AUTOMOTIVE GRADE

CS289

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.

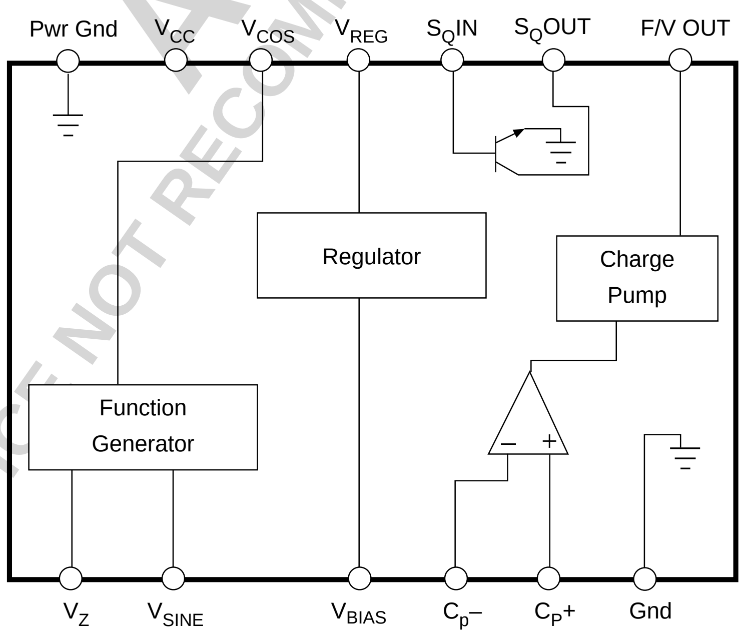
Features

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

Absolute Maximum Ratings

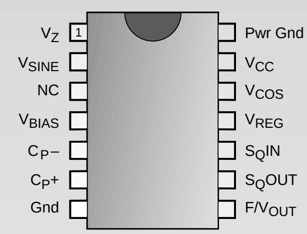
Supply Voltage (V_{CC})....................20V
Operating Temperature....................–40°C to +100°C
Junction Temperature....................–40°C to 150°C
Storage Temperature....................–65°C to +150°C
Lead Temperature Soldering
  Wave Solder (through hole styles only)...........10 sec. max,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

Block Diagram

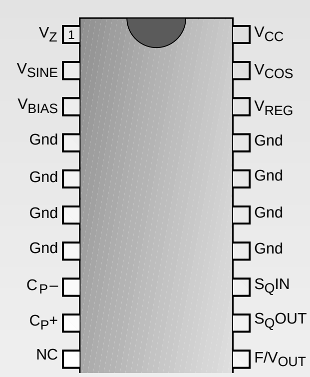


Package Options

14L PDIP



20L SOIC Wide



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Electrical Characteristics: (V_{CC} = 13.1V, -30°C ≤ T_A ≤ 85°C)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Supply Current (Note 2)	V_{CC} = 15.0V V_{CC} = 13.1V V_{CC} = 11.3V		54 60 60	 65 65	mA mA 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°C	0.1	2.0	4.0	mA
Saturation Voltage	I_{SQ} OUT = 5mA, I_{SQ} IN = 500µA		0.20	0.55	V
Leakage Current	I_{SQ} OUT = 16V, V_{SQ} IN = 0V			10	µA
Input Current	C_P+ = 0, T = 25°C		1	15	nA
F to V Output	V_{SQ}IN = 0 (zero input), ∅ = 0° V_{COS} = 0 (Note 1), ∅ = 270°	1.8 6.3	2.1 7.1	2.4 7.9	 V
Linearity	E_O vs. Frequency V_{COS} = 0 (Note 1), ∅ = 270°, T = 25°C	 -1.5		 1.5	 %
V_{sine} at ∅ = 0°	V_{SQ} IN = 0 (zero input), ∅ = 0°	-0.55	0.00	0.55	V
MAX V_{sine+}	V_{COS} = 0 (Note 1), ∅=90°	3.8	4.5	5.8	V
MAX V_{sine-}	V_{COS} = 0 (Note 1), ∅ = 270°	-3.8	-4.5	-5.8	V
Coil Drive Current	V_{COS} = 0 (Note 1), ∅ = 90°, T = 25°C V_{COS} = 0 (Note 1), ∅ = 270°		20 20	25 25	mA mA
MAX V_{COS+}	V_{SQ} IN = 0 (zero input), ∅ = 0°	3.8	4.5	5.8	V
MAX V_{COS-}	V_{sine} = 0 (Note 1), ∅ = 180°	-3.8	-4.5	-5.8	V
Coil Drive Current	V_{SQ} IN = 0 (zero input), ∅ = 0° V_{sine} = 0 (Note 1), ∅ = 180°		20 20	25 25	mA 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 ≤V_{CC} X I_{CC} - (V_2 I_{sine} + V12 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.

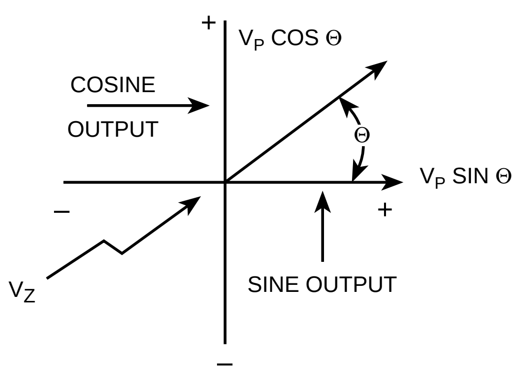
Package Pin Description: continued

PACKAGE PIN #		PIN SYMBOL	FUNCTION
20L SO	**14L PDIP**		
12	9	S_QOUT	Buffered square wave output signal.
13	10	S_QIN	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.

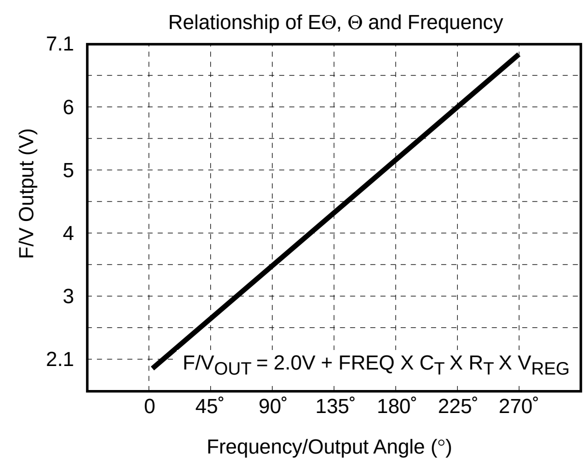
Note 1: V_{sine} measured V_{sine} to V_Z. V_{COS} measured V_{COS} to V_Z. All other voltages specified are measured to ground.
Note 2: Max PWR dissipation $\leq V_{CC}$ X I_{CC} - (V_2 I_{sine} + V12 I_{COS}).

Typical Performance Characteristics

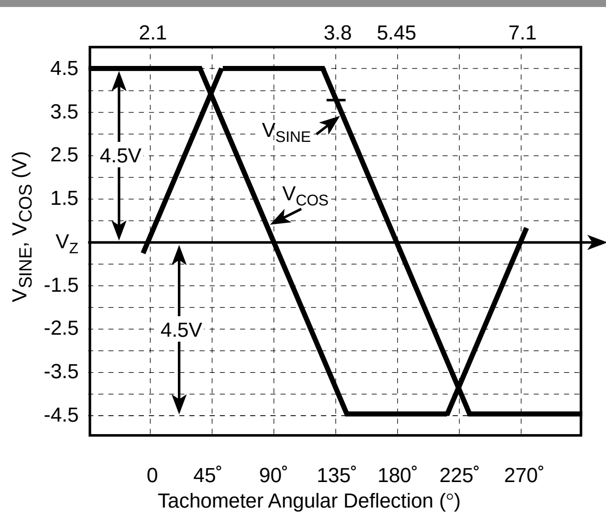
Output Angle in Polar Form



Charge Pump Output Voltage



Function Generator Output Voltage



Circuit Description

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∅, will range from 2.1V with no input (∅= 0°) to 7.1V at ∅ = 270°. The charge that appears on C_T is reflected to C_{OUT} through a Norton amplifier. The frequency applied at S_QIN 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∅ 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 (∅): V_{CC}=13.1V, T_A=25°C

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

For $\varnothing_A$=45°, 90°, 135°, 180°, 225°, 270°, (Desired angle)

$(\varnothing_A - \varnothing_M) \leq 4.0°$

Temperature Sensitivity: V_{CC}=13.1V

$\Delta\varnothing_{MT} = \varnothing_M$ (T=25°C) -∅M (-20°C≤T≤+85°C)

$(\Delta\varnothing_{MT}) \leq 3.5°C$, -20°C≤T≤+85°C

Voltage Sensitivity: T_A=25°C

$\Delta\varnothing_{MV} = \varnothing_M$ (V_{CC}=13.1V) -$\varnothing_M$ (11.3V≤V_{CC}≤15V)

$(\Delta\varnothing_{MV}) \leq 2°$, 11.3V≤$V_{CC}$≤15V

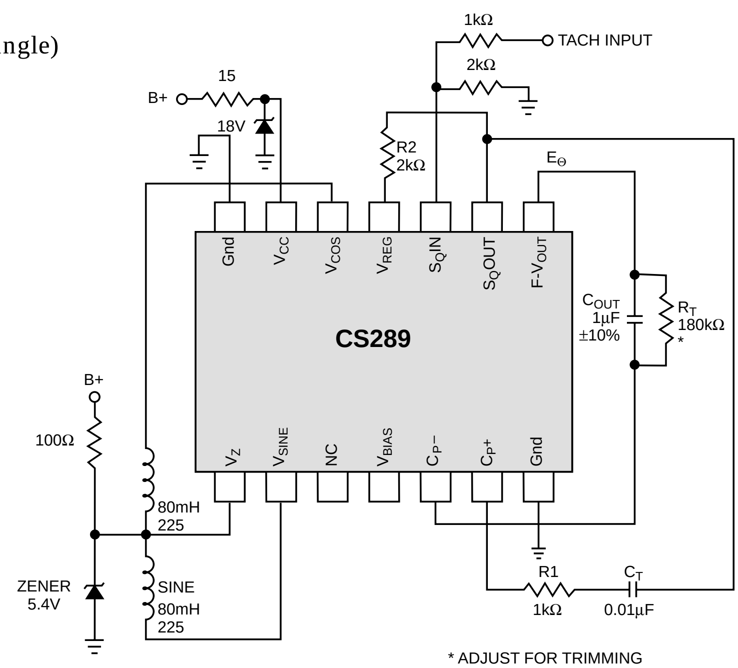


Figure 1. Functional Diagram of CS289 Circuit.

Tachometer Application

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

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

The above equations were used in calculating the following values, where $V_{F/V_{OUT}} = 7.1V$ at =270° 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.

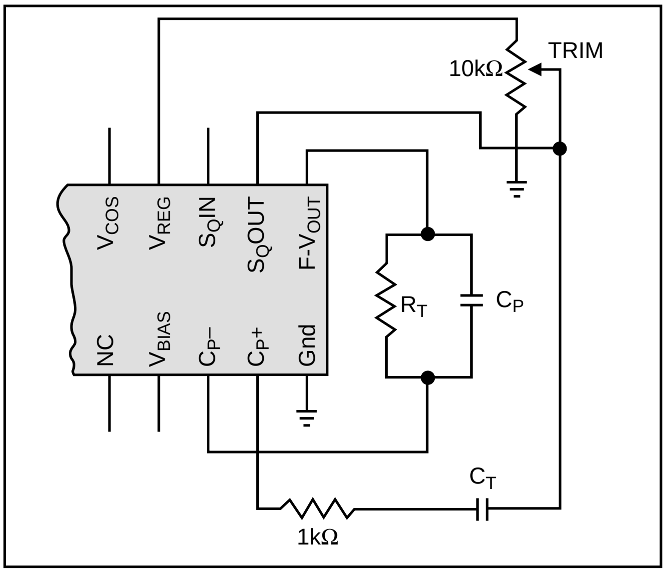


Figure 2: Alternate Trimming Method

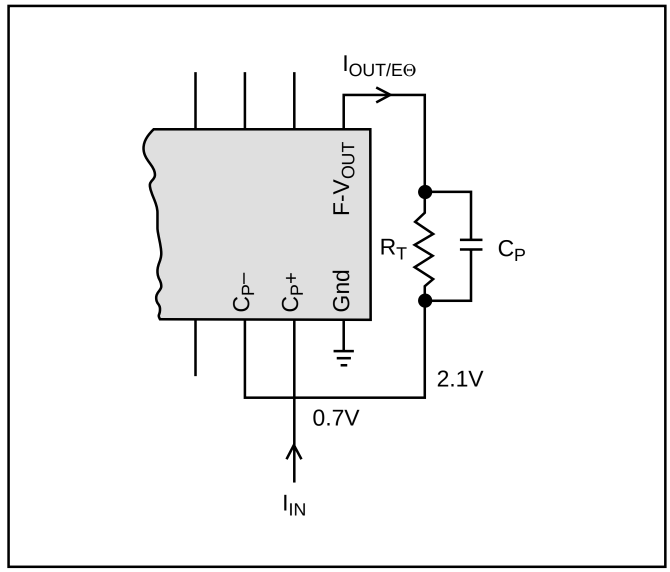


Figure 3: DC Application

Package Specification

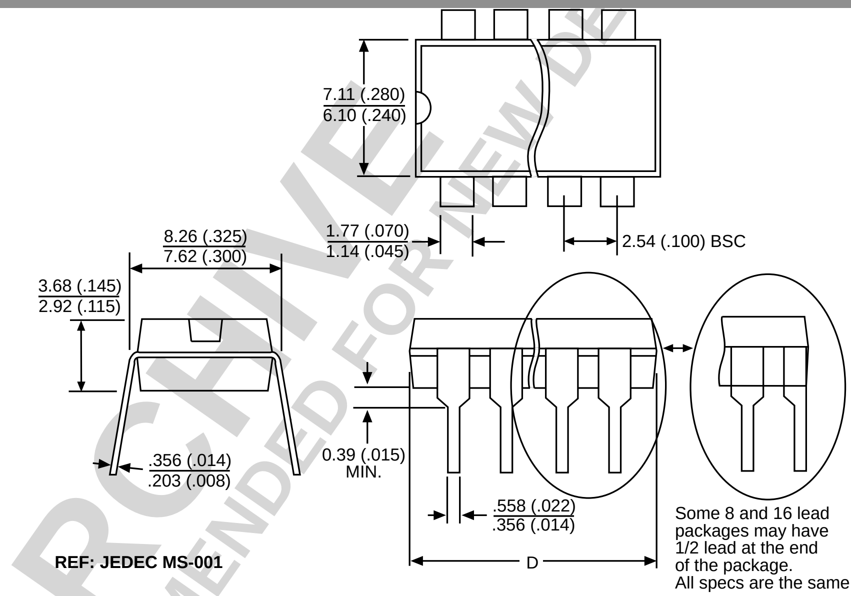
PACKAGE DIMENSIONS IN mm (INCHES)

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

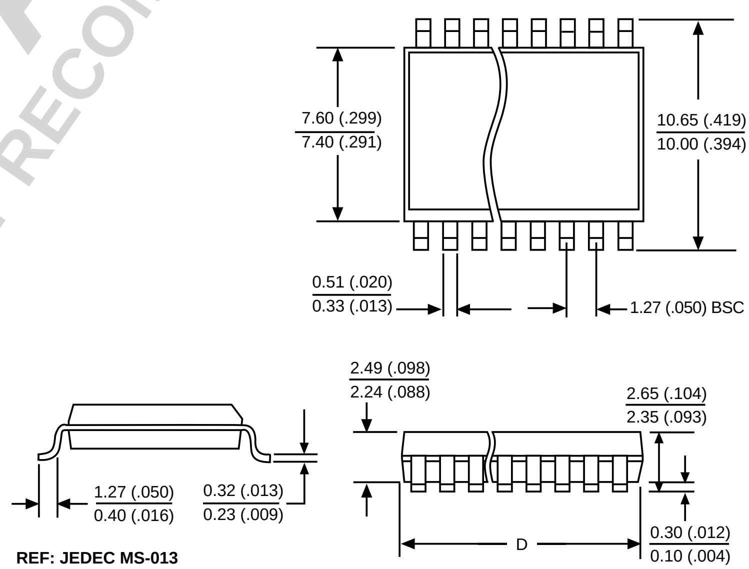
Thermal Data		14L PDIP	20L SOIC	
$R_{\Theta JC}$	typ	48	17	°C/W
$R_{\Theta JA}$	typ	85	90	°C/W

Plastic DIP (N); 300 mil wide



REF: JEDEC MS-001

Surface Mount Wide Body (DW); 300 mil wide



REF: JEDEC MS-013

Ordering Information

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

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Notes

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