

CAT5111

100-Tap Digitally Programmable Potentiometer (DPP™) with Buffered Wiper

Description

The CAT5111 is a single digitally programmable potentiometer (DPP™) designed as an electronic replacement for mechanical potentiometers. 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 CAT5111 contains a 100-tap series resistor array connected between two terminals R_H and R_L . An up/down counter and decoder that are controlled by three input pins, determines which tap is connected to the wiper, R_{WB} . The CAT5111 wiper is buffered by an op amp that operates rail to rail. The wiper setting, stored in non-volatile memory, is not lost when the device is powered down and is automatically recalled when power is returned. The wiper can be adjusted to test new system values without effecting the stored setting. Wiper-control of the CAT5111 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 digitally programmable potentiometer can be used as a buffered voltage divider. For applications where the potentiometer is used as a 2-terminal variable resistor, please refer to the CAT5113. The buffered wiper of the CAT5111 is not compatible with that application.

Features

- 100-position Linear Taper Potentiometer
- Non-volatile EEPROM Wiper Storage; Buffered Wiper
- Low Power CMOS Technology
- Single Supply Operation: 2.5 V – 6.0 V
- Increment Up/Down Serial Interface
- Resistance Values: 10 k Ω , 50 k Ω and 100 k Ω
- Available in PDIP, SOIC, TSSOP and MSOP Packages
- These Devices are 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



ON Semiconductor®

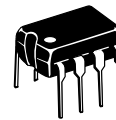
<http://onsemi.com>



SOIC-8
V SUFFIX
CASE 751BD



MSOP-8
Z SUFFIX
CASE 846AD

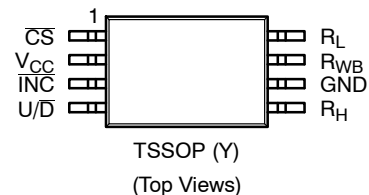
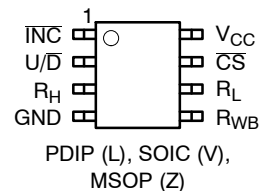


PDIP-8
L SUFFIX
CASE 646AA



TSSOP-8
Y SUFFIX
CASE 948AL

PIN CONFIGURATIONS



PIN FUNCTION

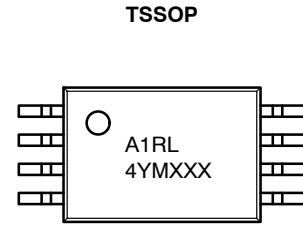
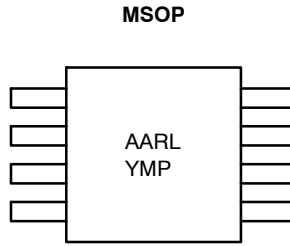
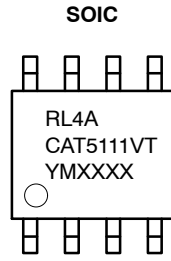
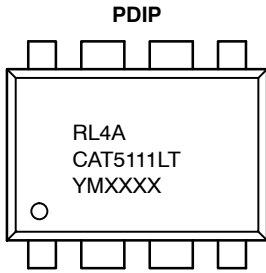
| Pin Name | Function |
|------------------|-----------------------------|
| \overline{INC} | Increment Control |
| U/\overline{D} | Up/Down Control |
| R_H | Potentiometer High Terminal |
| GND | Ground |
| R_{WB} | Buffered Wiper Terminal |
| R_L | Potentiometer Low Terminal |
| \overline{CS} | Chip Select |
| V_{CC} | Supply Voltage |

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 13 of this data sheet.

CAT5111

DEVICE MARKING INFORMATION



R = Resistance:
 2 = 10 kΩ
 4 = 50 kΩ
 5 = 100 kΩ
 L = Assembly Location
 4 = Lead Finish – NiPdAu
 A = Product Revision (Fixed as "A")
 CAT5111L = Device Code (PDIP)
 CAT5111V = Device Code (SOIC)
 T = Temperature Range (Industrial)
 Y = Production Year (Last Digit)
 M = Production Month (1–9, A, B, C)
 XXXX = Last Four Digits of Assembly Lot Number

AARL = CAT5111ZI–10–T3
 AAPX = CAT5111ZI–50–T3
 AAPX = CAT5111ZI–00–T3
 Y = Production Year (Last Digit)
 M = Production Month (1–9, A, B, C)
 P = Product Revision

A1 = Device Code
 R = Resistance:
 2 = 10 kΩ
 4 = 50 kΩ
 5 = 100 kΩ
 L = Assembly Location
 4 = Lead Finish – NiPdAu
 Y = Production Year (Last Digit)
 M = Production Month (1–9, A, B, C)
 XXX = Last Three Digits of Assembly Lot Number

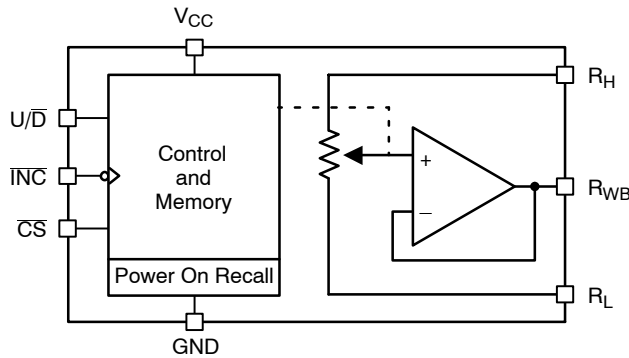


Figure 1. Functional Diagram

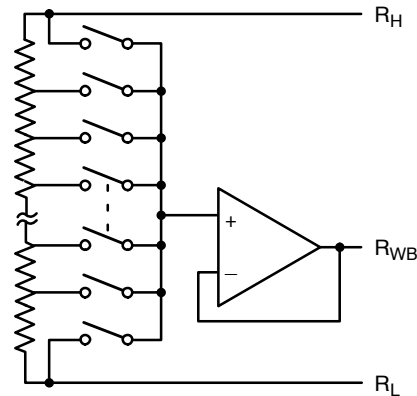


Figure 2. Electronic Potentiometer Implementation

Pin Description

$\overline{\text{INC}}$: Increment Control Input

The $\overline{\text{INC}}$ input (on the falling edge) moves the wiper in the up or down direction determined by the condition of the $\text{U}/\overline{\text{D}}$ input.

$\text{U}/\overline{\text{D}}$: Up/Down Control Input

The $\text{U}/\overline{\text{D}}$ input controls the direction of the wiper movement. When in a high state and $\overline{\text{CS}}$ is low, any high-to-low transition on $\overline{\text{INC}}$ will cause the wiper to move one increment toward the R_H terminal. When in a low state and $\overline{\text{CS}}$ is low, any high-to-low transition on $\overline{\text{INC}}$ will cause the wiper to move one increment towards the R_L terminal.

R_H : High End Potentiometer Terminal

R_H is the high end terminal of the potentiometer. It is not required that this terminal be connected to a potential greater than the R_L terminal. Voltage applied to the R_H terminal cannot exceed the supply voltage, V_{CC} or go below ground, GND.

R_WB : Wiper Potentiometer Terminal (Buffered)

R_WB is the buffered wiper terminal of the potentiometer. Its position on the resistor array is controlled by the control inputs, $\overline{\text{INC}}$, $\text{U}/\overline{\text{D}}$ and $\overline{\text{CS}}$.

R_L : Low End Potentiometer Terminal

R_L is the low end terminal of the potentiometer. It is not required that this terminal be connected to a potential less than the R_H terminal. Voltage applied to the R_L terminal cannot exceed the supply voltage, V_{CC} or go below ground, GND. R_L and R_H are electrically interchangeable.

$\overline{\text{CS}}$: Chip Select

The chip select input is used to activate the control input of the CAT5111 and is active low. When in a high state, activity on the $\overline{\text{INC}}$ and $\text{U}/\overline{\text{D}}$ inputs will not affect or change the position of the wiper.

Device Operation

The CAT5111 operates like a digitally controlled potentiometer with R_H and R_L equivalent to the high and low terminals and R_WB equivalent to the mechanical potentiometer's wiper. There are 100 available tap positions including the resistor end points, R_H and R_L . There are 99 resistor elements connected in series between the R_H and R_L terminals. The wiper terminal is connected to one of the 100 taps and controlled by three inputs, $\overline{\text{INC}}$, $\text{U}/\overline{\text{D}}$ and $\overline{\text{CS}}$. These inputs control a seven-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 $\overline{\text{INC}}$ and $\overline{\text{CS}}$ inputs.

With $\overline{\text{CS}}$ set LOW the CAT5111 is selected and will respond to the $\text{U}/\overline{\text{D}}$ and $\overline{\text{INC}}$ inputs. HIGH to LOW transitions on $\overline{\text{INC}}$ will increment or decrement the wiper (depending on the state of the $\text{U}/\overline{\text{D}}$ input and seven-bit counter). The wiper, when at either fixed 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 $\overline{\text{CS}}$ transitions HIGH while the $\overline{\text{INC}}$ input is also HIGH. When the CAT5111 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 $\overline{\text{INC}}$ set low, the CAT5111 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.

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Table 1. OPERATION MODES

| INC | CS | U/D | Operation |
|-------------|-------------|------|-----------------------------|
| High to Low | Low | High | Wiper toward R _H |
| High to Low | Low | Low | Wiper toward R _L |
| High | Low to High | X | Store Wiper Position |
| Low | Low to High | X | No Store, Return to Standby |
| X | High | X | Standby |

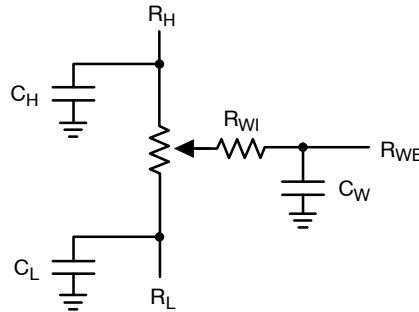


Figure 3. Potentiometer Equivalent Circuit

Table 2. ABSOLUTE MAXIMUM RATINGS

| Parameters | Ratings | Units |
|-------------------------------------------------------------------|-------------------------------|-------|
| Supply Voltage V _{CC} to GND | -0.5 to +7 | V |
| Inputs CS to GND | -0.5 to V _{CC} + 0.5 | V |
| INC to GND | -0.5 to V _{CC} + 0.5 | V |
| U/D to GND | -0.5 to V _{CC} + 0.5 | V |
| R _H to GND | -0.5 to V _{CC} + 0.5 | V |
| R _L to GND | -0.5 to V _{CC} + 0.5 | V |
| R _{WB} to GND | -0.5 to V _{CC} + 0.5 | V |
| Operating Ambient Temperature Commercial ('C' or Blank suffix) | 0 to 70 | °C |
| Industrial ('I' suffix) | -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 3. 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

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Table 4. DC ELECTRICAL CHARACTERISTICS ($V_{CC} = +2.5\text{ V}$ to $+6\text{ V}$ unless otherwise specified)

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|--------------------------------------|-------------------------------|---------------------------------------------------------------------------------------------------------------|---------------------|--------|---------------------|-------------------------|
| POWER SUPPLY | | | | | | |
| V_{CC} | Operating Voltage Range | | 2.5 | – | 6 | V |
| I_{CC1} | Supply Current (Increment) | $V_{CC} = 6\text{ V}$, $f = 1\text{ MHz}$, $I_W = 0$ | – | – | 200 | μA |
| | | $V_{CC} = 6\text{ V}$, $f = 250\text{ kHz}$, $I_W = 0$ | – | – | 100 | μA |
| I_{CC2} | Supply Current (Write) | Programming, $V_{CC} = 6\text{ V}$ | – | – | 1000 | μA |
| | | $V_{CC} = 3\text{ V}$ | – | – | 500 | μA |
| I_{SB1} (Note 4) | Supply Current (Standby) | $\overline{CS} = V_{CC} - 0.3\text{ V}$ U/\overline{D} , $\overline{INC} = V_{CC} - 0.3\text{ V}$ or GND | – | 75 | 150 | μA |
| LOGIC INPUTS | | | | | | |
| I_{IH} | Input Leakage Current | $V_{IN} = V_{CC}$ | – | – | 10 | μA |
| I_{IL} | Input Leakage Current | $V_{IN} = 0\text{ V}$ | – | – | –10 | μA |
| V_{IH1} | TTL High Level Input Voltage | $4.5\text{ V} \leq V_{CC} \leq 5.5\text{ V}$ | 2 | – | V_{CC} | V |
| V_{IL1} | TTL Low Level Input Voltage | | 0 | – | 0.8 | V |
| V_{IH2} | CMOS High Level Input Voltage | $2.5\text{ V} \leq V_{CC} \leq 6\text{ V}$ | $V_{CC} \times 0.7$ | – | $V_{CC} + 0.3$ | V |
| V_{IL2} | CMOS Low Level Input Voltage | | –0.3 | – | $V_{CC} \times 0.2$ | V |
| POTENTIOMETER CHARACTERISTICS | | | | | | |
| R_{POT} | Potentiometer Resistance | –10 Device | | 10 | | k Ω |
| | | –50 Device | | 50 | | |
| | | –00 Device | | 100 | | |
| | Pot. Resistance Tolerance | | | | ± 20 | % |
| V_{RH} | Voltage on R_H pin | | 0 | | V_{CC} | V |
| V_{RL} | Voltage on R_L pin | | 0 | | V_{CC} | V |
| | Resolution | | | 1 | | % |
| INL | Integral Linearity Error | $I_W \leq 2\ \mu\text{A}$ | | 0.5 | 1 | LSB |
| DNL | Differential Linearity Error | $I_W \leq 2\ \mu\text{A}$ | | 0.25 | 0.5 | LSB |
| R_{OUT} | Buffer Output Resistance | $0.05\ V_{CC} \leq V_{WB} \leq 0.95\ V_{CC}$, $V_{CC} = 5\text{ V}$ | | | 1 | Ω |
| I_{OUT} | Buffer Output Current | $0.05\ V_{CC} \leq V_{WB} \leq 0.95\ V_{CC}$, $V_{CC} = 5\text{ V}$ | | | 3 | mA |
| TC_{RPOT} | TC of Pot Resistance | | | 300 | | ppm/ $^{\circ}\text{C}$ |
| TC_{RATIO} | Ratiometric TC | | | | 20 | ppm/ $^{\circ}\text{C}$ |
| $C_{RH}/C_{RL}/C_{RW}$ | Potentiometer Capacitances | | | 8/8/25 | | pF |
| fc | Frequency Response | Passive Attenuator, 10 k Ω | | 1.7 | | MHz |
| $V_{WB(SWING)}$ | Output Voltage Range | $I_{OUT} \leq 100\ \mu\text{A}$, $V_{CC} = 5\text{ V}$ | $0.01\ V_{CC}$ | | $0.99\ V_{CC}$ | |

3. This parameter is tested initially and after a design or process change that affects the parameter.

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.

Table 5. AC TEST CONDITIONS

| | |
|---------------------------|--------------------------------------------|
| V _{CC} Range | 2.5 V ≤ V _{CC} ≤ 6 V |
| Input Pulse Levels | 0.2 V _{CC} to 0.7 V _{CC} |
| Input Rise and Fall Times | 10 ns |
| Input Reference Levels | 0.5 V _{CC} |

Table 6. AC OPERATING CHARACTERISTICS (V_{CC} = +2.5 V to +6.0 V, V_H = V_{CC}, V_L = 0 V, unless otherwise specified)

| Symbol | Parameter | Min | Typ (Note 7) | Max | Units |
|------------------------------------------|--------------------------------|-----|--------------|-----|-------|
| t _{CI} | CS to INC Setup | 100 | - | - | ns |
| t _{DI} | U/D to INC Setup | 50 | - | - | ns |
| t _{ID} | U/D to INC Hold | 100 | - | - | ns |
| t _{IL} | INC LOW Period | 250 | - | - | ns |
| t _{IH} | INC HIGH Period | 250 | - | - | ns |
| t _{IC} | INC Inactive to CS Inactive | 1 | - | - | μs |
| t _{CPH} | CS Deselect Time (NO STORE) | 100 | - | - | ns |
| t _{CPH} | CS Deselect Time (STORE) | 10 | - | - | ms |
| t _{IW} | INC to V _{OUT} Change | - | 1 | 5 | μs |
| t _{CYC} | INC Cycle Time | 1 | - | - | μs |
| t _R , t _F (Note 8) | INC Input Rise and Fall Time | - | - | 500 | μs |
| t _{PU} (Note 8) | Power-up to Wiper Stable | - | - | 1 | ms |
| t _{WR} | Store Cycle | - | 5 | 10 | ms |

7. Typical values are for T_A = 25°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.

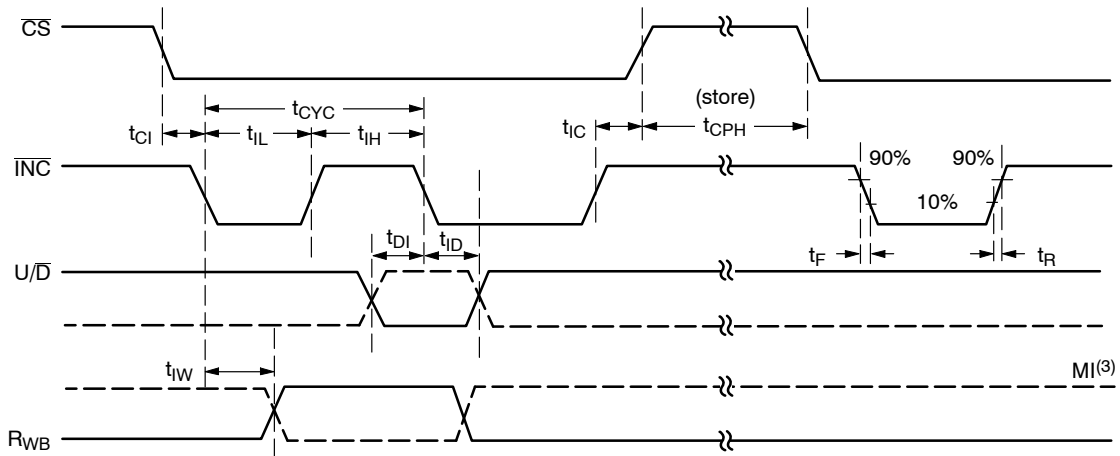


Figure 4. A.C. Timing

CAT5111

Applications Information

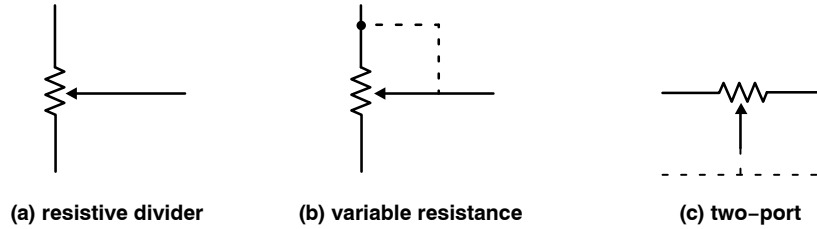


Figure 5. Potentiometer Configuration

Applications

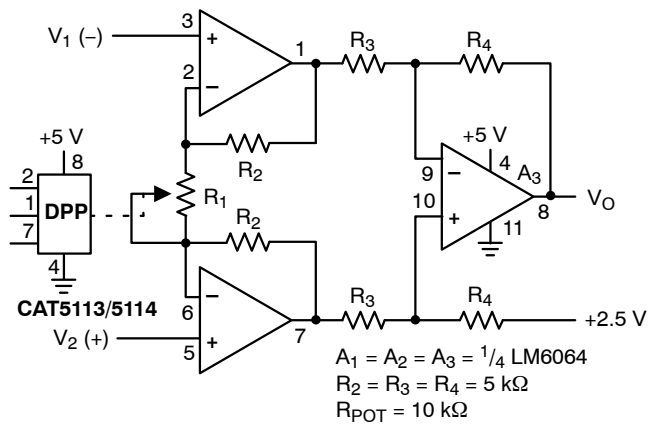


Figure 6. Programmable Instrumentation Amplifier

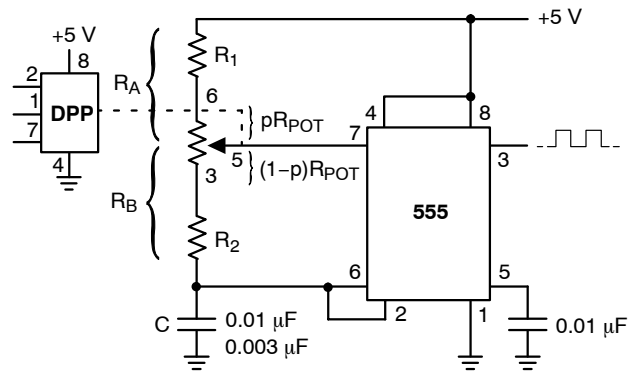


Figure 7. Programmable Sq. Wave Oscillator (555)

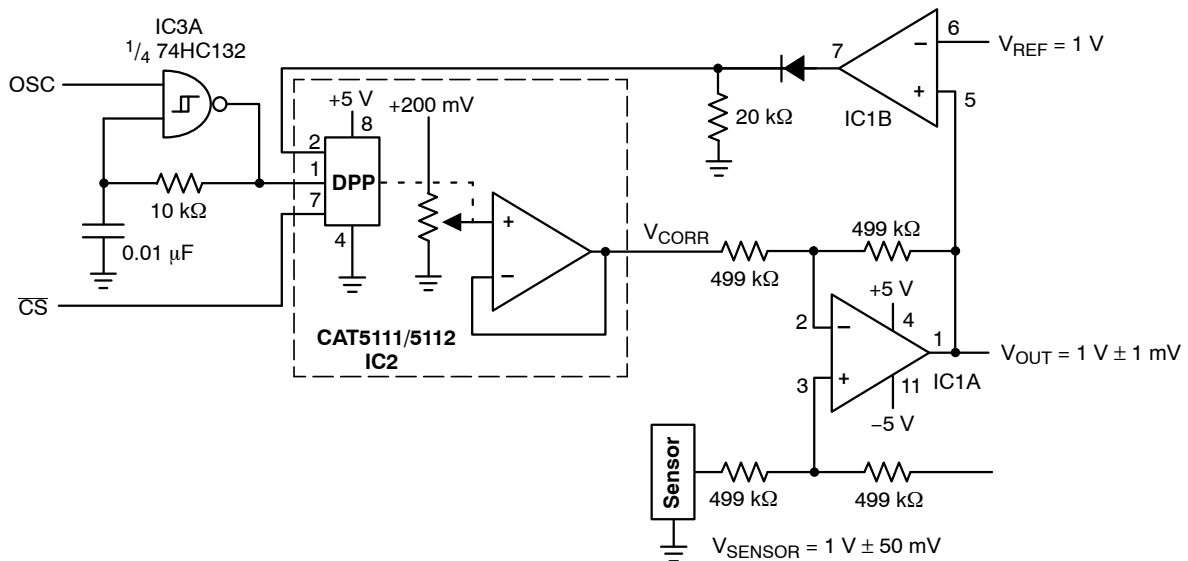


Figure 8. Sensor Auto Referencing Circuit

CAT5111

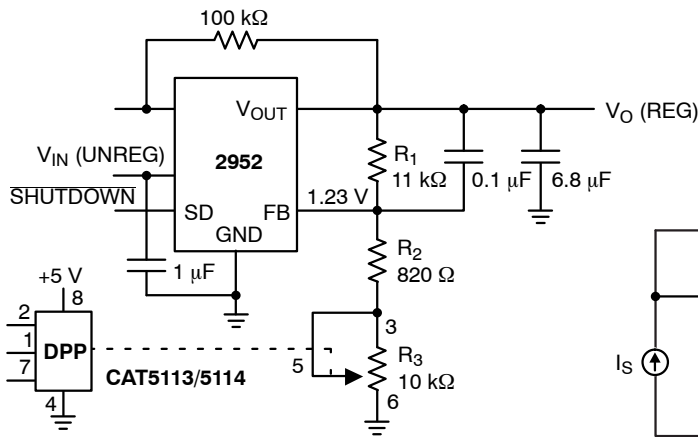


Figure 9. Programmable Voltage Regulator

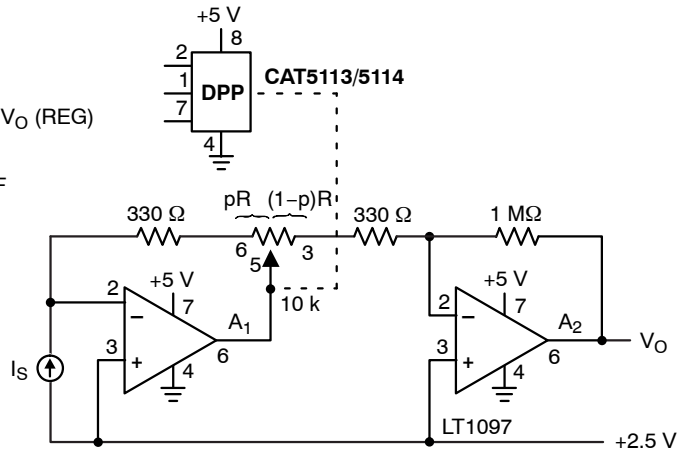


Figure 10. Programmable I to V Converter

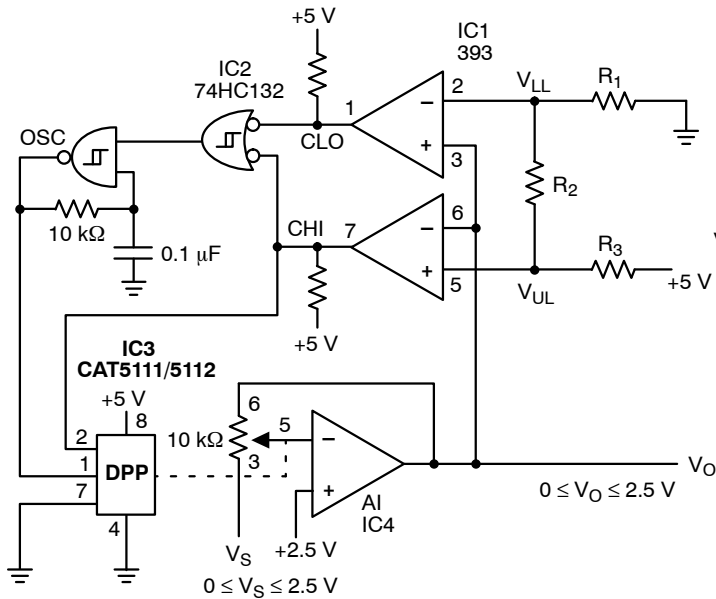


Figure 11. Automatic Gain Control

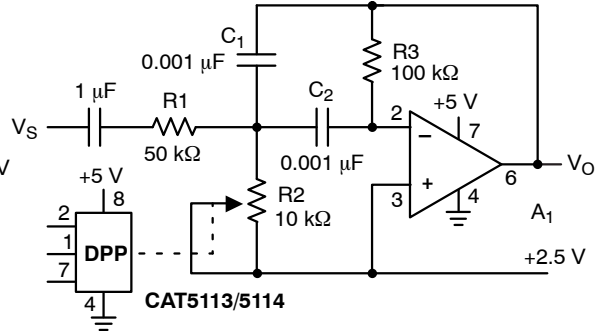


Figure 12. Programmable Bandpass Filter

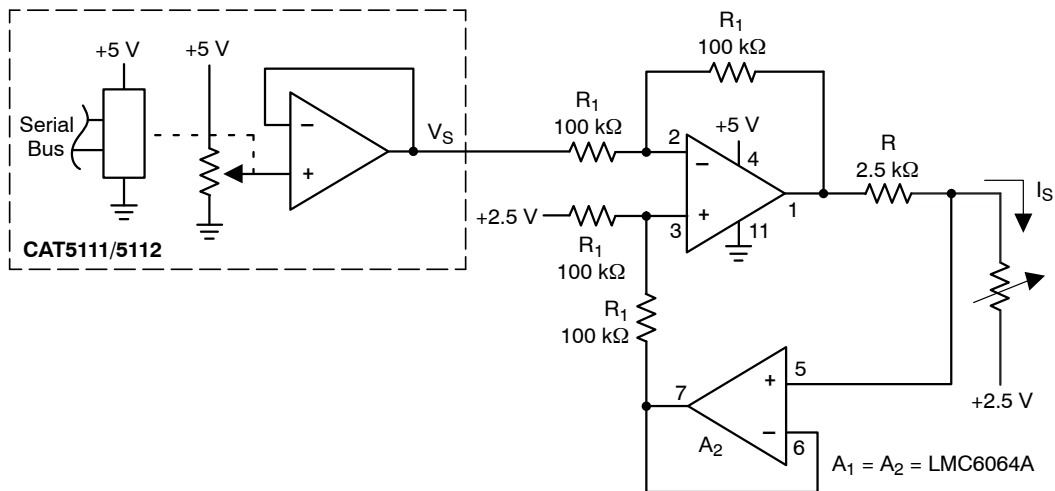
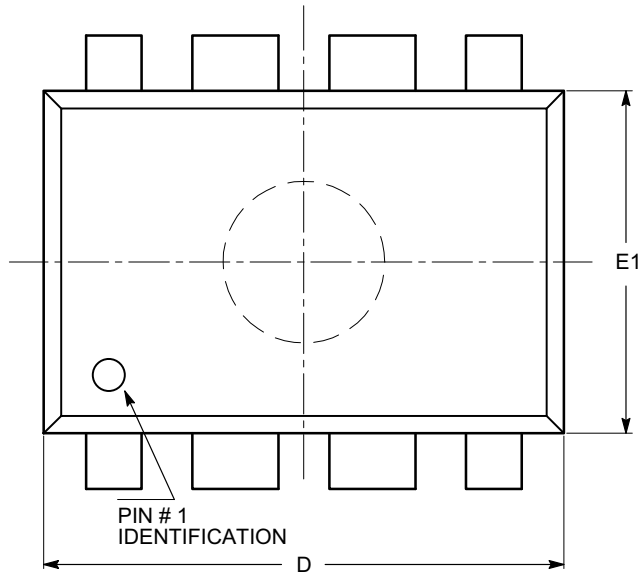


Figure 13. Programmable Current Source/Sink

CAT5111

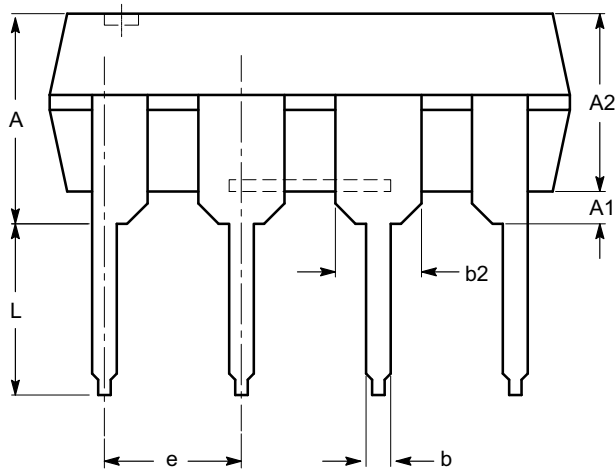
PACKAGE DIMENSIONS

PDIP-8, 300 mils
CASE 646AA-01
ISSUE A

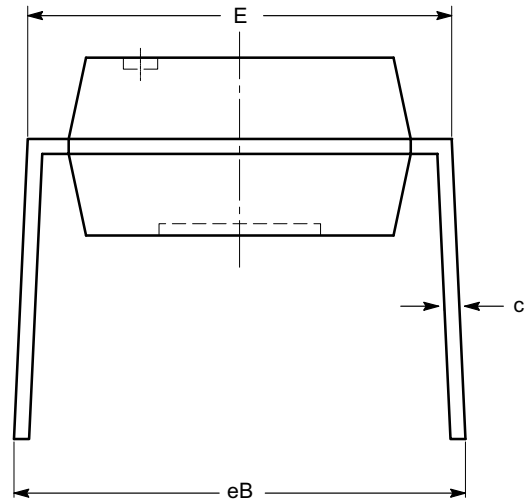


TOP VIEW

| SYMBOL | MIN | NOM | MAX |
|--------|----------|------|-------|
| A | | | 5.33 |
| A1 | 0.38 | | |
| A2 | 2.92 | 3.30 | 4.95 |
| b | 0.36 | 0.46 | 0.56 |
| b2 | 1.14 | 1.52 | 1.78 |
| c | 0.20 | 0.25 | 0.36 |
| D | 9.02 | 9.27 | 10.16 |
| E | 7.62 | 7.87 | 8.25 |
| E1 | 6.10 | 6.35 | 7.11 |
| e | 2.54 BSC | | |
| eB | 7.87 | | 10.92 |
| L | 2.92 | 3.30 | 3.80 |



SIDE VIEW



END VIEW

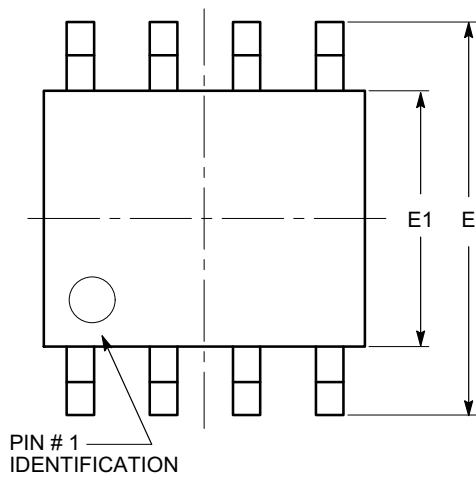
Notes:

- (1) All dimensions are in millimeters.
- (2) Complies with JEDEC MS-001.

CAT5111

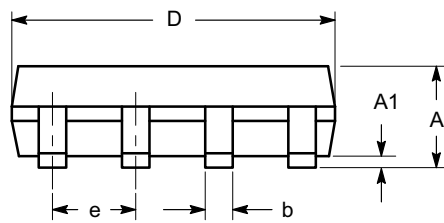
PACKAGE DIMENSIONS

SOIC 8, 150 mils
CASE 751BD-01
ISSUE O

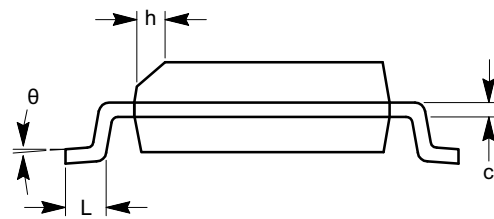


TOP VIEW

| SYMBOL | MIN | NOM | MAX |
|----------|----------|-----|------|
| A | 1.35 | | 1.75 |
| A1 | 0.10 | | 0.25 |
| b | 0.33 | | 0.51 |
| c | 0.19 | | 0.25 |
| D | 4.80 | | 5.00 |
| E | 5.80 | | 6.20 |
| E1 | 3.80 | | 4.00 |
| e | 1.27 BSC | | |
| h | 0.25 | | 0.50 |
| L | 0.40 | | 1.27 |
| θ | 0° | | 8° |



SIDE VIEW



END VIEW

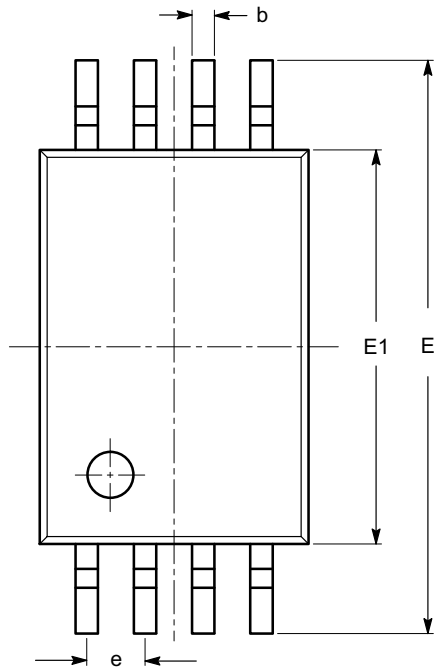
Notes:

- (1) All dimensions are in millimeters. Angles in degrees.
- (2) Complies with JEDEC MS-012.

CAT5111

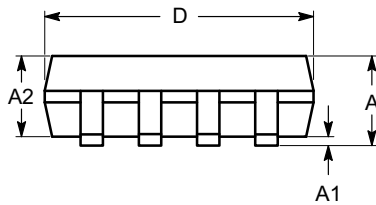
PACKAGE DIMENSIONS

TSSOP8, 4.4x3
CASE 948AL-01
ISSUE O

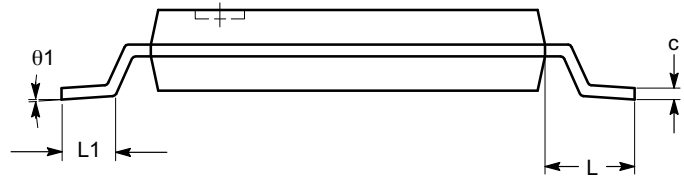


| SYMBOL | MIN | NOM | MAX |
|----------|----------|------|------|
| A | | | 1.20 |
| A1 | 0.05 | | 0.15 |
| A2 | 0.80 | 0.90 | 1.05 |
| b | 0.19 | | 0.30 |
| c | 0.09 | | 0.20 |
| D | 2.90 | 3.00 | 3.10 |
| E | 6.30 | 6.40 | 6.50 |
| E1 | 4.30 | 4.40 | 4.50 |
| e | 0.65 BSC | | |
| L | 1.00 REF | | |
| L1 | 0.50 | 0.60 | 0.75 |
| θ | 0° | | 8° |

TOP VIEW



SIDE VIEW



END VIEW

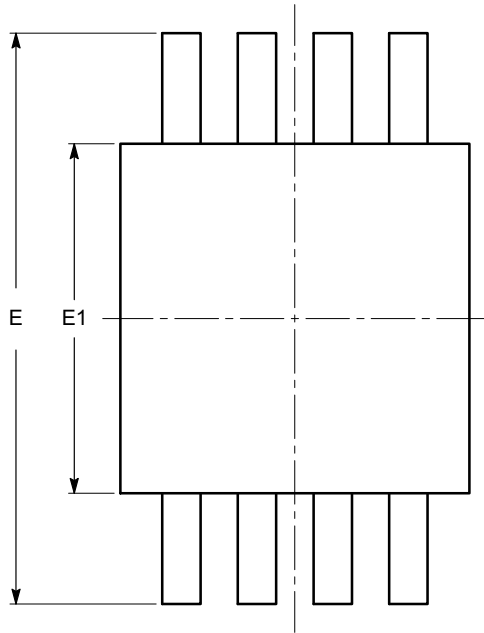
Notes:

- (1) All dimensions are in millimeters. Angles in degrees.
- (2) Complies with JEDEC MO-153.

CAT5111

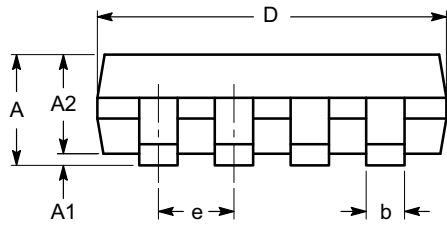
PACKAGE DIMENSIONS

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

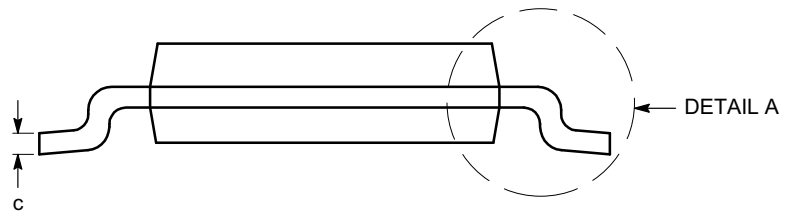


TOP VIEW

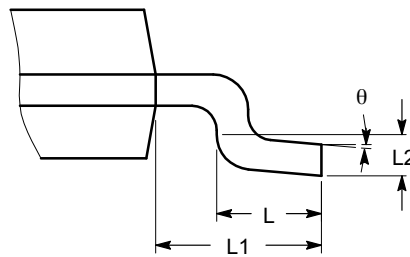
| SYMBOL | MIN | NOM | MAX |
|----------|----------|------|------|
| A | | | 1.10 |
| A1 | 0.05 | 0.10 | 0.15 |
| A2 | 0.75 | 0.85 | 0.95 |
| b | 0.22 | | 0.38 |
| c | 0.13 | | 0.23 |
| D | 2.90 | 3.00 | 3.10 |
| E | 4.80 | 4.90 | 5.00 |
| E1 | 2.90 | 3.00 | 3.10 |
| e | 0.65 BSC | | |
| L | 0.40 | 0.60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



SIDE VIEW



END VIEW



DETAIL A

Notes:

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

CAT5111

Example of Ordering Information (Note 13)

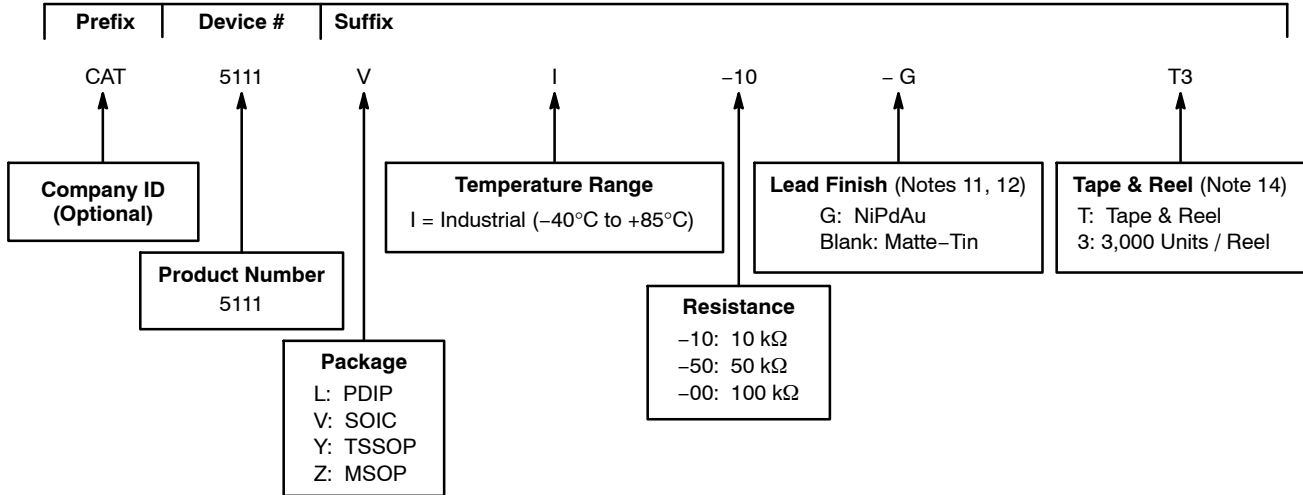


Table 7. ORDERING INFORMATION

| Orderable Part Number | Resistance (kΩ) | Package-Pins | Lead Finish |
|-----------------------|-----------------|--------------|-------------|
| CAT5111LI-10-G | 10 | PDIP-8 | NiPdAu |
| CAT5111LI-50-G | 50 | | |
| CAT5111LI-00-G | 100 | | |
| CAT5111VI-10-GT3 | 10 | SOIC-8 | NiPdAu |
| CAT5111VI-50-GT3 | 50 | | |
| CAT5111VI-00-GT3 | 100 | | |
| CAT5111YI-10-GT3 | 10 | TSSOP-8 | NiPdAu |
| CAT5111YI-50-GT3 | 50 | | |
| CAT5111YI-00-GT3 | 100 | | |
| CAT5111ZI-10-T3 | 10 | MSOP-8 | Matte-Tin |
| CAT5111ZI-50-T3 | 50 | | |
| CAT5111ZI-00-T3 | 100 | | |

10. All packages are RoHS compliant.


11. Standard lead finish is NiPdAu, except MSOP package is Matte-Tin.

12. Contact factory for Matte-Tin finish availability for PDIP, SOIC and TSSOP packages.

13. The device used in the above example is a CAT5111VI-10-GT3 (SOIC, Industrial Temperature, 10 kΩ, NiPdAu, Tape & Reel, 3,000/Reel).

14. 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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