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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.

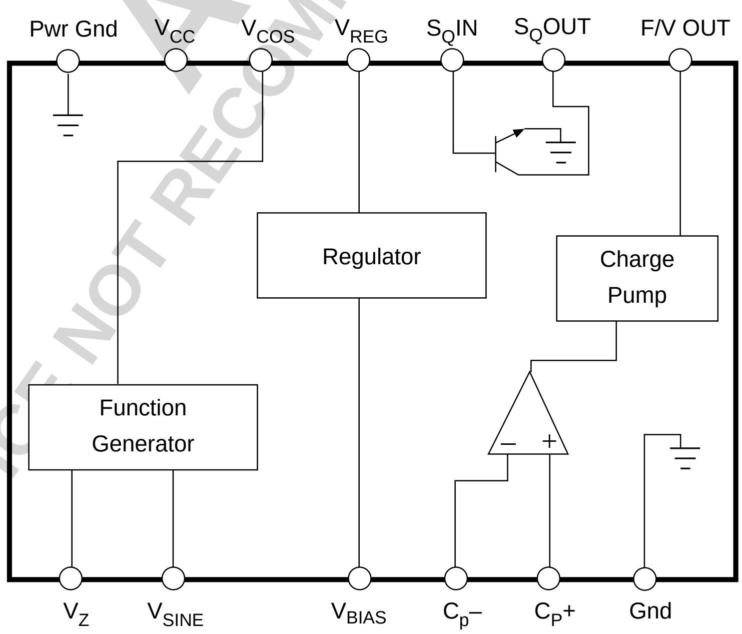
## Features

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

### Absolute Maximum Ratings

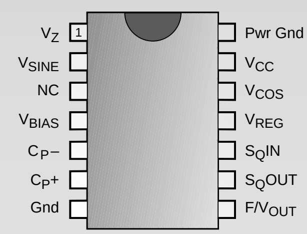
Supply Voltage ($V_{CC}$)........20V
Operating Temperature........–40°C to +100°C
Junction Temperature........–40°C to 150°C
Storage Temperature........–65°C to +150°C
Lead Temperature Soldering
Wave Solder (through hole styles only)...........10 sec. max, 260°C peak
Reflow (SMD styles only)...........60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

### Block Diagram

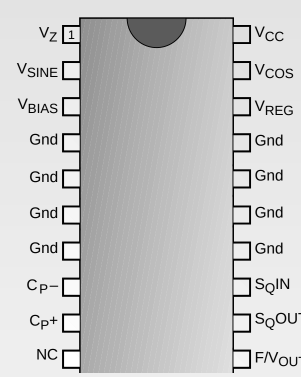



## Package Options

**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 | | 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°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° | 1.8 | 2.1 | 2.4 | |
| | $V_{COS}$ = 0 (Note 1), ∅ = 270° | 6.3 | 7.1 | 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 | | 20 | 25 | mA |
| | $V_{COS}$ = 0 (Note 1), ∅ = 270° | | 20 | 25 | 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° | | 20 | 25 | mA |
| | $V_{sine}$ = 0 (Note 1), ∅ = 180° | | 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 ≤$V_{CC}$ 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. |

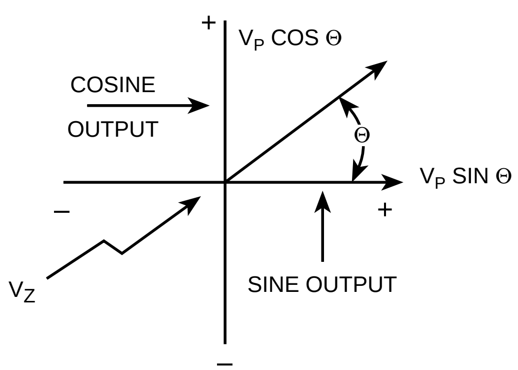
## Package Pin Description: continued

| 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. |

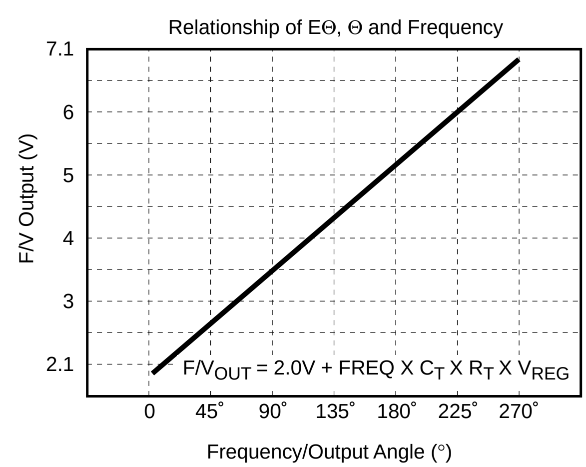
Note 1: $V_{sine}$ measured $V_{sine}$ to $V_Z$. $V_{COS}$ measured $V_{COS}$ to $V_Z$. All other voltages specified are measured to ground.
Note 2: Max PWR dissipation $\leq V_{CC}$ X $I_{CC}$ - ($V_2$ $I_{sine}$ + V12 $I_{COS}$).

## Typical Performance Characteristics

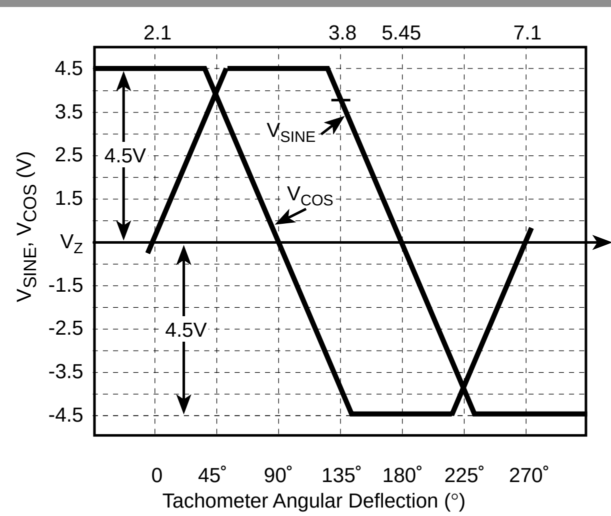
### Output Angle in Polar Form




### 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 $S_Q$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∅ 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

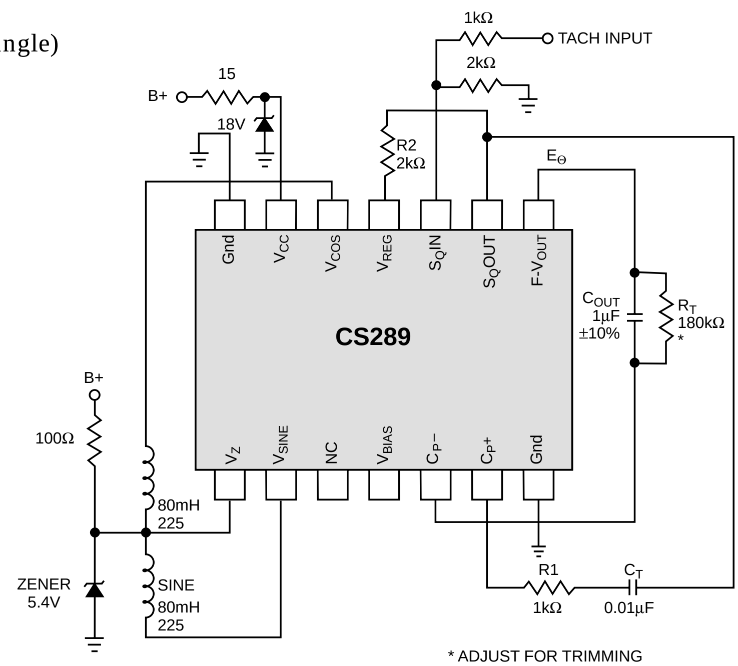



**Figure 1. Functional Diagram of CS289 Circuit.**

## 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.

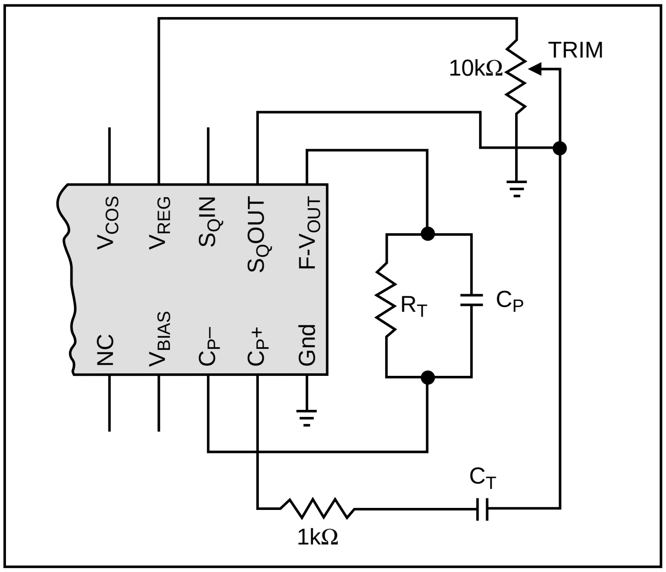



**Figure 2: Alternate Trimming Method**

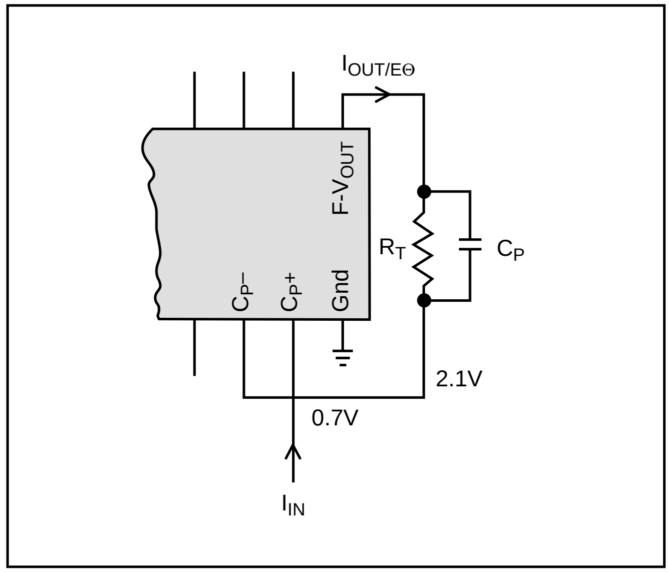



**Figure 3: DC Application**

## Package Specification

### PACKAGE DIMENSIONS IN mm (INCHES)

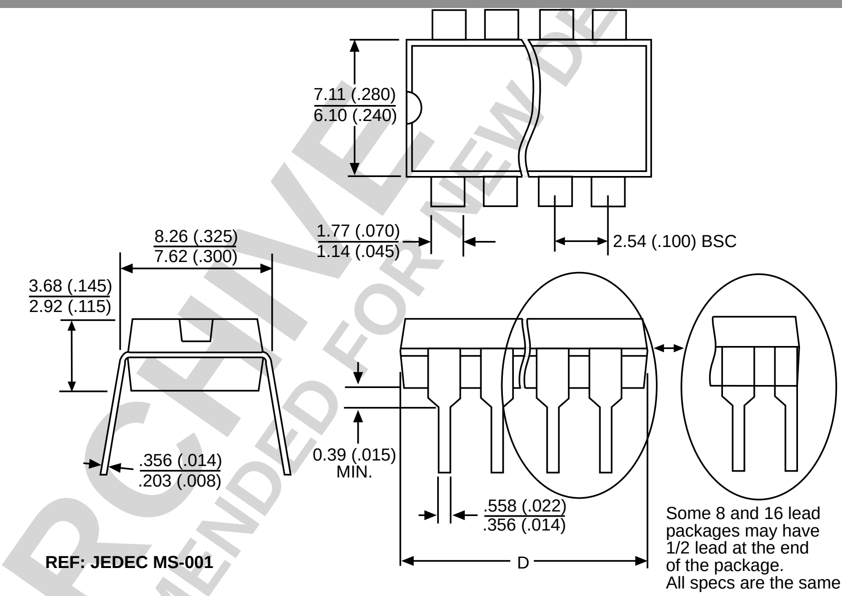
| Lead Count | D | | | |
|---|---|---|---|---|
| | Metric | | English | |
| | Max | Min | Max | Min |
| 14L PDIP | 19.69 | 18.67 | .775 | .735 |
| 20L SO Wide | 13.00 | 12.60 | .512 | .496 |

### PACKAGE THERMAL DATA

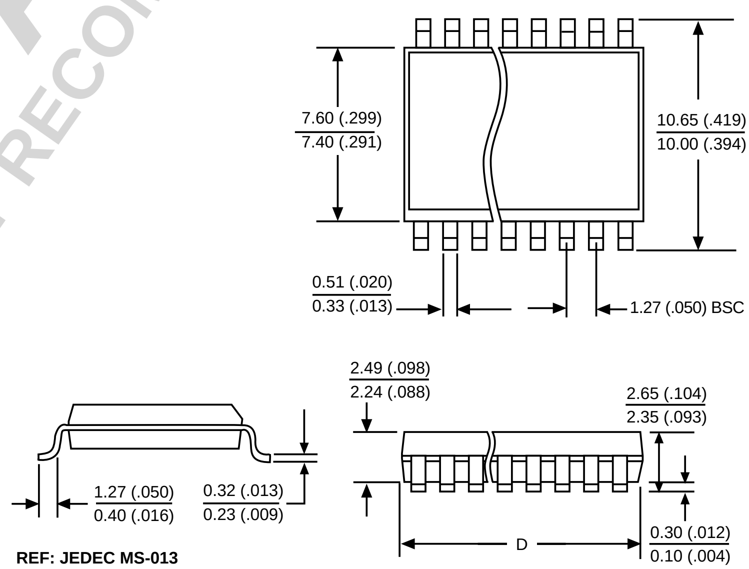
| Thermal Data | | 14L PDIP | 20L SOIC | |
|---|---|---|---|---|
| $R_{\Theta JC}$ | typ | 48 | 17 | °C / W |
| $R_{\Theta JA}$ | typ | 85 | 90 | °C / W |



### Plastic DIP (N); 300 mil wide




### 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 |

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# Notes

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