

# CAT5127, CAT5129

## 32-Tap Digitally Programmable Potentiometer (DPP™)

### Description

The CAT5127/CAT5129 are single digitally programmable potentiometers (DPP™) designed as an electronic replacement for mechanical potentiometers and trim pots. Ideal for automated adjustments on high volume production lines, they are also well suited for applications where equipment requiring periodic adjustment is either difficult to access or located in a hazardous or remote environment.

The CAT5127 contains a 32-tap series resistor array connected between two terminals  $R_H$  and  $R_L$ . The CAT5129 contains a 32-tap series resistor array connected between two terminals  $R_H$  and GND. An up/down counter and decoder that are controlled by three input pins, determines which tap is connected to the wiper. The wiper setting, stored in nonvolatile memory, is not lost when the device is powered down and is automatically reinstated when power is returned. The wiper can be adjusted to test new system values without effecting the stored setting. Wiper-control of the CAT5127/CAT5129 is accomplished with three input control pins,  $\overline{CS}$ ,  $U/\overline{D}$ , and  $\overline{INC}$ . The  $\overline{INC}$  input increments the wiper in the direction which is determined by the logic state of the  $U/\overline{D}$  input. The  $\overline{CS}$  input is used to select the device and also store the wiper position prior to power down.

The devices are used as two-terminal variable resistors. DPPs bring variability and programmability to a wide variety of applications including control, parameter adjustments, and signal processing.

### Features

- 32-position Linear Taper Potentiometer
- Non-volatile EEPROM Wiper Storage
- Low Standby Current
- Single Supply Operation: 2.5 V – 5.5 V
- Increment Up/Down Serial Interface
- Resistance Values: 10 k $\Omega$ , 50 k $\Omega$  and 100 k $\Omega$
- CAT5127 in MSOP Packages
- CAT5129 in the 6-lead TSOT23 Package
- This Device is Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

### Applications

- Automated Product Calibration
- Remote Control Adjustments
- Offset, Gain and Zero Control
- Tamper-proof Calibrations
- Contrast, Brightness and Volume Controls
- Motor Controls and Feedback Systems
- Programmable Analog Functions



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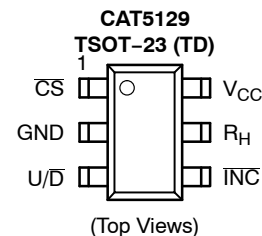
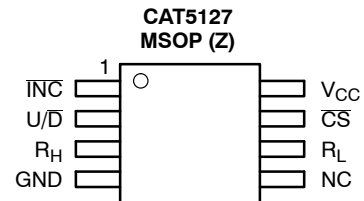


MSOP-8  
Z SUFFIX  
CASE 846AD



TSOT-23  
TD SUFFIX  
CASE 419AF

### PIN CONFIGURATIONS



### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 10 of this data sheet.

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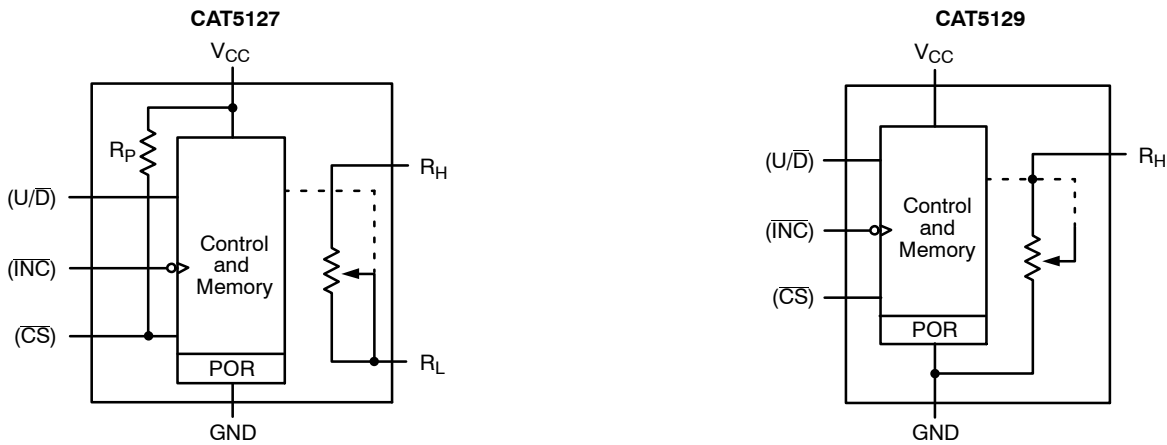


Figure 1. Functional Diagrams

Table 1. PIN DESCRIPTIONS

| Name            | Function                    | CAT5127<br>MSOP/TDFN | CAT5129<br>SOT23 |
|-----------------|-----------------------------|----------------------|------------------|
| INC             | Increment Control           | 1                    | 4                |
| U/D             | Up/Down Control             | 2                    | 3                |
| R <sub>H</sub>  | Potentiometer High Terminal | 3                    | 5                |
| GND             | Ground                      | 4                    | 2                |
| NC              | No Connect                  | 5                    | –                |
| R <sub>L</sub>  | Potentiometer Low Terminal  | 6                    | –                |
| CS              | Chip Select                 | 7                    | 1                |
| V <sub>CC</sub> | Supply Voltage              | 8                    | 6                |

## Device Description

### INC: Increment Control Input

The INC input moves the wiper in the up or down direction determined by the condition of the U/D input.

### U/D: Up/Down Control Input

The U/D input controls the direction of the wiper movement. When in a high state and CS is low, any high-to-low transition on INC will cause the wiper to move one increment toward the R<sub>H</sub> terminal. When in a low state and CS is low, any high-to-low transition on INC will cause the wiper to move one increment towards the R<sub>L</sub> terminal.

### R<sub>H</sub>: High End Potentiometer Terminal

R<sub>H</sub> is the high end terminal of the potentiometer. It is not required that this terminal be connected to a potential greater than the R<sub>L</sub> terminal. Voltage applied to the R<sub>H</sub> terminal cannot exceed the supply voltage, V<sub>CC</sub> or go below ground, GND.

### R<sub>L</sub>: Low End Potentiometer Terminal (CAT5127 only)

R<sub>L</sub> is the low end terminal of the potentiometer. It is not required that this terminal be connected to a potential less than the R<sub>H</sub> terminal. Voltage applied to the R<sub>L</sub> terminal cannot exceed the supply voltage, V<sub>CC</sub> or go below ground, GND. R<sub>L</sub> and R<sub>H</sub> are electrically interchangeable.

### CS: Chip Select

The chip select input is used to activate the control input of the device and is active low. When in a high state, activity on the INC and U/D inputs will not affect or change the position of the wiper. CAT5127 has an internal pull-up resistor on the CS input pin.

### V<sub>CC</sub>: Supply Input for the device.

## Device Operation

The CAT5127 operates like a digitally controlled variable resistor with  $R_H$  and  $R_L$  equivalent to the high and low terminals. There are 32 available tap positions including the resistor end points,  $R_H$  and  $R_L$ . There are 31 resistor elements connected in series between the  $R_H$  and  $R_L$  terminals.

The CAT5129 operates like a digitally controlled variable resistor with  $R_H$  equivalent to the high terminal. There are 32 available tap positions including the resistor end points,  $R_H$  and GND. There are 31 resistor elements connected in series between the  $R_H$  and GND terminals.

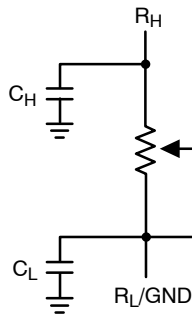
Operation is controlled by three inputs,  $\overline{INC}$ ,  $U/\overline{D}$  and  $\overline{CS}$ . These inputs control a five-bit up/down counter whose output is decoded to select the wiper position. The selected wiper position can be stored in nonvolatile memory using the  $\overline{INC}$  and  $\overline{CS}$  inputs.

With  $\overline{CS}$  set LOW, the device is selected and will respond to the  $U/\overline{D}$  and  $\overline{INC}$  inputs. HIGH to LOW transitions on  $\overline{INC}$  will increment or decrement the wiper (depending on the state of the  $U/\overline{D}$  input and five-bit counter). The wiper, when at either end terminal, acts like its mechanical equivalent and does not move beyond the last position. The value of the counter is stored in nonvolatile memory whenever  $\overline{CS}$  transitions HIGH while the  $\overline{INC}$  input is also HIGH. When the device is powered-down, the last stored wiper counter position is maintained in the nonvolatile memory. When power is restored, the contents of the memory are recalled and the counter is set to the value stored.

With  $\overline{INC}$  set low, the device may be de-selected and powered down without storing the current wiper position in nonvolatile memory. This allows the system to always power up to a preset value stored in nonvolatile memory.

**Table 2. OPERATION MODES**

| INC         | CS          | U/D  | Operation                   |
|-------------|-------------|------|-----------------------------|
| High to Low | Low         | High | Wiper toward H              |
| High to Low | Low         | Low  | Wiper toward L/GND          |
| High        | Low to High | X    | Store Wiper Position        |
| Low         | Low to High | X    | No Store, Return to Standby |
| X           | High        | X    | Standby                     |



**Figure 2. Variable Resistor Equivalent Circuit**

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**Table 3. ABSOLUTE MAXIMUM RATINGS**

| Parameters   | Ratings  | Units |
|--|--|-------|
| Supply Voltage<br>$V_{CC}$ to GND  | -0.5 to +7   | V     |
| Inputs<br>CS to GND<br>INC to GND<br>U/D to GND<br>H to GND<br>L to GND<br>W to GND          | -0.5 to $V_{CC} + 0.5$<br>-0.5 to $V_{CC} + 0.5$<br>-0.5 to $V_{CC} + 0.5$<br>-0.5 to $V_{CC} + 0.5$<br>-0.5 to $V_{CC} + 0.5$<br>-0.5 to $V_{CC} + 0.5$ | V     |
| Operating Ambient Temperature<br>Commercial ('C' or Blank suffix)<br>Industrial ('I' suffix) | 0 to 70<br>-40 to +85  | °C    |
| Junction Temperature   | +150   | °C    |
| Storage Temperature  | -65 to 150   | °C    |
| Lead Soldering (10 s max)  | +300   | °C    |

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

**Table 4. RELIABILITY CHARACTERISTICS**

| Symbol                 | Parameter          | Test Method                   | Min       | Typ | Max | Units  |
|------------------------|--------------------|-------------------------------|-----------|-----|-----|--------|
| $V_{ZAP}$ (Note 1)     | ESD Susceptibility | MIL-STD-883, Test Method 3015 | 2000      |     |     | V      |
| $I_{LTH}$ (Notes 1, 2) | Latch-Up           | JEDEC Standard 17             | 100       |     |     | mA     |
| $T_{DR}$               | Data Retention     | MIL-STD-883, Test Method 1008 | 100       |     |     | Years  |
| $N_{END}$              | Endurance          | MIL-STD-883, Test Method 1003 | 1,000,000 |     |     | Stores |

1. This parameter is tested initially and after a design or process change that affects the parameter.
2. Latch-up protection is provided for stresses up to 100 mA on address and data pins from -1 V to  $V_{CC} + 1$  V
3. These parameters are periodically sampled and are not 100% tested.

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**Table 5. DC ELECTRICAL CHARACTERISTICS** ( $V_{CC} = +2.5\text{ V}$  to  $+5.5\text{ V}$  unless otherwise specified)

| Symbol                | Parameter                             | Conditions   | Min | Typ  | Max | Units         |
|-----------------------|---------------------------------------|--|-----|------|-----|---------------|
| <b>POWER SUPPLY</b>   |                                       |  |     |      |     |               |
| $V_{CC}$              | Operating Voltage Range               |  | 2.5 |      | 5.5 | V             |
| $I_{CC1}$             | CAT5127<br>Supply Current (Increment) | $V_{CC} = 5.5\text{ V}$ , $f = 1\text{ MHz}$ , $I_W = 0$                                       |     |      | 260 | $\mu\text{A}$ |
|                       |                                       | $V_{CC} = 3.3\text{ V}$ , $f = 1\text{ MHz}$ , $I_W = 0$                                       |     |      | 150 | $\mu\text{A}$ |
|                       | CAT5129<br>Supply Current (Increment) | $V_{CC} = 5.5\text{ V}$ , $f = 1\text{ MHz}$ , $I_W = 0$                                       |     |      | 160 | $\mu\text{A}$ |
|                       |                                       | $V_{CC} = 3.3\text{ V}$ , $f = 1\text{ MHz}$ , $I_W = 0$                                       |     |      | 50  | $\mu\text{A}$ |
| $I_{CC2}$             | Supply Current (Write)                | Programming, $V_{CC} = 5.5\text{ V}$   |     | 300  | 600 | $\mu\text{A}$ |
|                       |                                       | Programming, $V_{CC} = 3.3\text{ V}$   |     | 150  | 400 | $\mu\text{A}$ |
| $I_{SB1}$<br>(Note 4) | Supply Current (Standby)              | $\overline{CS} = V_{CC} - 0.3\text{ V}$<br>$U/\overline{D}$ , $\overline{INC} = V_{CC}$ or GND |     | 0.35 | 1   | $\mu\text{A}$ |

## LOGIC INPUTS

|           |                                      |  |                     |  |                     |               |
|-----------|--------------------------------------|--|---------------------|--|---------------------|---------------|
| $I_{IH}$  | CAT5127 Input Leakage Current        | $U/\overline{D}$ , $\overline{INC} = V_{CC}$ |                     |  | 1                   | $\mu\text{A}$ |
|           |                                      | $\overline{CS} = V_{CC} - 0.3\text{ V}$      |                     |  | 1                   | $\mu\text{A}$ |
|           | CAT5129 Input Leakage Current        | $V_{IN} = V_{CC}$                            |                     |  | 1                   | $\mu\text{A}$ |
| $I_{IL}$  | CAT5127 Input Leakage Current        | $U/\overline{D}$ , $\overline{INC} = 0$      |                     |  | -1                  | $\mu\text{A}$ |
|           |                                      | $\overline{CS} = 0$                          |                     |  | -120                | $\mu\text{A}$ |
|           | CAT5129 Input Leakage Current        | $V_{IN} = 0\text{ V}$                        |                     |  | -1                  | $\mu\text{A}$ |
| $V_{IH2}$ | CMOS High Level Input Voltage        | $2.5\text{ V} \leq V_{CC} \leq 5.5\text{ V}$ | $V_{CC} \times 0.7$ |  | $V_{CC} + 0.3$      | V             |
| $V_{IL2}$ | CMOS Low Level Input Voltage         |  | -0.3                |  | $V_{CC} \times 0.2$ | V             |
| $V_{IH1}$ | CAT5129 TTL High Level Input Voltage | $3.6\text{ V} \leq V_{CC} \leq 5.5\text{ V}$ | 2                   |  | $V_{CC}$            | V             |
| $V_{IL1}$ | CAT5129 TTL Low Level Input Voltage  |  | 0                   |  | 0.8                 | V             |

**Table 6. POTENTIOMETER CHARACTERISTICS**

| Symbol                 | Parameter                    | Conditions                       | Min | Typ      | Max       | Units                   |
|------------------------|------------------------------|----------------------------------|-----|----------|-----------|-------------------------|
| $R_{POT}$              | Potentiometer Resistance     | -10 Device                       |     | 10       |           | $k\Omega$               |
|                        |                              | -50 Device                       |     | 50       |           |                         |
|                        |                              | -00 Device                       |     | 100      |           |                         |
| $R_{TOL}$              | Pot Resistance Tolerance     |                                  |     |          | $\pm 20$  | %                       |
| $V_{RH}$               | Voltage on $R_H$ pin         |                                  | 0   |          | $V_{CC}$  | V                       |
| $V_{RL}$               | Voltage on $R_L$ pin         |                                  | 0   |          | $V_{CC}$  | V                       |
| RES                    | Resolution                   |                                  |     | 3.2      |           | %                       |
| INL                    | Integral Linearity Error     |                                  |     | 0.5      | 1         | LSB                     |
| DNL                    | Differential Linearity Error |                                  |     | 0.25     | 0.5       | LSB                     |
| $R_{Wi}$               | Wiper Resistance             | $V_{CC} = 5\text{ V}$            |     | 70       | 100       | $\Omega$                |
|                        |                              | $V_{CC} = 2.5\text{ V}$          |     | 150      | 200       | $\Omega$                |
| $TC_{RPOT}$ (Note 6)   | TC of Pot Resistance         |                                  |     | $\pm 30$ | $\pm 300$ | ppm/ $^{\circ}\text{C}$ |
| $TC_{RATIO}$ (Note 6)  | Ratiometric TC               |                                  |     | $\pm 3$  | 20        | ppm/ $^{\circ}\text{C}$ |
| $V_N$ (Note 6)         | Noise                        | 100 kHz / 1 kHz                  |     | 8/24     |           | nV/ $\sqrt{\text{Hz}}$  |
| $C_H/C_L/C_W$ (Note 6) | Potentiometer Capacitances   |                                  |     | 8/8/25   |           | pF                      |
| $F_c$ (Note 6)         | Frequency Response           | Passive Attenuator, 10 $k\Omega$ |     | 1.7      |           | MHz                     |

4. Latch-up protection is provided for stresses up to 100 mA on address and data pins from -1 V to  $V_{CC} + 1\text{ V}$

5.  $I_W$  = source or sink

6. These parameters are periodically sampled and are not 100% tested.

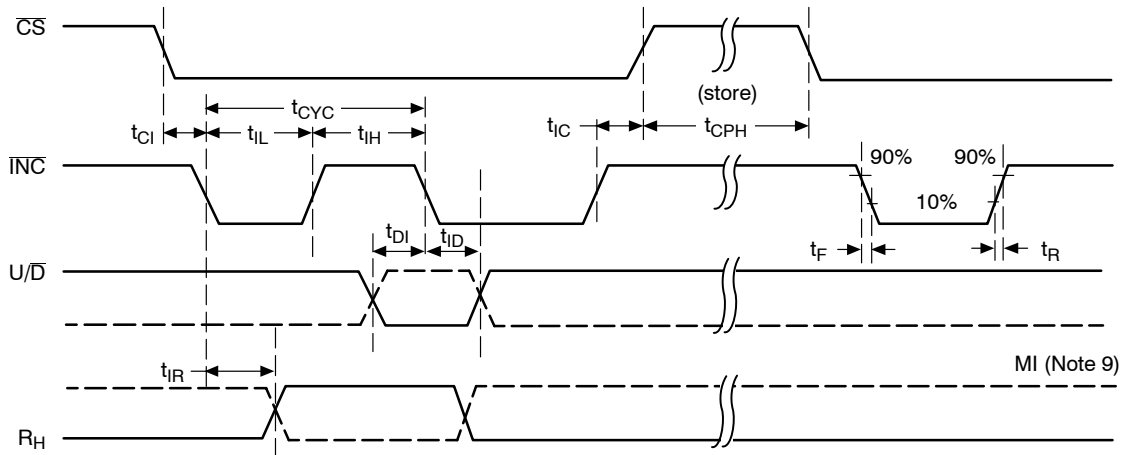
# CAT5127, CAT5129

**Table 7. AC TEST CONDITIONS**

|                           |  |
|---------------------------|--|
| $V_{CC}$ Range            | $2.5\text{ V} \leq V_{CC} \leq 5.5\text{ V}$ |
| Input Pulse Levels        | $0.2 \times V_{CC}$ to $0.7 \times V_{CC}$   |
| Input Rise and Fall Times | 10 ns  |
| Input Reference Levels    | $0.5 \times V_{CC}$                          |

**Table 8. AC OPERATING CHARACTERISTICS** ( $V_{CC} = +2.5\text{ V}$  to  $+5.5\text{ V}$ ,  $V_H = V_{CC}$ ,  $V_L = 0\text{ V}$ , unless otherwise specified)

| Symbol              | Parameter   | Min | Typ (Note 7) | Max | Units         |
|---------------------|---|-----|--------------|-----|---------------|
| $t_{CI}$            | $\overline{CS}$ to $\overline{INC}$ Setup             | 100 |              |     | ns            |
| $t_{DI}$            | $U/\overline{D}$ to $\overline{INC}$ Setup            | 50  |              |     | ns            |
| $t_{ID}$            | $U/\overline{D}$ to $\overline{INC}$ Hold             | 100 |              |     | ns            |
| $t_{iL}$            | $\overline{INC}$ LOW Period                           | 250 |              |     | ns            |
| $t_{iH}$            | $\overline{INC}$ HIGH Period                          | 250 |              |     | ns            |
| $t_{iC}$            | $\overline{INC}$ Inactive to $\overline{CS}$ Inactive | 1   |              |     | $\mu\text{s}$ |
| $t_{CPH}$           | $\overline{CS}$ Deselect Time (NO STORE)              | 100 |              |     | ns            |
| $t_{CPH}$           | $\overline{CS}$ Deselect Time (STORE)                 | 10  |              |     | ms            |
| $t_{iR}$            | $\overline{INC}$ to $R_H$ Change                      |     | 1            | 5   | $\mu\text{s}$ |
| $t_{CYC}$           | $\overline{INC}$ Cycle Time                           | 1   |              |     | $\mu\text{s}$ |
| $t_R, t_F$ (Note 8) | $\overline{INC}$ Input Rise and Fall Time             |     |              | 500 | $\mu\text{s}$ |
| $t_{PU}$ (Note 8)   | Power-up to Wiper Stable                              |     |              | 1   | ms            |
| $t_{WR}$            | Store Cycle   |     | 2            | 5   | ms            |



**Figure 3. A.C. Timing**

7. Typical values are for  $T_A = 25^\circ\text{C}$  and nominal supply voltage.

8. This parameter is periodically sampled and not 100% tested.

9. MI in the A.C. Timing diagram refers to the minimum incremental change in the W output due to a change in the wiper position.

## Application Information

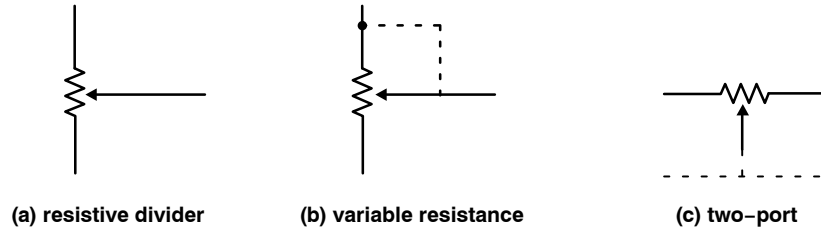


Figure 4. Potentiometer Configurations

## Applications

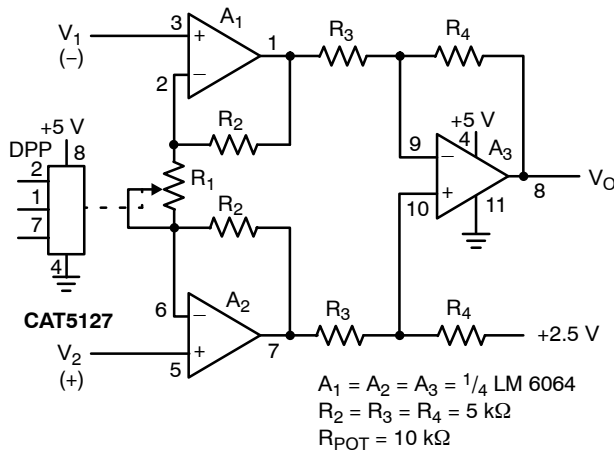


Figure 5. Programmable Instrumentation Amplifier

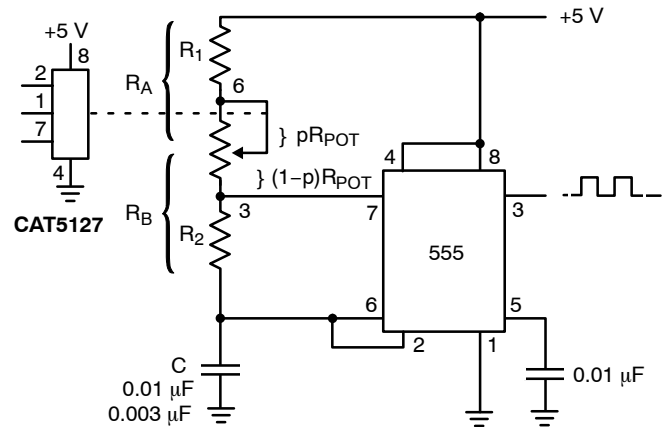


Figure 6. Programmable Sq. Wave Oscillator (555)

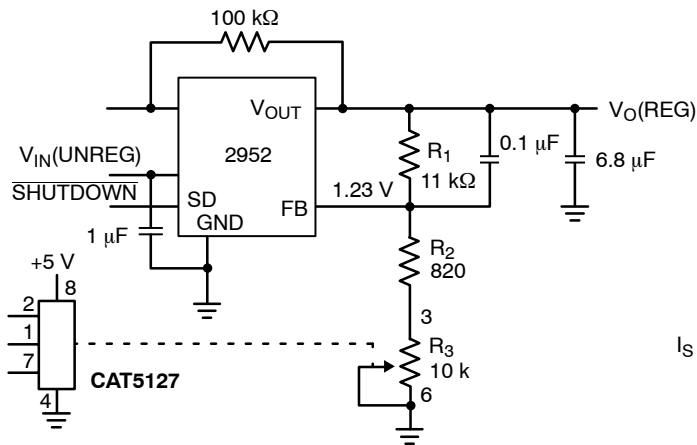


Figure 7. Programmable Voltage Regulator

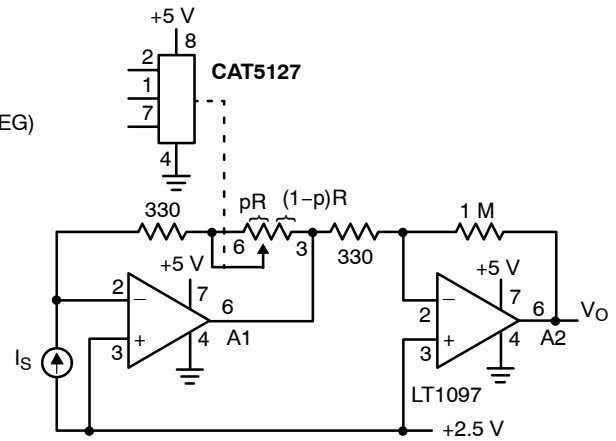
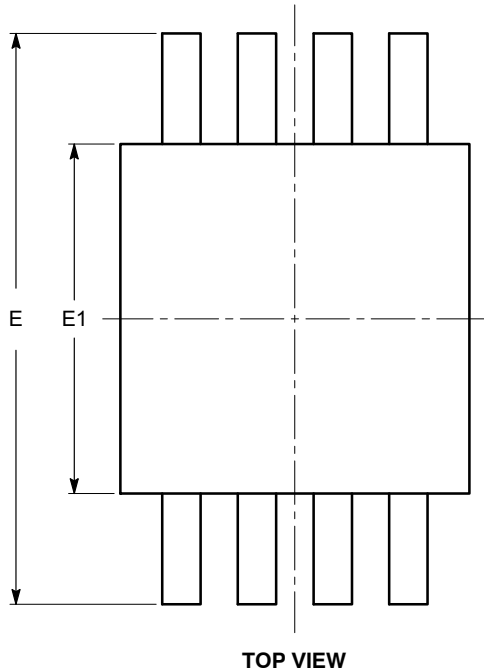


Figure 8. Programmable I to V Converter

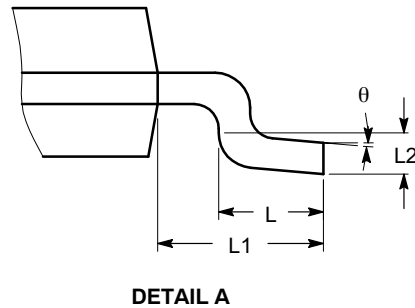
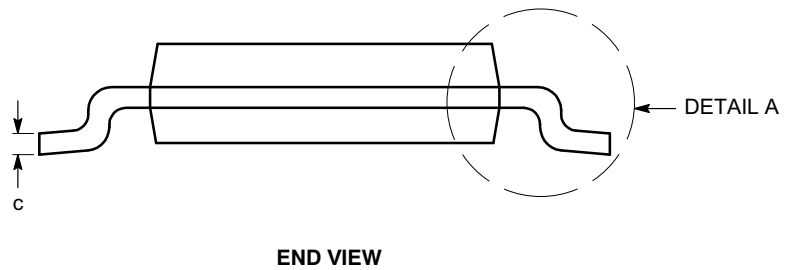
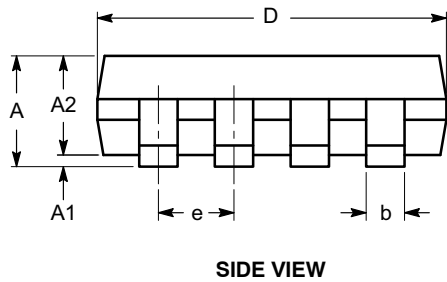
# CAT5127, CAT5129

## PACKAGE DIMENSIONS

MSOP 8, 3x3  
CASE 846AD-01  
ISSUE O



| SYMBOL   | MIN      | NOM  | MAX  |
|----------|----------|------|------|
| A        |          |      | 1.10 |
| A1       | 0.05     | 0.10 | 0.15 |
| A2       | 0.75     | 0.85 | 0.95 |
| b        | 0.22     |      | 0.38 |
| c        | 0.13     |      | 0.23 |
| D        | 2.90     | 3.00 | 3.10 |
| E        | 4.80     | 4.90 | 5.00 |
| E1       | 2.90     | 3.00 | 3.10 |
| e        | 0.65 BSC |      |      |
| L        | 0.40     | 0.60 | 0.80 |
| L1       | 0.95 REF |      |      |
| L2       | 0.25 BSC |      |      |
| $\theta$ | 0°       |      | 6°   |



### Notes:

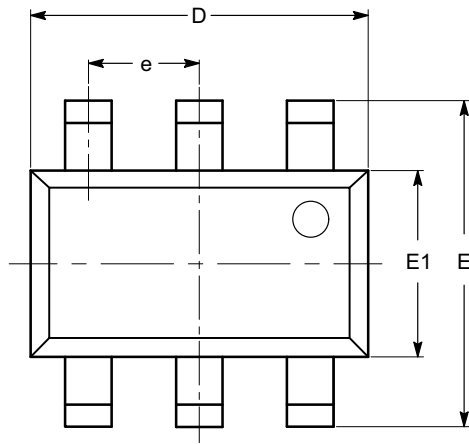
- (1) All dimensions are in millimeters. Angles in degrees.
- (2) Complies with JEDEC MO-187.



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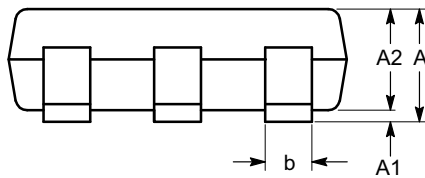
## PACKAGE DIMENSIONS

TSOT-23, 6 LEAD  
CASE 419AF-01  
ISSUE O

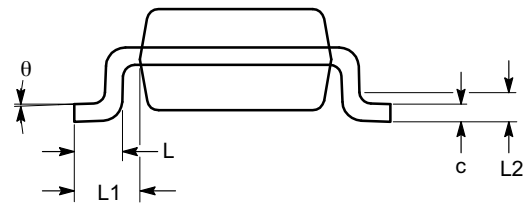


TOP VIEW

| SYMBOL   | MIN      | NOM  | MAX  |
|----------|----------|------|------|
| A        |          |      | 1.00 |
| A1       | 0.01     | 0.05 | 0.10 |
| A2       | 0.80     | 0.87 | 0.90 |
| b        | 0.30     |      | 0.45 |
| c        | 0.12     | 0.15 | 0.20 |
| D        | 2.90 BSC |      |      |
| E        | 2.80 BSC |      |      |
| E1       | 1.60 BSC |      |      |
| e        | 0.95 TYP |      |      |
| L        | 0.30     | 0.40 | 0.50 |
| L1       | 0.60 REF |      |      |
| L2       | 0.25 BSC |      |      |
| $\theta$ | 0°       |      | 8°   |



SIDE VIEW



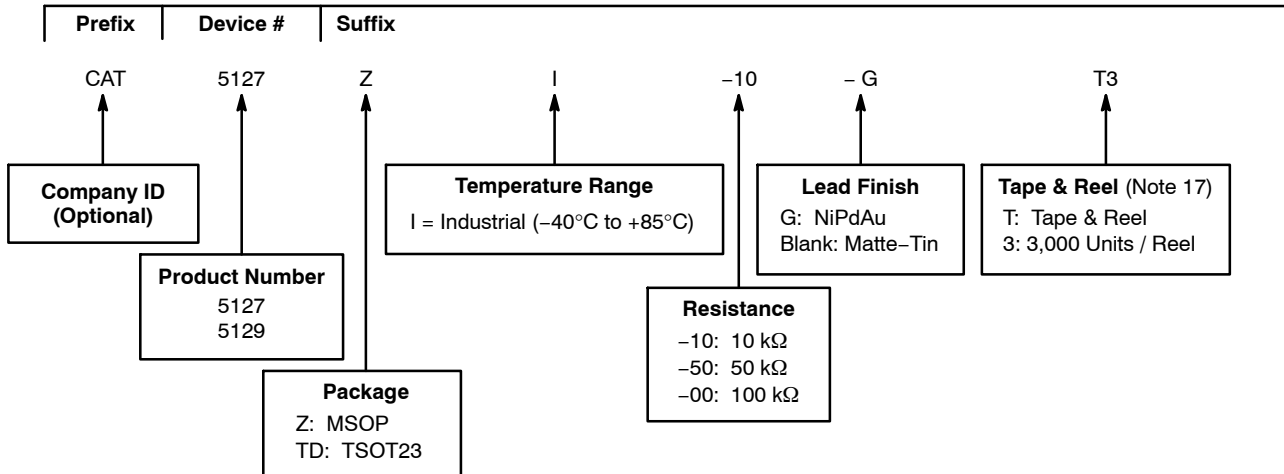
END VIEW

### Notes:

- (1) All dimensions are in millimeters. Angles in degrees.
- (2) Complies with JEDEC MO-193.

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## Example of Ordering Information (Note 13)



**Table 9. ORDERING INFORMATION**

| Device  | Orderable Part Number           | Resistor [kΩ] | Top Marking    | Pin/Package | Part Per Reel |
|---------|---------------------------------|---------------|----------------|-------------|---------------|
| CAT5127 | CAT5127ZI-10-T3                 | 10            | ABPU           | MSOP-8      | 3000          |
|         | CAT5127ZI-50-T3 (Note 15)       | 50            | ABPV           | MSOP-8      | 3000          |
|         | CAT5127ZI-00-T3 (Note 15)       | 100           | ABPY           | MSOP-8      | 3000          |
|         | CAT5127ZI-10-GT3                | 10            | ABNA           | MSOP-8      | 3000          |
|         | CAT5127ZI-50-GT3 (Note 15)      | 50            | ABNB           | MSOP-8      | 3000          |
|         | CAT5127ZI-00-GT3 (Note 15)      | 100           | ABNK           | MSOP-8      | 3000          |
| Device  | Orderable Part Number           | Resistor [kΩ] | Top Marking    | Pin/Package | Part Per Reel |
| CAT5129 | CAT5129TDI-10-T3                | 10            | SWym (Note 16) | TSOT23-6    | 3000          |
|         | CAT5129TDI-50-T3 (Note 15)      | 50            | SXym (Note 16) | TSOT23-6    | 3000          |
|         | CAT5129TDI-00-T3 (Note 15)      | 100           | SYym (Note 16) | TSOT23-6    | 3000          |
|         | CAT5129TDI-10GT3 (Note 10)      | 10            | SJym (Note 16) | TSOT23-6    | 3000          |
|         | CAT5129TDI-50GT3 (Notes 10, 15) | 50            | SUym (Note 16) | TSOT23-6    | 3000          |
|         | CAT5129TDI-00GT3 (Notes 10, 15) | 100           | SVym (Note 16) | TSOT23-6    | 3000          |

10. Part number is not exactly the same as the "Example of Ordering Information" shown above. For the indicated part numbers there is only one hyphen in the orderable part number, which is placed before the "Resistance".

11. All packages are RoHS-compliant (Lead-free, Halogen-free).

12. The standard lead finish is NiPdAu.

13. The device used in the above example is a CAT5127ZI-10-GT3 (MSOP, Industrial Temperature range, 10 kΩ, NiPdAu, Tape & Reel, 3,000 Units/Reel).


14. For additional package and temperature options, please contact your nearest ON Semiconductor Sales office.

15. Contact factory for availability.

16. y = Production year (digit), m = Production month (digit).

17. For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

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