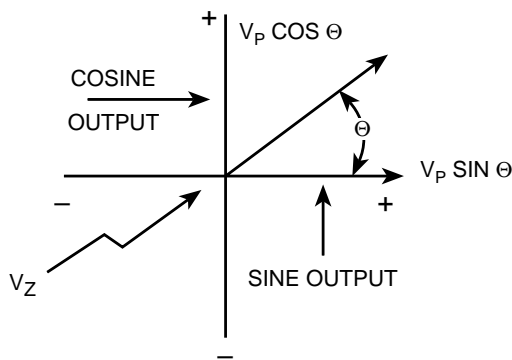
PACKAGE PIN #		PIN SYMBOL	FUNCTION
20L SO	14L PDIP		
12	9	S _Q OUT	Buffered square wave output signal.
13	10	S _Q IN	Speed or RPM input signal.
18	11	V _{REG}	Voltage regulator output.
19	12	V _{COS}	Cosine output signal.
20	13	V _{CC}	Supply voltage.
	14	Pwr Gnd	Power Ground connection.

Note 1: V_{sine} measured V_{sine} to V_Z. V_{cos} measured V_{cos} to V_Z. All other voltages specified are measured to ground.

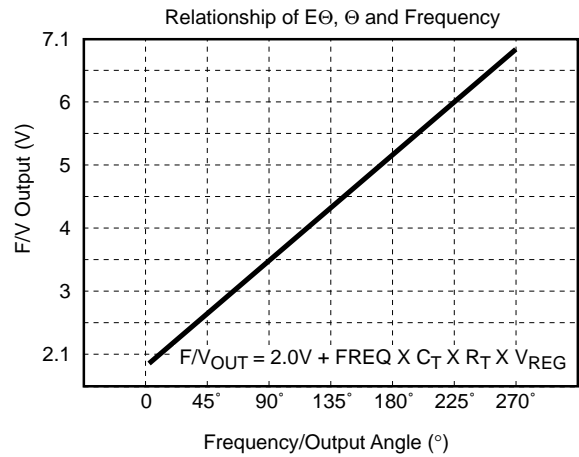
Note 2: Max PWR dissipation ≤ V_{CC} X I_{CC} - (V_Z I_{sine} + V_{I2} I_{cos}).

Typical Performance Characteristics

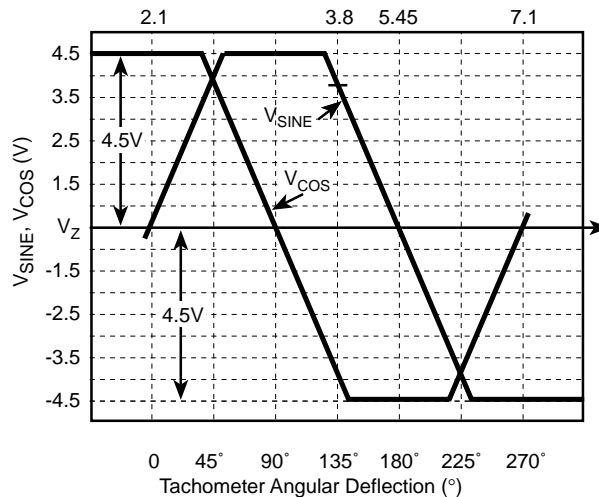
Output Angle in Polar Form



Charge Pump Output Voltage



Function Generator Output Voltage



Charge Pump

The input frequency is buffered through a transistor, then applied to the charge pump for frequency-to-voltage conversion (Figure 1). The charge pump output voltage, E_{ϕ} , will range from 2.1V with no input ($\phi = 0^\circ$) to 7.1V at $\phi = 270^\circ$. The charge that appears on C_T is reflected to C_{OUT} through a Norton amplifier. The frequency applied at $S_{\phi IN}$ charges and discharges C_T through R_1 and R_2 . C_{OUT} reflects the charge as a voltage across resistor R_T .

Function Generator/Sine and Cosine Amplifiers

The output waveforms of the sine and cosine amplifiers are derived by On-Chip Amplifier/Comparator circuitry. The various trip points for the circuit (i.e. 90° , 180° , 270°) are determined by an internal resistor divider connected to the voltage regulator. The voltage E_{ϕ} is compared to the divider network by the function generator circuitry. Use of an external zener reference at V_Z allows both sine and cosine amplifiers to swing positive and negative with respect to this reference. The output magnitudes and directions have the relationship as shown in Typical Characteristics diagrams.

Note: Pin connections referenced are for the 14L DIP.

Function Generator Output (ϕ): $V_{CC}=13.1V$, $T_A=25^\circ C$

$$\phi = \text{ArcTan} \left(\frac{V_{\text{sine}}}{V_{\text{cos}}} \right) \text{ (Measured angle after calibration at } 180^\circ \text{C)}$$

For $\phi_A = 45^\circ, 90^\circ, 135^\circ, 180^\circ, 225^\circ, 270^\circ$, (Desired angle)

$$(\phi_A - \phi_M) \leq 4.0^\circ$$

Temperature Sensitivity: $V_{CC}=13.1V$

$$\Delta\phi_{MT} = \phi_M (T=25^\circ C) - \phi_M (-20^\circ C \leq T \leq +85^\circ C)$$

$$(\Delta\phi_{MT}) \leq 3.5^\circ C, -20^\circ C \leq T \leq +85^\circ C$$

Voltage Sensitivity: $T_A=25^\circ C$

$$\Delta\phi_{MV} = \phi_M (V_{CC}=13.1V) - \phi_M (11.3V \leq V_{CC} \leq 15V)$$

$$(\Delta\phi_{MV}) \leq 2^\circ, 11.3V \leq V_{CC} \leq 15V$$

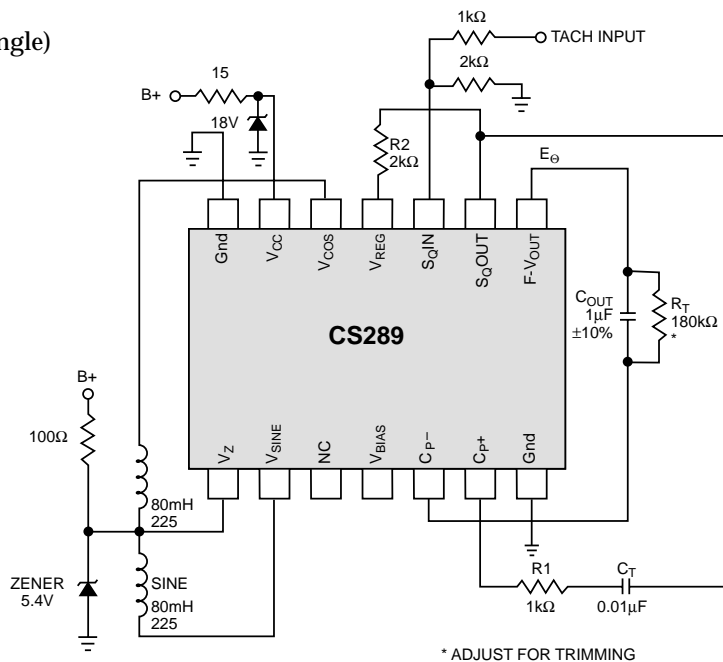


Figure 1. Functional Diagram of CS289 Circuit.

$$\frac{\text{RPM} \times \# \text{ OF CYL.}}{60 \times 2} = \text{Frequency}$$

$$V_{F/V_{OUT}} = 2.1 + \text{Frequency} \times C_T \times R_T (V_{REG} - 0.7)$$

The above equations were used in calculating the following values, where $V_{F/V_{OUT}} = 7.1V$ at $=270^\circ$ and $C_T = 0.01 F$.

4 cylinder: Freq = 200Hz, $R_T = 320k\Omega$

6 cylinder: Freq = 300Hz, $R_T = 220k\Omega$

8 cylinder: Freq = 400Hz, $R_T = 150k\Omega$

Typical values shown above apply to a nominal value of V_{REG} of 8.5 volts. It must be realized that trimming of R_T will be necessary to compensate for variations in regulator voltage from one unit to another.

An alternative to this adjustment is to replace R_2 with a potentiometer, as shown in Figure 2.

Partial schematic shown in Figure 3 represents one method for use with DC applications instead of frequency.

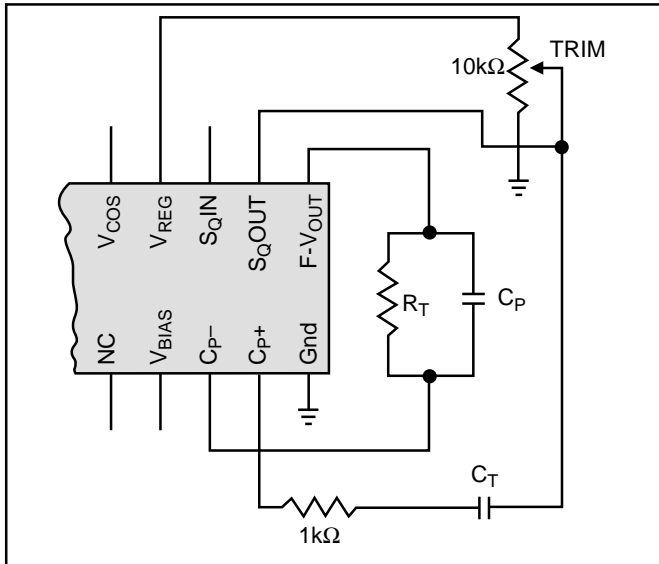


Figure 2: Alternate Trimming Method

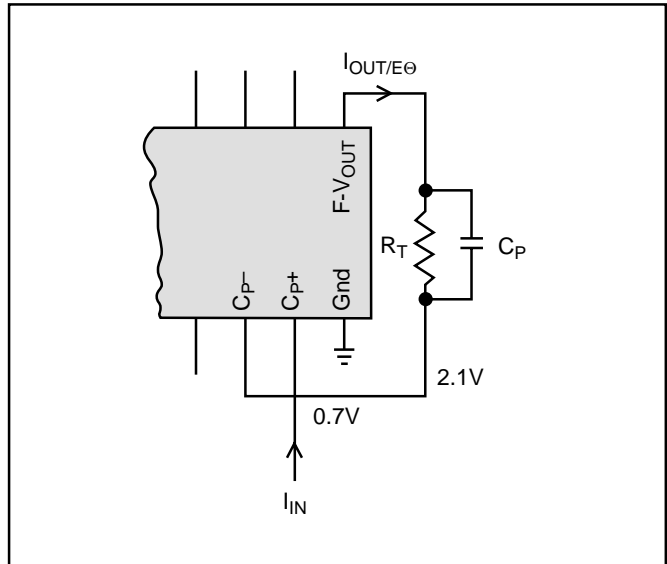


Figure 3: DC Application

Package Specification

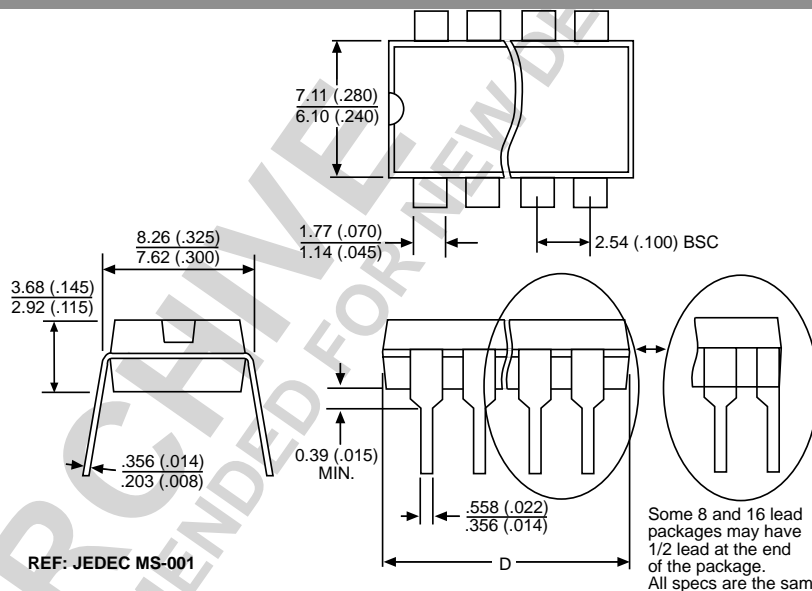
PACKAGE DIMENSIONS IN mm (INCHES)

Lead Count	D			
	Metric		English	
	Max	Min	Max	Min
14L PDIP	19.69	18.67	.775	.735
20L SO Wide	13.00	12.60	.512	.496

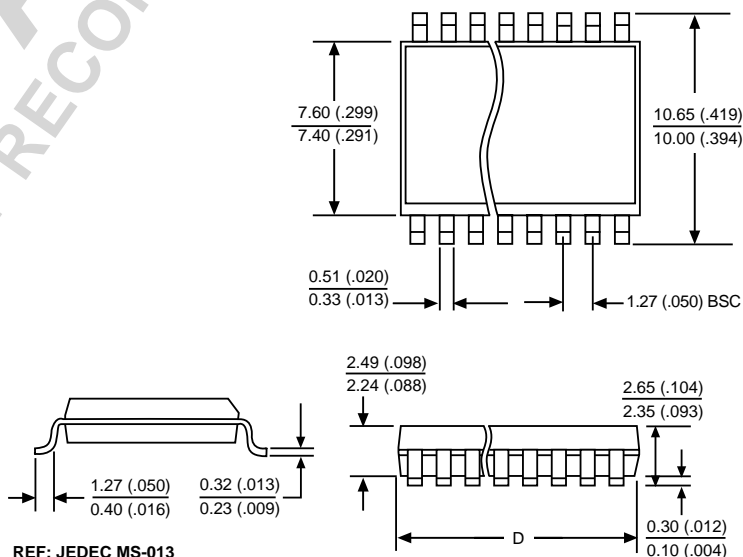
PACKAGE THERMAL DATA

Thermal Data	14L PDIP	20L SOIC	
$R_{\theta JC}$ typ	48	17	$^{\circ}\text{C}/\text{W}$
$R_{\theta JA}$ typ	85	90	$^{\circ}\text{C}/\text{W}$

Plastic DIP (N); 300 mil wide



Surface Mount Wide Body (DW); 300 mil wide



Ordering Information

Part Number	Description
CS289GDW20	20 Lead SO Wide
CS289GDWR20	20 Lead SO Wide (tape & reel)
CS289GN14	14 Lead PDIP

ON Semiconductor and the ON Logo are trademarks of Semiconductor Components Industries, LLC (SCILLC). ON Semiconductor reserves the right to make changes without further notice to any products herein. For additional information and the latest available information, please contact your local ON Semiconductor representative.

