



100-Tap Digitally Programmable Potentiometer (DPP™)

FEATURES

- 100-position linear taper potentiometer
- Non-volatile EEPROM wiper storage
- 10nA ultra-low standby current
- Single supply operation: 2.5V – 6.0V
- Increment up/down serial interface
- Resistance values: 1kΩ, 10kΩ, 50kΩ and 100kΩ
- Available in PDIP, SOIC, TSSOP and MSOP packages

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

For Ordering Information details, see page 12.

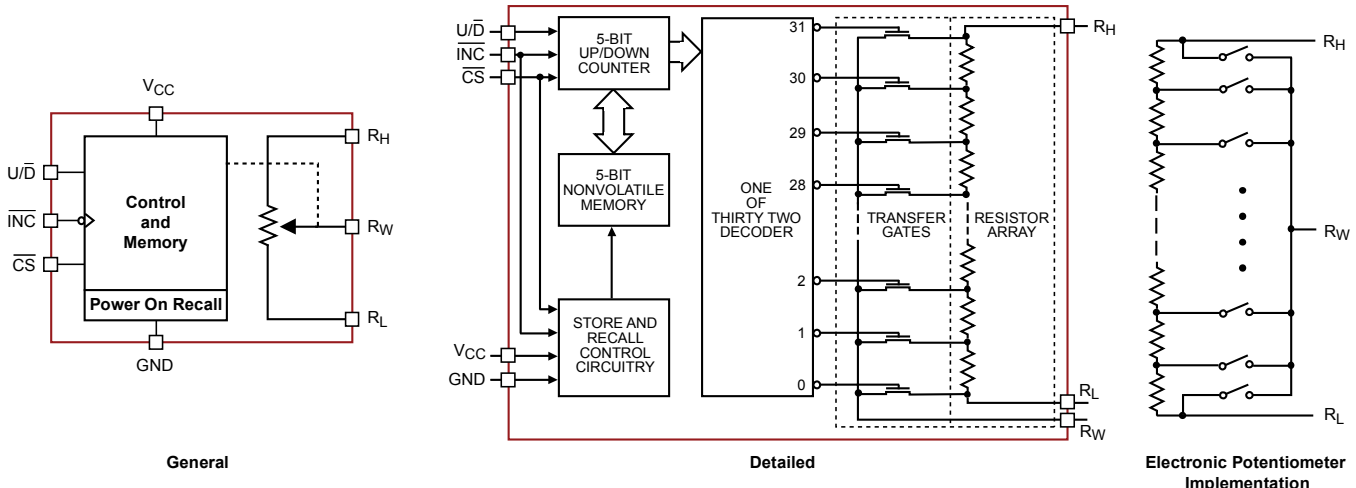
DESCRIPTION

The CAT5113 is a single digitally programmable potentiometer (DPP™) designed as a 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 CAT5113 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_W . 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 affecting the stored setting. Wiper-control of the CAT5113 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.

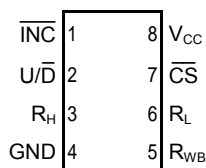
The digitally programmable potentiometer can be used as a three-terminal resistive divider or as a two-terminal variable resistor.

FUNCTIONAL DIAGRAM

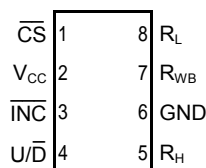


PIN CONFIGURATION

PDIP 8-Lead (L)
 SOIC 8 Lead (V)
 MSOP 8 Lead (Z)



TSSOP 8 Lead (Y)



PIN DESCRIPTION

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

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

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

The $\overline{\text{U/D}}$ 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_W : Wiper Potentiometer Terminal

R_W is the wiper terminal of the potentiometer. Its position on the resistor array is controlled by the control inputs, $\overline{\text{INC}}$, $\overline{\text{U/D}}$ and $\overline{\text{CS}}$. Voltage applied to the R_W terminal cannot exceed the supply voltage, V_CC or go below ground, GND.

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 CAT5113 and is active low. When in a

PIN DESCRIPTIONS

| Name | Function |
|-------------------------|-----------------------------|
| $\overline{\text{INC}}$ | Increment Control |
| $\overline{\text{U/D}}$ | Up/Down Control |
| R_H | Potentiometer High Terminal |
| GND | Ground |
| R_W | Buffered Wiper Terminal |
| R_L | Potentiometer Low Terminal |
| $\overline{\text{CS}}$ | Chip Select |
| V_CC | Supply Voltage |

high state, activity on the $\overline{\text{INC}}$ and $\overline{\text{U/D}}$ inputs will not affect or change the position of the wiper.

DEVICE OPERATION

The CAT5113 operates like a digitally controlled potentiometer with R_H and R_L equivalent to the high and low terminals and R_W 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, $\overline{\text{INC}}$, $\overline{\text{U/D}}$ 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 non-volatile memory using the $\overline{\text{INC}}$ and $\overline{\text{CS}}$ inputs.

With $\overline{\text{CS}}$ set LOW the CAT5113 is selected and will respond to the $\overline{\text{U/D}}$ 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 $\overline{\text{U/D}}$ 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 CAT5113 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 CAT5113 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 non-volatile memory.

OPERATION MODES

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

ABSOLUTE MAXIMUM RATINGS⁽¹⁾

| Parameters | Ratings | Units |
|-----------------------------------|------------------------|-------|
| Supply Voltage V_{CC} to GND | -0.5 to +7V | V |
| Inputs | | |
| \overline{CS} to GND | -0.5 to $V_{CC} + 0.5$ | V |
| \overline{INC} to GND | -0.5 to $V_{CC} + 0.5$ | V |
| U/\overline{D} to GND | -0.5 to $V_{CC} + 0.5$ | V |
| H to GND | -0.5 to $V_{CC} + 0.5$ | V |
| L to GND | -0.5 to $V_{CC} + 0.5$ | V |
| W to GND | -0.5 to $V_{CC} + 0.5$ | V |

| Parameters | Ratings | Units |
|----------------------------------|------------|-------|
| 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 (10s max) | +300 | °C |

RELIABILITY CHARACTERISTICS

| Symbol | Parameter | Test Method | Min | Typ | Max | Units |
|--------------------|--------------------|-------------------------------|-----------|-----|-----|--------|
| $V_{ZAP}^{(2)}$ | ESD Susceptibility | MIL-STD-883, Test Method 3015 | 2000 | | | V |
| $I_{LTH}^{(2)(3)}$ | 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 |

DC ELECTRICAL CHARACTERISTICS

$V_{CC} = +2.5V$ to $+6V$ unless otherwise specified

Power Supply

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|-----------------|----------------------------|--|-----|------|------|---------|
| V_{CC} | Operating Voltage Range | | 2.5 | – | 6.0 | V |
| I_{CC1} | Supply Current (Increment) | $V_{CC} = 6V, f = 1MHz, I_W = 0$ | – | – | 100 | μA |
| | | $V_{CC} = 6V, f = 250kHz, I_W = 0$ | – | – | 50 | μA |
| I_{CC2} | Supply Current (Write) | Programming, $V_{CC} = 6V$ | – | – | 1000 | μA |
| | | $V_{CC} = 3V$ | – | – | 500 | μA |
| $I_{SB1}^{(3)}$ | Supply Current (Standby) | $\overline{CS} = V_{CC} - 0.3V$ $U/\overline{D}, \overline{INC} = V_{CC} - 0.3V$ or GND | – | 0.01 | 1 | μA |

Notes:

- (1) Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions outside of those listed in the operational sections of this specification is not implied. Exposure to any absolute maximum rating for extended periods may affect device performance and reliability.
- (2) This parameter is tested initially and after a design or process change that affects the parameter.
- (3) Latch-up protection is provided for stresses up to 100mA on address and data pins from $-1V$ to $V_{CC} + 1V$
- (4) I_W = source or sink
- (5) These parameters are periodically sampled and are not 100% tested.

Logic Inputs

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|-----------|-------------------------------|------------------------------|---------------------|-----|---------------------|---------|
| I_{IH} | Input Leakage Current | $V_{IN} = V_{CC}$ | – | – | 10 | μA |
| I_{IL} | Input Leakage Current | $V_{IN} = 0V$ | – | – | -10 | μA |
| V_{IH1} | TTL High Level Input Voltage | $4.5V \leq V_{CC} \leq 5.5V$ | 2 | – | V_{CC} | V |
| V_{IL1} | TTL Low Level Input Voltage | | 0 | – | 0.8 | V |
| V_{IH2} | CMOS High Level Input Voltage | $2.5V \leq V_{CC} \leq 6V$ | $V_{CC} \times 0.7$ | – | $V_{CC} + 0.3$ | V |
| V_{IL2} | CMOS Low Level Input Voltage | | -0.3 | – | $V_{CC} \times 0.2$ | V |

Potentiometer Characteristics

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---------------|------------------------------|----------------------------------|------|--------|----------|------------------|
| R_{POT} | Potentiometer Resistance | -01 Device | | 1 | | k Ω |
| | | -10 Device | | 10 | | |
| | | -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 | $I_W \leq 2\mu A$ | | 0.5 | 1 | LSB |
| DNL | Differential Linearity Error | $I_W \leq 2\mu A$ | | 0.25 | 0.5 | LSB |
| R_{WI} | Wiper Resistance | $V_{CC} = 5V, I_W = 1mA$ | | | 400 | Ω |
| | | $V_{CC} = 2.5V, I_W = 1mA$ | | | 1000 | Ω |
| I_W | Wiper Current | (1) | -4.4 | | 4.4 | mA |
| TC_{RPOT} | TC of Pot Resistance | | | 300 | | ppm/ $^{\circ}C$ |
| TC_{RATIO} | Ratiometric TC | | | | 20 | ppm/ $^{\circ}C$ |
| V_N | Noise | 100kHz / 1kHz | | 8/24 | | nV/ \sqrt{Hz} |
| $C_H/C_L/C_W$ | Potentiometer Capacitances | | | 8/8/25 | | pF |
| fc | Frequency Response | Passive Attenuator, 10k Ω | | 1.7 | | MHz |

Note:

(1) This parameter is not 100% tested.

AC CONDITIONS OF TEST

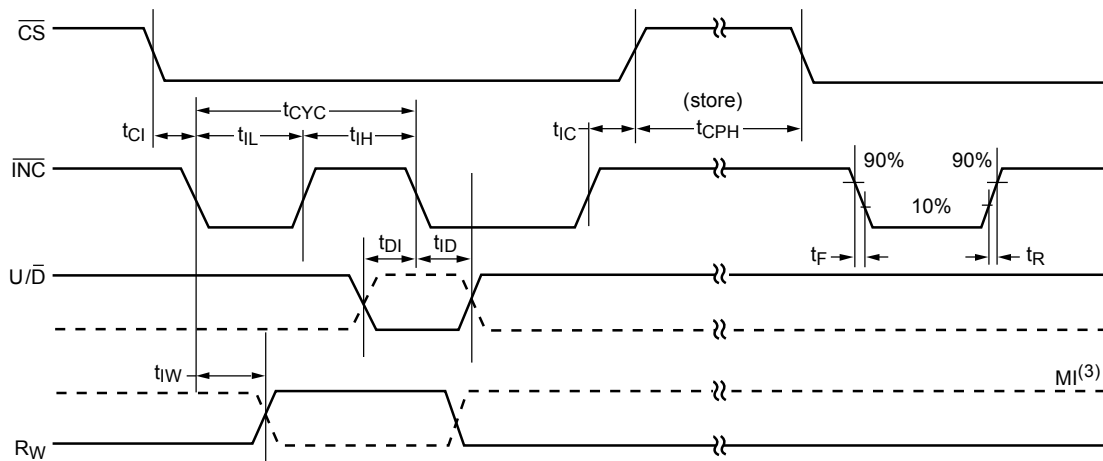
| | |
|---------------------------|--|
| V _{CC} Range | 2.5V ≤ V _{CC} ≤ 6V |
| Input Pulse Levels | 0.2V _{CC} to 0.7V _{CC} |
| Input Rise and Fall Times | 10ns |
| Input Reference Levels | 0.5V _{CC} |

AC OPERATING CHARACTERISTICS

V_{CC} = +2.5V to +6.0V, V_H = V_{CC}, V_L = 0V, unless otherwise specified

| Symbol | Parameter | Min | Typ ⁽¹⁾ | 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 | – | – | μs |
| t _{CPH} | \overline{CS} Deselect Time (NO STORE) | 100 | – | – | ns |
| t _{CPH} | \overline{CS} Deselect Time (STORE) | 10 | – | – | ms |
| t _{IW} | \overline{INC} to V _{OUT} Change | – | 1 | 5 | μs |
| t _{CYC} | \overline{INC} Cycle Time | 1 | – | – | μs |
| t _R , t _F ⁽²⁾ | \overline{INC} Input Rise and Fall Time | – | – | 500 | μs |
| t _{PU} ⁽²⁾ | Power-up to Wiper Stable | – | – | 1 | ms |
| t _{WR} | Store Cycle | – | 5 | 10 | ms |

A.C. TIMING

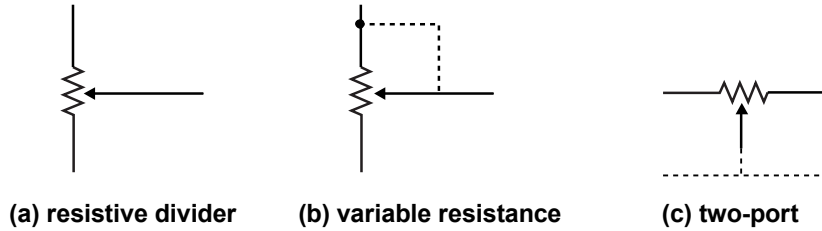


Notes:

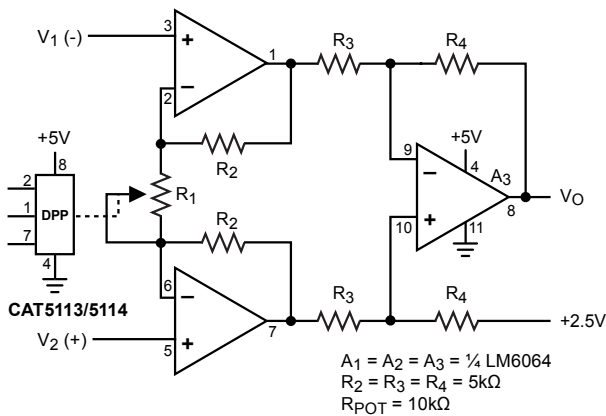
- (1) Typical values are for T_A = 25°C and nominal supply voltage.
- (2) This parameter is periodically sampled and not 100% tested.
- (3) M_I in the A.C. Timing diagram refers to the minimum incremental change in the W output due to a change in the wiper position.

APPLICATIONS INFORMATION

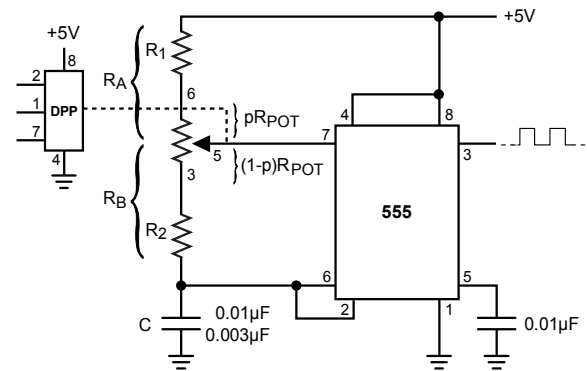
Potentiometer Configuration



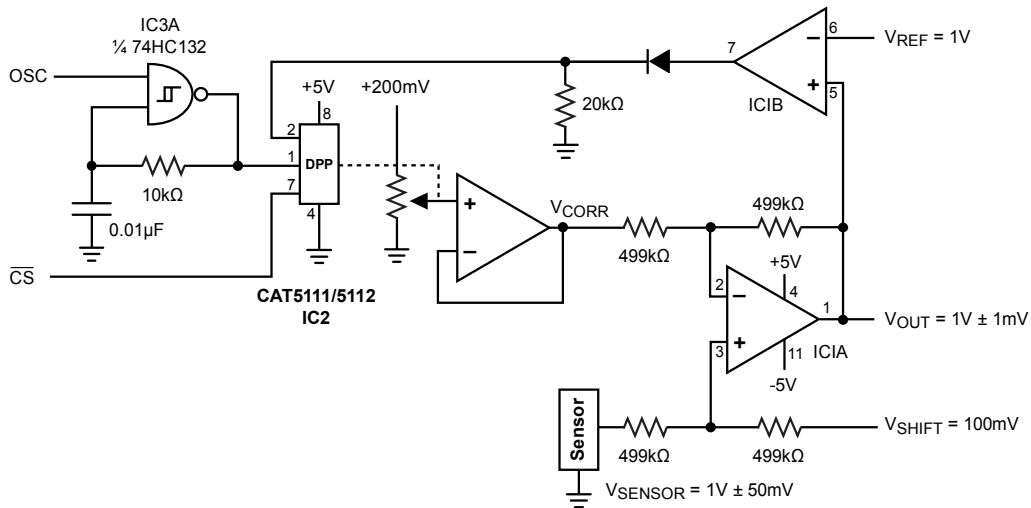
Applications



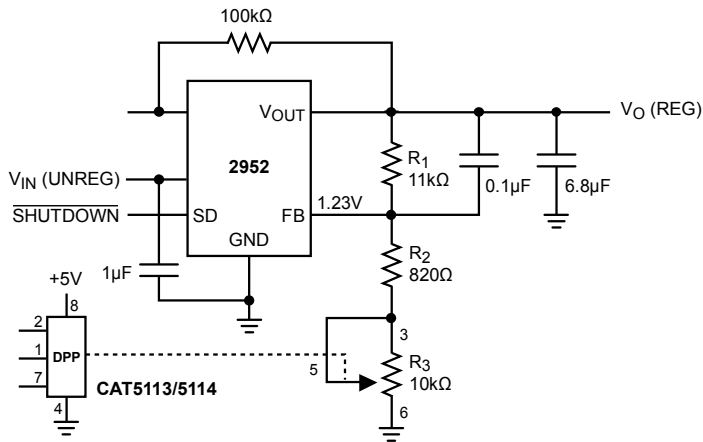
Programmable Instrumentation Amplifier



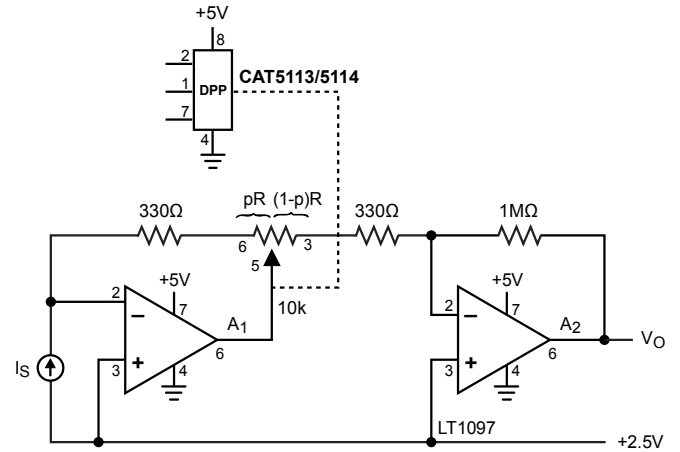
Programmable Sq. Wave Oscillator (555)



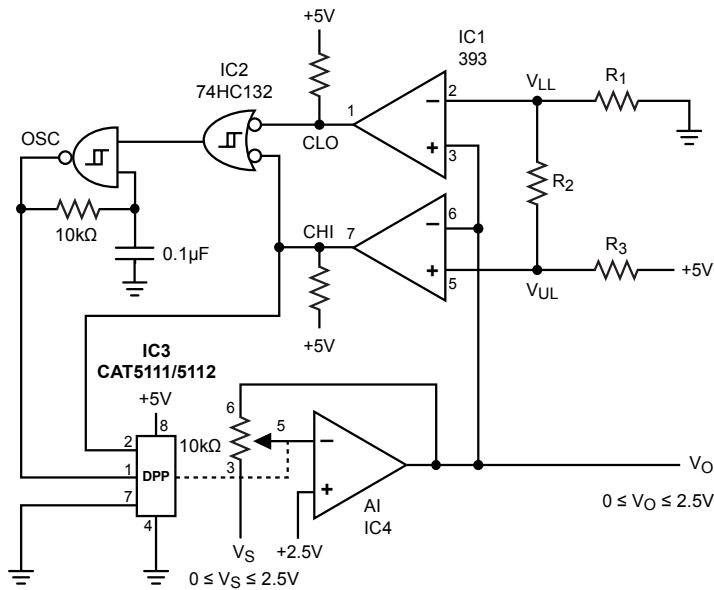
Sensor Auto Referencing Circuit



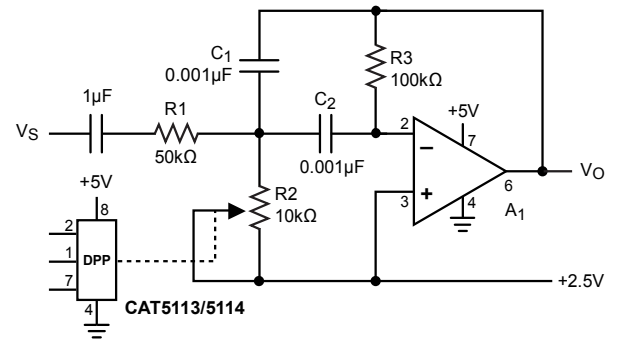
Programmable Voltage Regulator



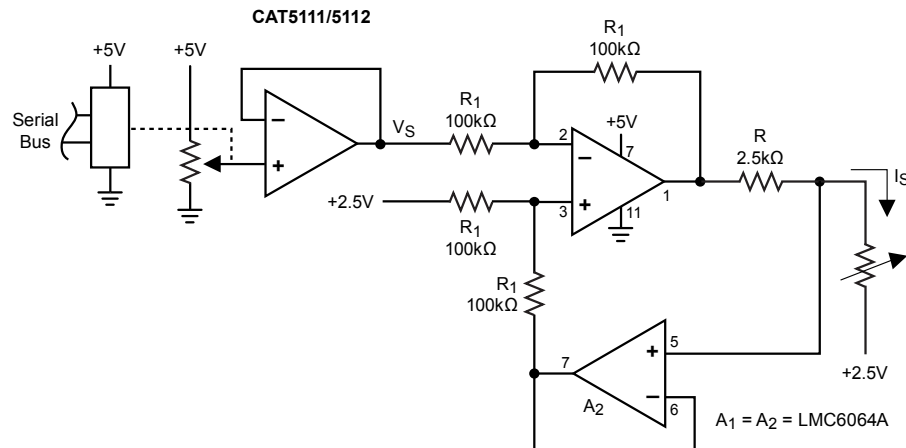
Programmable I to V Converter



Automatic Gain Control



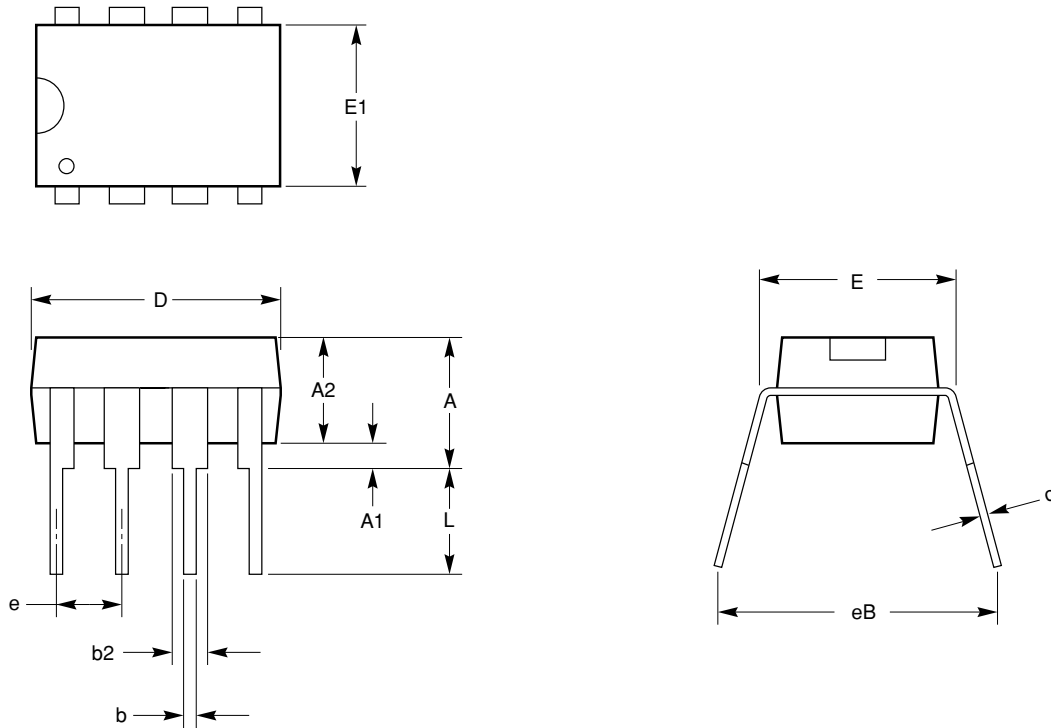
Programmable Bandpass Filter



Programmable Current Source/Sink

PACKAGE OUTLINES

PDIP 8-LEAD (300MIL) (L)



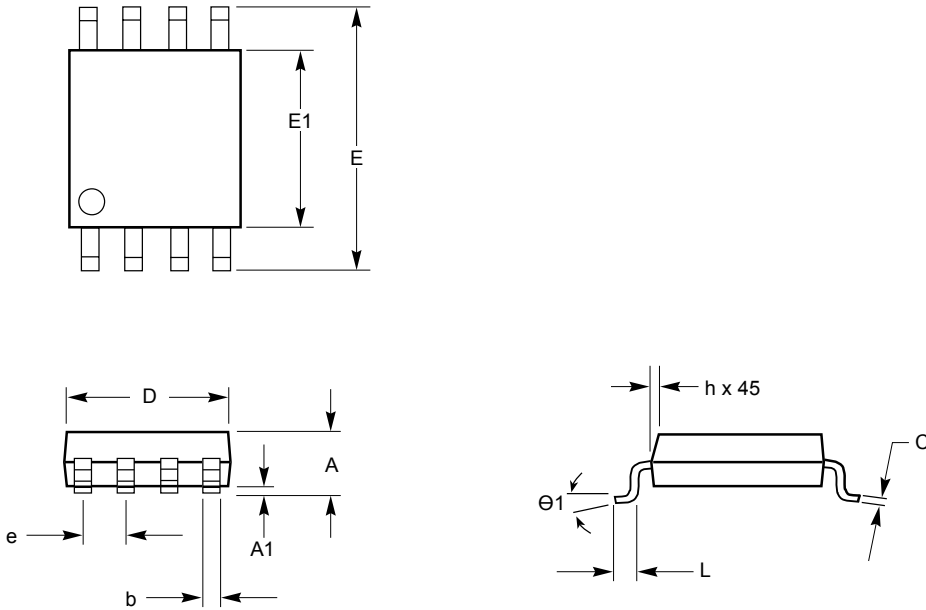
| SYMBOL | MIN | NOM | MAX |
|--------|----------|------|-------|
| A | | | 4.57 |
| A1 | 0.38 | | |
| A2 | 3.05 | | 3.81 |
| b | 0.36 | 0.46 | 0.56 |
| b2 | 1.14 | | 1.77 |
| c | 0.21 | 0.26 | 0.35 |
| D | 9.02 | | 10.16 |
| E | 7.62 | 7.87 | 8.25 |
| E1 | 6.09 | 6.35 | 7.11 |
| e | 2.54 BSC | | |
| eB | 7.87 | | 9.65 |
| L | 2.92 | | 3.81 |

For current Tape and Reel information, download the PDF file from:
<http://www.catsemi.com/documents/tapeandreeel.pdf>

Notes:

- (1) All dimensions are in millimeters.
- (2) Complies with JEDEC Standard MS001.
- (3) Dimensioning and tolerancing per ANSI Y14.5M-1982

SOIC 8-LEAD NARROW BODY (150MIL) (V)



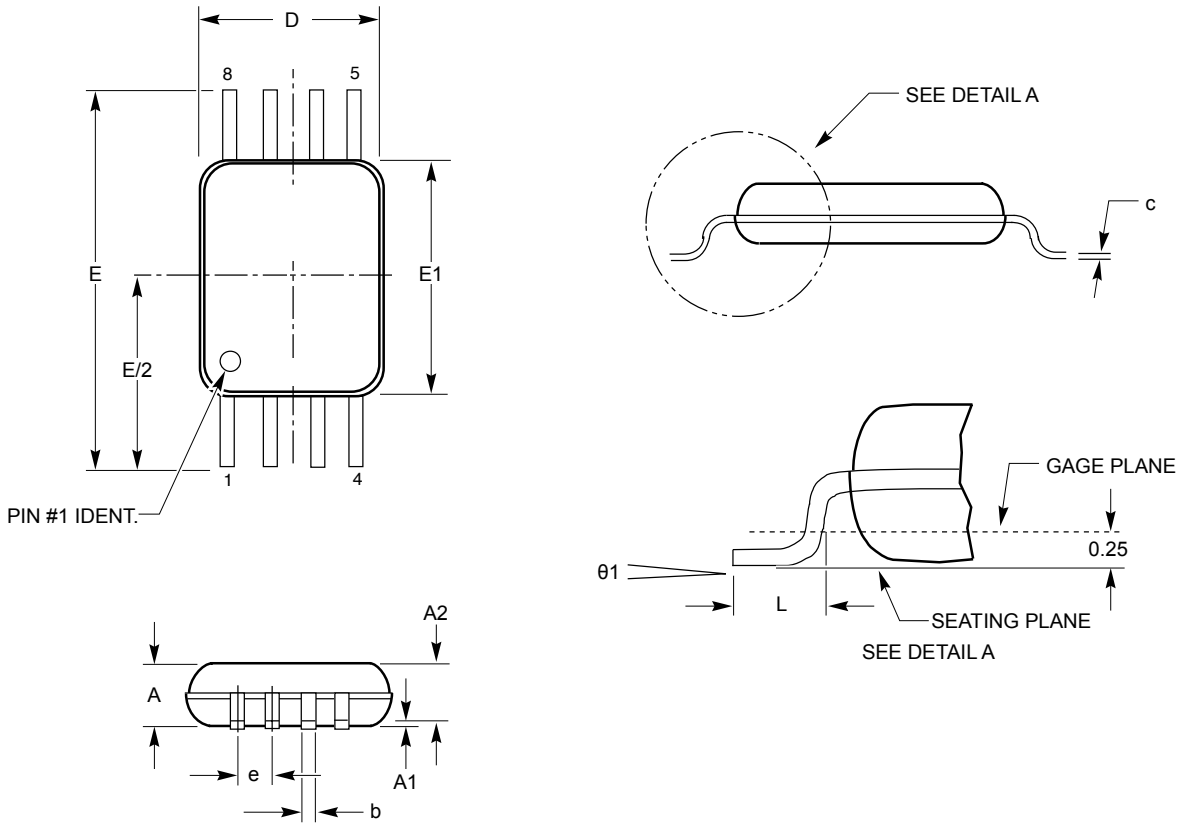
| SYMBOL | MIN | NOM | MAX |
|--------|----------|-----|------|
| A1 | 0.10 | | 0.25 |
| A | 1.35 | | 1.75 |
| b | 0.33 | | 0.51 |
| C | 0.19 | | 0.25 |
| D | 4.80 | | 5.00 |
| E | 5.80 | | 6.20 |
| E1 | 3.80 | | 4.00 |
| e | 1.27 BSC | | |
| h | 0.25 | | 0.50 |
| L | 0.40 | | 1.27 |
| θ1 | 0° | | 8° |

**For current Tape and Reel information, download the PDF file from:
<http://www.catsemi.com/documents/tapeandreel.pdf>.**

Notes:

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

8-LEAD TSSOP (Y)



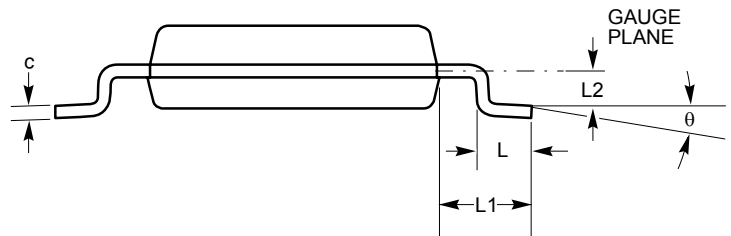
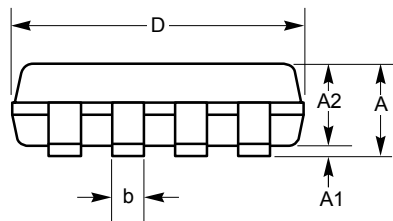
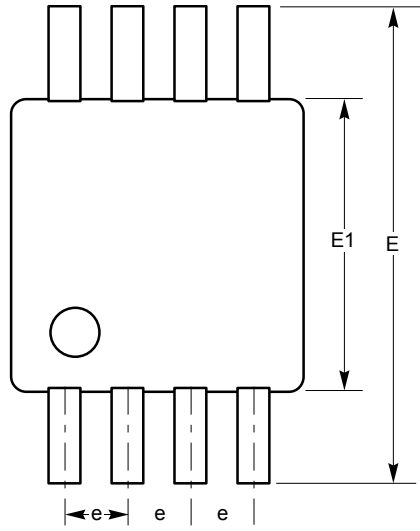
| SYMBOL | MIN | NOM | MAX |
|------------|----------|------|------|
| A | | | 1.20 |
| A1 | 0.05 | | 0.15 |
| A2 | 0.80 | 0.90 | 1.05 |
| b | 0.19 | | 0.30 |
| c | 0.09 | | 0.20 |
| D | 2.90 | 3.00 | 3.10 |
| E | 6.30 | 6.4 | 6.50 |
| E1 | 4.30 | 4.40 | 4.50 |
| e | 0.65 BSC | | |
| L | 0.50 | 0.60 | 0.75 |
| $\theta 1$ | 0.00 | | 8.00 |

For current Tape and Reel information, download the PDF file from:
<http://www.catsemi.com/documents/tapeandreeel.pdf>

Notes:

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

8-LEAD MSOP (Z)



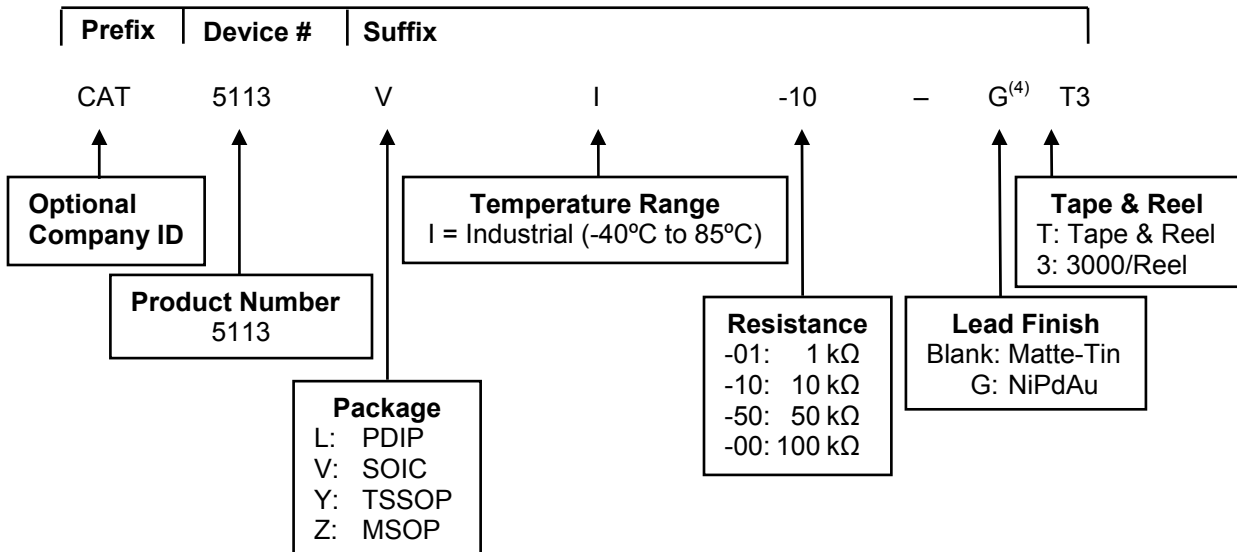
| SYMBOL | MIN | NOM | MAX |
|--------|----------|------|------|
| A | | | 1.1 |
| A1 | 0.05 | 0.10 | 0.15 |
| A2 | 0.75 | 0.85 | 0.95 |
| b | 0.28 | 0.33 | 0.38 |
| c | | | |
| D | 2.90 | 3.00 | 3.10 |
| E | 4.80 | 4.90 | 5.00 |
| E1 | 2.90 | 3.00 | 3.10 |
| e | 0.65 BSC | | |
| L | 0.35 | 0.45 | 0.55 |
| L1 | | | |
| L2 | | | |
| θ | 0° | | 6° |

**For current Tape and Reel information,
download the PDF file from:
<http://www.catsemi.com/documents/tapeandreel.pdf>.**

Notes:

- (1) All dimensions are in millimeters. Angles in degrees.
- (2) Complies with JEDEC Specification MS-187.
- (3) Stand off height/coplanarity are considered as special characteristics.

EXAMPLE OF ORDERING INFORMATION



Notes:

- (1) All packages are RoHS-compliant (Lead-free, Halogen-free).
- (2) The standard lead finish is NiPdAu.
- (3) This device used in the above example is a CAT5113VI-10-GT3 (SOIC, Industrial Temperature, 10kΩ, NiPdAu, Tape & Reel).
- (4) For Matte-Tin finish, contact factory.

| ORDERING PART NUMBER |
|-----------------------------|
| CAT5113LI-01-G |
| CAT5113LI-10-G |
| CAT5113LI-50-G |
| CAT5113LI-00-G |
| CAT5113VI-01-G |
| CAT5113VI-10-G |
| CAT5113VI-50-G |
| CAT5113VI-00-G |
| CAT5113YI-01-G |
| CAT5113YI-10-G |
| CAT5113YI-50-G |
| CAT5113YI-00-G |
| CAT5113ZI-01-G |
| CAT5113ZI-10-G |
| CAT5113ZI-50-G |
| CAT5113ZI-00-G |

REVISION HISTORY

| Date | Rev. | Reason |
|------------|------|--|
| 10/09/2003 | M | Revised Features Revised DC Electrical Characteristics |
| 03/10/2004 | N | Updated Potentiometer Parameters |
| 03/29/2004 | O | Changed Green Package marking for SOIC from W to V |
| 04/02/2004 | P | Add 1kW version to data sheet |
| 04/08/2004 | Q | Eliminated data sheet designation Updated Tape and Reel specs in Ordering Information |
| 01/25/2005 | R | Updated Potentiometer Parameters |
| 04/22/2006 | S | Updated Example of Ordering Information |
| 06/01/2007 | T | Added Package Outline Added MD- in front of Document No. |
| | | |

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