

# CAT5115

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

### Description

The CAT5115 is a single digitally programmable potentiometer (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 CAT5115 contains a 32-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 is always set to the mid point, tap 15 at power up. The tap position is not stored in memory. Wiper-control of the CAT5115 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.

The digitally programmable potentiometer can be used as a three-terminal resistive divider or as a two-terminal variable resistor. DPPs bring variability and programmability to a wide variety of applications including control, parameter adjustments, and signal processing.

For a pin-compatible device that recalls a stored tap position on power-up refer to the CAT5114 data sheet.

### Features

- 32-position Linear Taper Potentiometer
- Low Power CMOS Technology
- Single Supply Operation: 2.5 V – 6.0 V
- Increment Up/Down Serial Interface
- Resistance Values: 10 k $\Omega$ , 50 k $\Omega$  and 100 k $\Omega$
- Available in PDIP, SOIC, TSSOP, MSOP and Space Saving 2 x 2.5 mm TDFN 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



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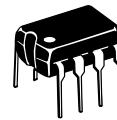
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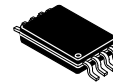
SOIC-8  
V SUFFIX  
CASE 751BD



MSOP-8  
Z SUFFIX  
CASE 846AD



PDIP-8  
L SUFFIX  
CASE 646AA

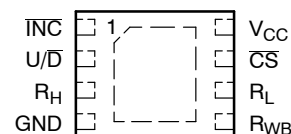
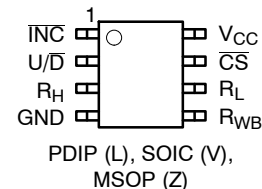


TSSOP-8  
Y SUFFIX  
CASE 948AL



TDFN-8  
ZD7 SUFFIX  
CASE 511AJ

### PIN CONFIGURATIONS



TDFN (ZD7)  
(Top Views)

### ORDERING INFORMATION

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

Functional Diagram

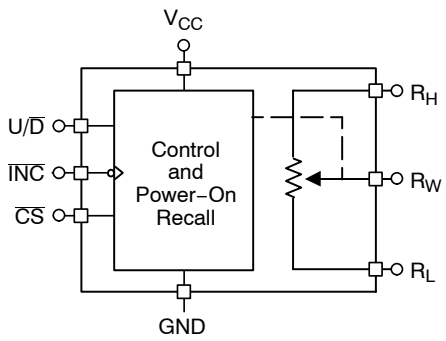


Figure 1. General

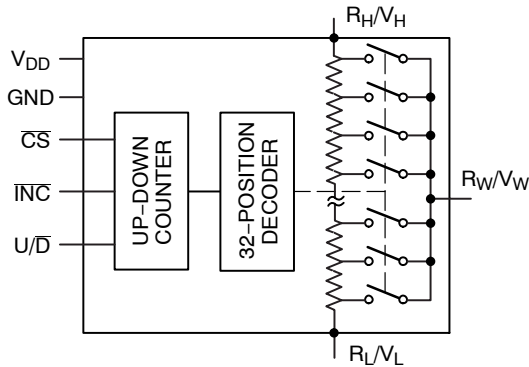


Figure 2. Detailed

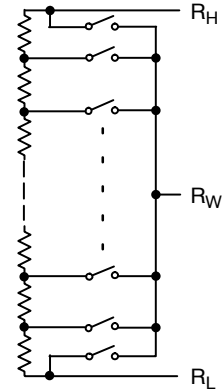


Figure 3. Electronic Potentiometer Implementation

Table 1. PIN DESCRIPTIONS

Name	Function
INC	Increment Control
U/D	Up/Down Control
R <sub>H</sub>	Potentiometer High Terminal
GND	Ground
R <sub>W</sub>	Buffered Wiper Terminal
R <sub>L</sub>	Potentiometer Low Terminal
CS	Chip Select
V <sub>CC</sub>	Supply Voltage

Pin Function

**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>W</sub>:** Wiper Potentiometer Terminal

R<sub>W</sub> is the wiper terminal of the potentiometer. Its position on the resistor array is controlled by the control inputs, INC,

U/D and CS. Voltage applied to the R<sub>W</sub> terminal cannot exceed the supply voltage, V<sub>CC</sub> or go below ground, GND.

**R<sub>L</sub>:** Low End Potentiometer Terminal

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 CAT5115 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.

Device Operation

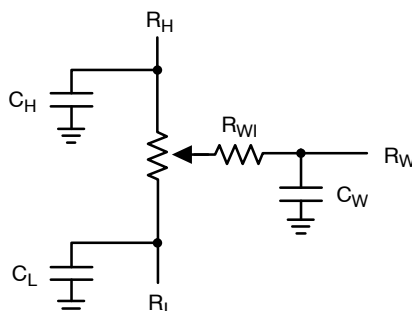
The CAT5115 operates like a digitally controlled potentiometer with R<sub>H</sub> and R<sub>L</sub> equivalent to the high and low terminals and R<sub>W</sub> equivalent to the mechanical potentiometer's wiper. There are 32 available tap positions including the resistor end points, R<sub>H</sub> and R<sub>L</sub>. There are 31 resistor elements connected in series between the R<sub>H</sub> and R<sub>L</sub> terminals. The wiper terminal is connected to one of the 32 taps and controlled by three inputs, INC, U/D and CS. These inputs control a five-bit up/down counter whose output is decoded to select the wiper position.

With CS set LOW the CAT5115 is selected and will respond to the U/D and INC inputs. HIGH to LOW transitions on INC will increment or decrement the wiper (depending on the state of the U/D input and five-bit counter). The wiper, when at either fixed terminal, acts like its mechanical equivalent and does not move beyond the last position. When the CAT5115 is powered-down, the wiper position is reset. When power is restored, the counter is set to the mid point, tap 15.

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**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
High	Low to High	X	Store Wiper Position
Low	Low to High	X	No Store, Return to Standby
X	High	X	Standby



**Figure 4. Potentiometer Equivalent Circuit**

**Table 3. 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
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
Operating Ambient Temperature 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 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.

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**Table 5. DC ELECTRICAL CHARACTERISTICS** ( $V_{CC} = +2.5\text{ V to }+6\text{ V}$  unless otherwise specified)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
<b>POWER SUPPLY</b>						
$V_{CC}$	Operating Voltage Range		2.5	–	6.0	V
$I_{CC1}$	Supply Current (Increment)	$V_{CC} = 6\text{ V}, f = 1\text{ MHz}, I_W = 0$	–	–	100	$\mu\text{A}$
		$V_{CC} = 6\text{ V}, f = 250\text{ kHz}, I_W = 0$	–	–	50	$\mu\text{A}$
$I_{SB1}$ (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	–	0.01	1	$\mu\text{A}$
<b>LOGIC INPUTS</b>						
$I_{IH}$	Input Leakage Current	$V_{IN} = V_{CC}$	–	–	10	$\mu\text{A}$
$I_{IL}$	Input Leakage Current	$V_{IN} = 0\text{ V}$	–	–	–10	$\mu\text{A}$
$V_{IH1}$	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
<b>POTENTIOMETER CHARACTERISTICS</b>						
$R_{POT}$	Potentiometer Resistance	–10 Device		10		k $\Omega$
		–50 Device		50		
		–00 Device		100		
	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
	Resolution			3.2		%
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
$R_{WI}$	Wiper Resistance	$V_{CC} = 5\text{ V}, I_W = 1\text{ mA}$		70	200	$\Omega$
		$V_{CC} = 2.5\text{ V}, I_W = 1\text{ mA}$		150	400	$\Omega$
$I_W$	Wiper Current	(1)			1	mA
$TC_{RPOT}$	TC of Pot Resistance			$\pm 50$	$\pm 300$	ppm/ $^{\circ}\text{C}$
$TC_{RATIO}$	Ratiometric TC				20	ppm/ $^{\circ}\text{C}$
$V_N$	Noise	100 kHz / 1 kHz		8/24		nV/ $\sqrt{\text{Hz}}$
$C_H/C_L/C_W$	Potentiometer Capacitances			8/8/25		pF
fc	Frequency Response	Passive Attenuator, 10 k $\Omega$		1.7		MHz

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  $-1\text{ V}$  to  $V_{CC} + 1\text{ V}$ .

5.  $I_W$  = source or sink.

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

**Table 6. AC TEST CONDITIONS**

V <sub>CC</sub> Range	2.5 V ≤ V <sub>CC</sub> ≤ 6.0 V
Input Pulse Levels	0.2 × V <sub>CC</sub> to 0.7 × V <sub>CC</sub>
Input Rise and Fall Times	10 ns
Input Reference Levels	0.5 × V <sub>CC</sub>

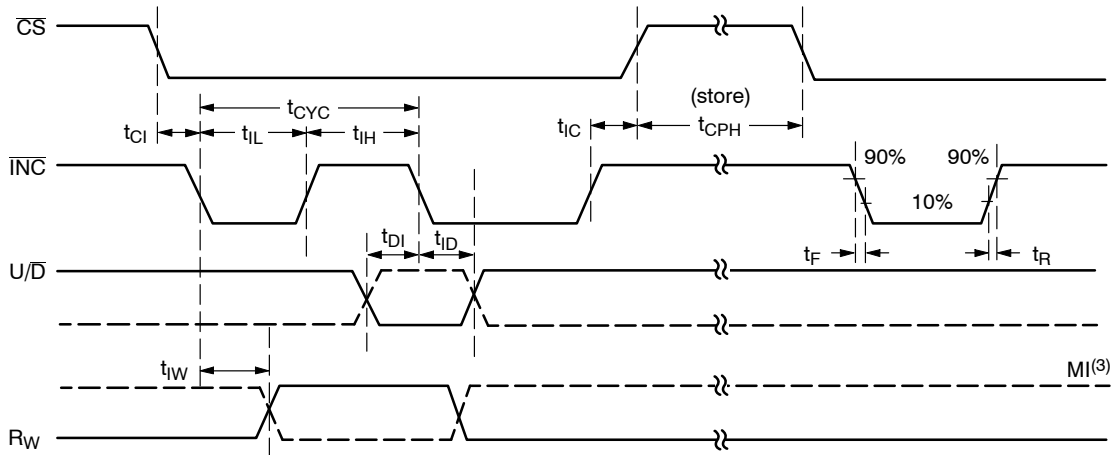
**Table 7. AC OPERATING CHARACTERISTICS** (V<sub>CC</sub> = +2.5 V to +6.0 V, V<sub>H</sub> = V<sub>CC</sub>, V<sub>L</sub> = 0 V, unless otherwise specified)

Symbol	Parameter	Min	Typ (Note 7)	Max	Units
t <sub>CI</sub>	CS to $\overline{\text{INC}}$ Setup	100	–	–	ns
t <sub>DI</sub>	U/D to $\overline{\text{INC}}$ Setup	50	–	–	ns
t <sub>ID</sub>	U/D to $\overline{\text{INC}}$ Hold	100	–	–	ns
t <sub>IL</sub>	$\overline{\text{INC}}$ LOW Period	250	–	–	ns
t <sub>IH</sub>	$\overline{\text{INC}}$ HIGH Period	250	–	–	ns
t <sub>IC</sub>	$\overline{\text{INC}}$ Inactive to CS Inactive	1	–	–	μs
t <sub>CPH</sub>	$\overline{\text{CS}}$ Deselect Time	100	–	–	ns
t <sub>IW</sub>	$\overline{\text{INC}}$ to V <sub>OUT</sub> Change	–	1	5	μs
t <sub>CYC</sub>	$\overline{\text{INC}}$ Cycle Time	1	–	–	μs
t <sub>R</sub> , t <sub>F</sub> (Note 8)	$\overline{\text{INC}}$ Input Rise and Fall Time	–	–	500	μs
t <sub>PU</sub> (Note 8)	Power-up to Wiper Stable	–	–	1	ms

7. Typical values are for T<sub>A</sub> = 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 5. A.C. Timing**

# CAT5115

## Applications Information

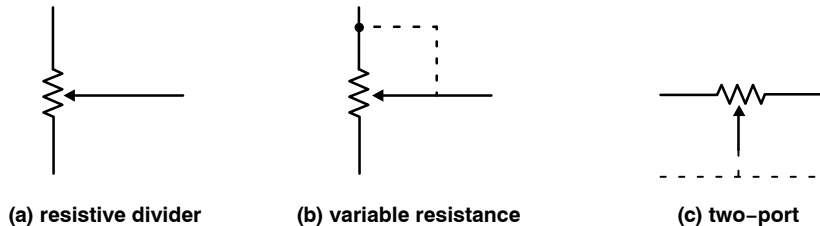


Figure 6. Potentiometer Configuration

## Applications

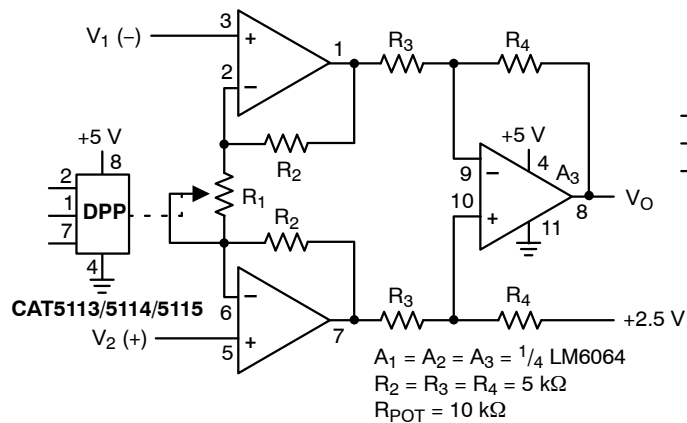


Figure 7. Programmable Instrumentation Amplifier

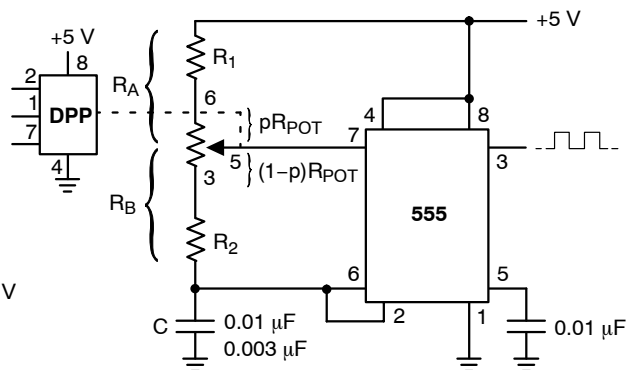


Figure 8. Programmable Sq. Wave Oscillator (555)

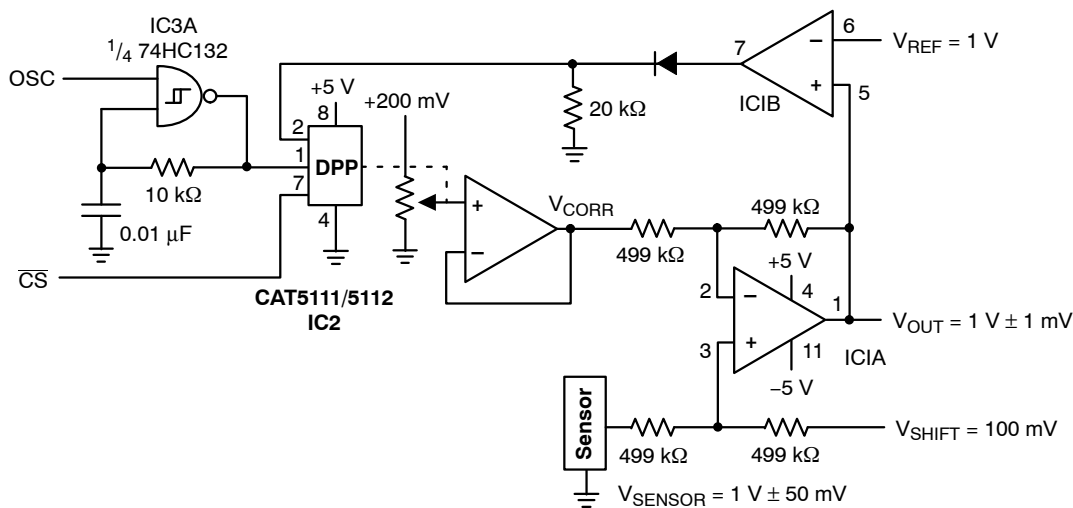


Figure 9. Sensor Auto Referencing Circuit

# CAT5115

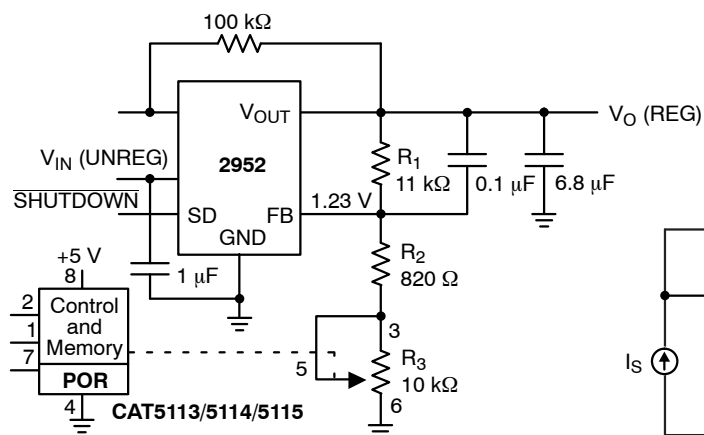


Figure 10. Programmable Voltage Regulator

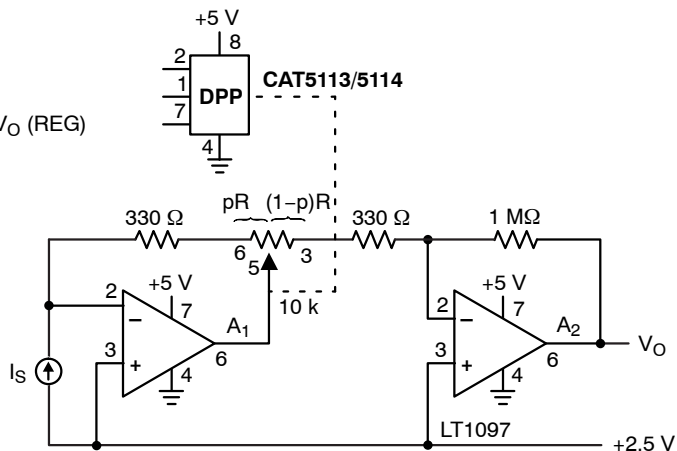


Figure 11. Programmable I to V Converter

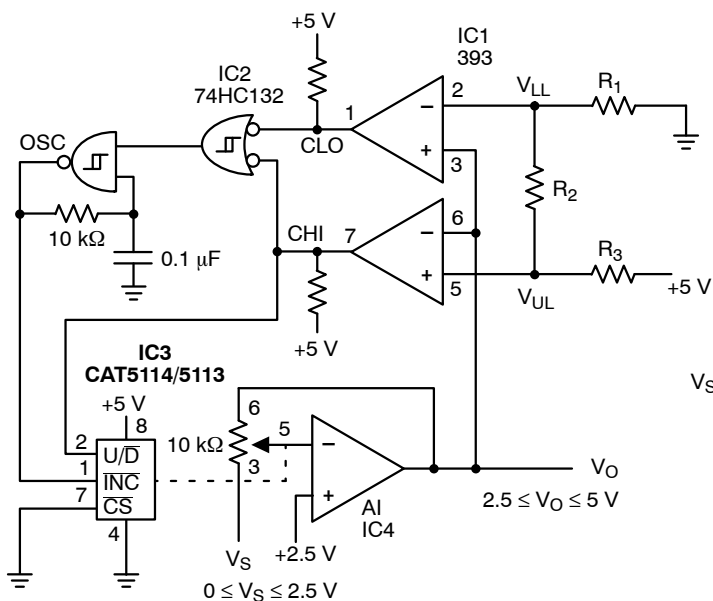


Figure 12. Automatic Gain Control

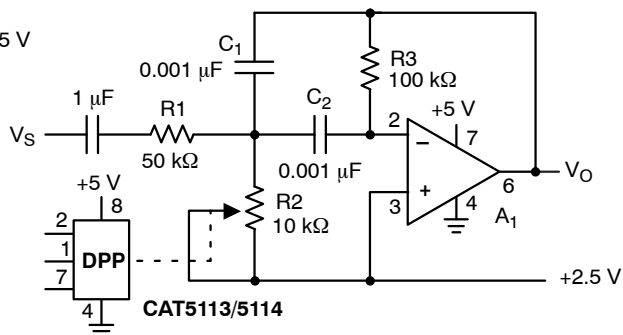


Figure 13. Programmable Bandpass Filter

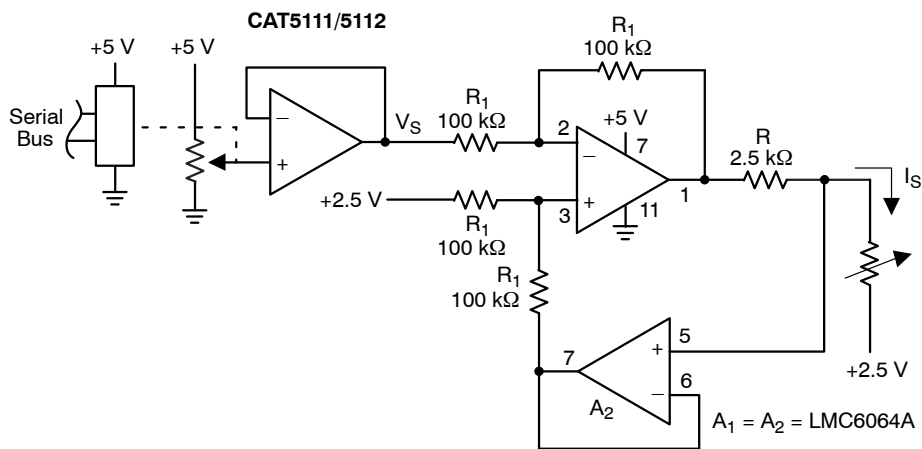
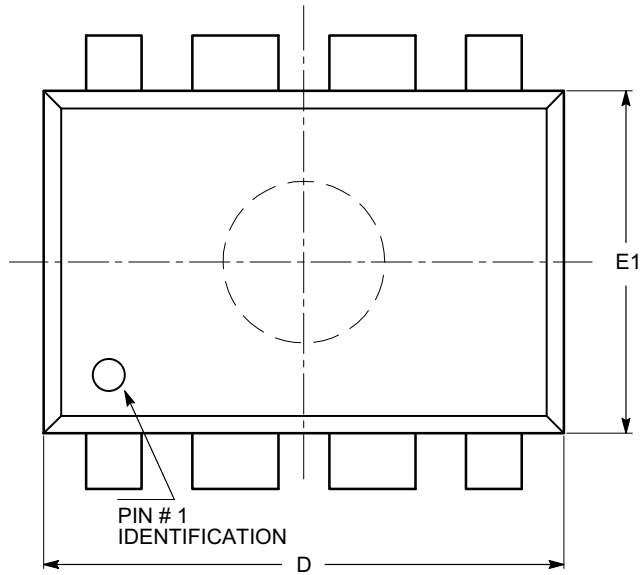


Figure 14. Programmable Current Source/Sink

# CAT5115

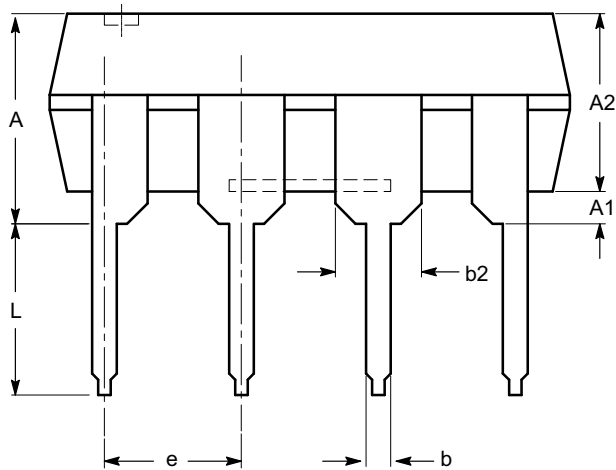
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PDIP-8, 300 mils  
CASE 646AA-01  
ISSUE A

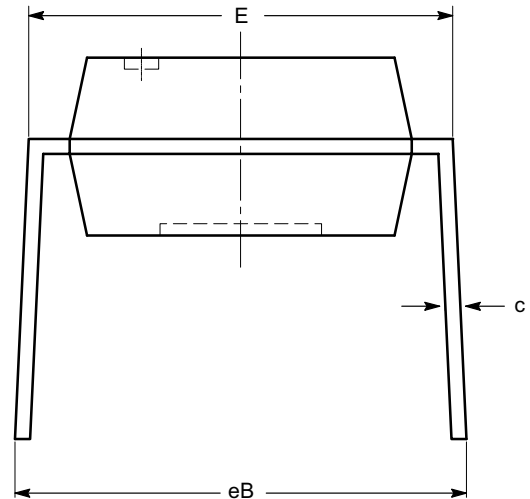


TOP VIEW

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:**

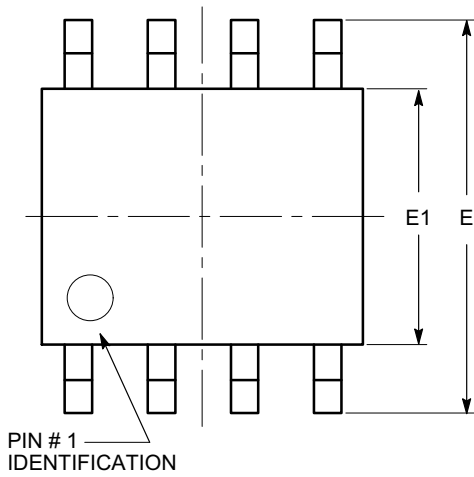
- (1) All dimensions are in millimeters.
- (2) Complies with JEDEC MS-001.



# CAT5115

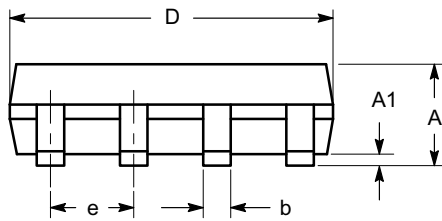
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SOIC 8, 150 mils  
CASE 751BD-01  
ISSUE O

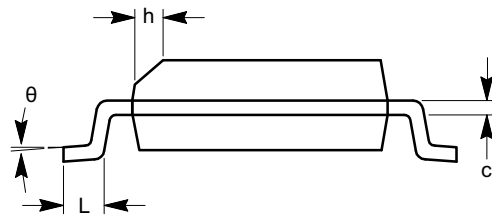


TOP VIEW

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
$\theta$	0°		8°



SIDE VIEW



END VIEW

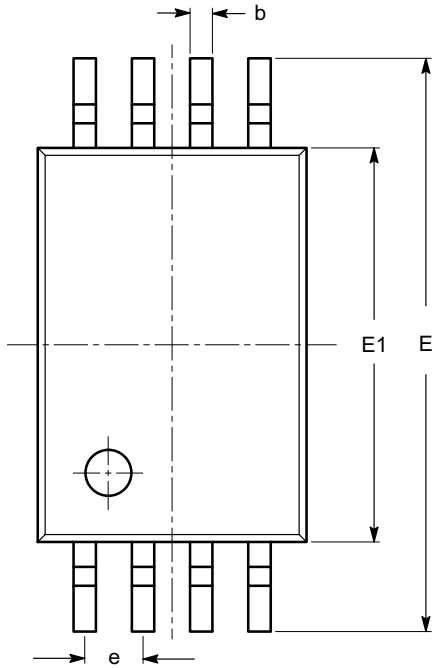
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- (1) All dimensions are in millimeters. Angles in degrees.
- (2) Complies with JEDEC MS-012.

# CAT5115

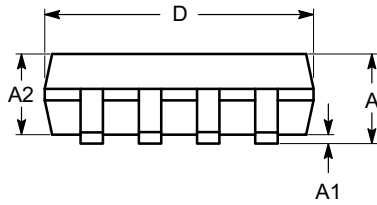
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CASE 948AL-01  
ISSUE O

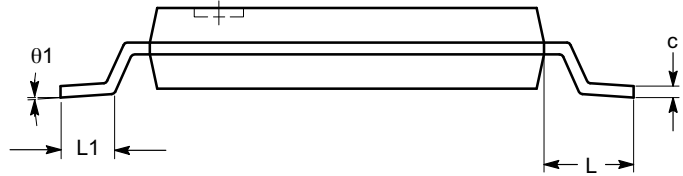


SYMBOL	MIN	NOM	MAX
A			1.20
A1	0.05		0.15
A2	0.80	0.90	1.05
b	0.19		0.30
c	0.09		0.20
D	2.90	3.00	3.10
E	6.30	6.40	6.50
E1	4.30	4.40	4.50
e	0.65 BSC		
L	1.00 REF		
L1	0.50	0.60	0.75
$\theta$	0°		8°

TOP VIEW



SIDE VIEW



END VIEW

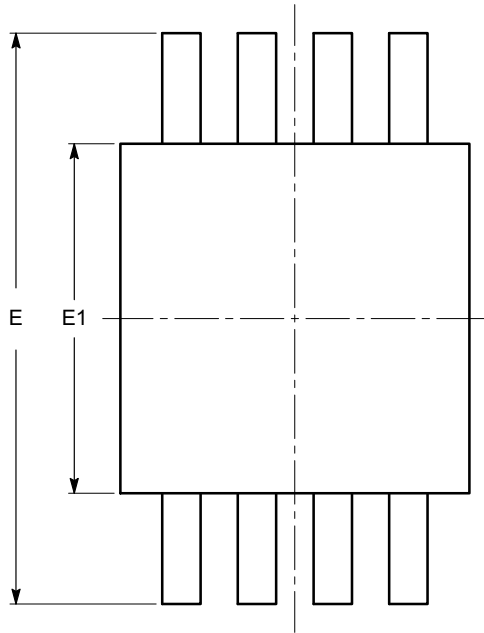
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- (2) Complies with JEDEC MO-153.

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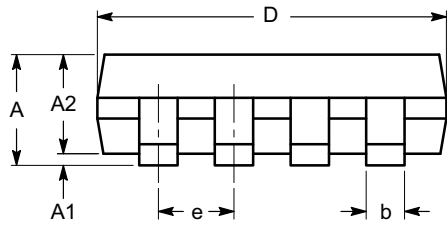
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MSOP 8, 3x3  
CASE 846AD-01  
ISSUE O

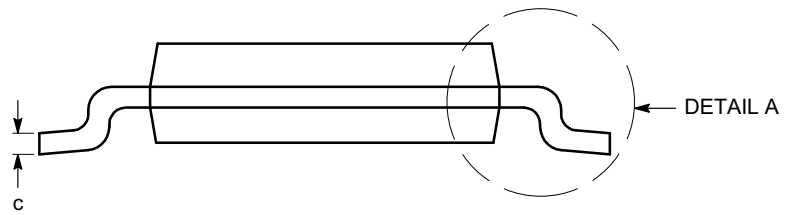


TOP VIEW

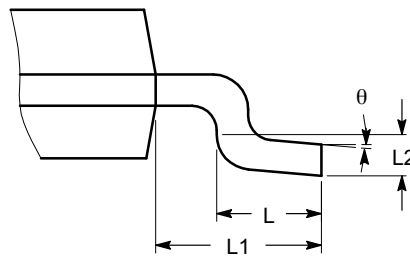
SYMBOL	MIN	NOM	MAX
A			1.10
A1	0.05	0.10	0.15
A2	0.75	0.85	0.95
b	0.22		0.38
c	0.13		0.23
D	2.90	3.00	3.10
E	4.80	4.90	5.00
E1	2.90	3.00	3.10
e	0.65 BSC		
L	0.40	0.60	0.80
L1	0.95 REF		
L2	0.25 BSC		
$\theta$	0°		6°



SIDE VIEW



END VIEW



DETAIL A

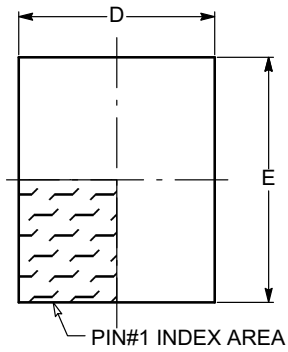
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- (1) All dimensions are in millimeters. Angles in degrees.
- (2) Complies with JEDEC MO-187.

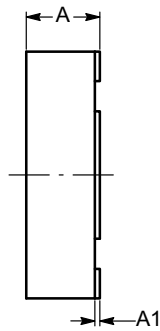
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## PACKAGE DIMENSIONS

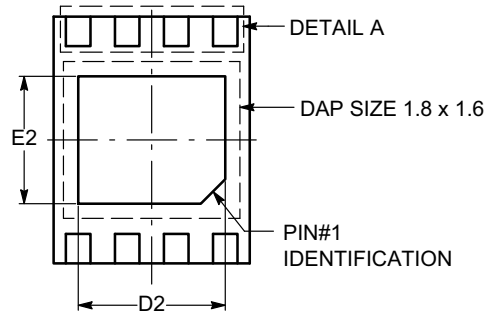
TDFN8, 2x2.5  
CASE 511AJ-01  
ISSUE A



TOP VIEW

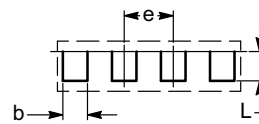


SIDE VIEW

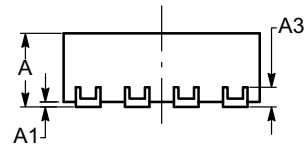


BOTTOM VIEW

SYMBOL	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A3	0.20 REF		
b	0.20	0.25	0.30
D	1.90	2.00	2.10
D2	1.40	1.50	1.60
E	2.40	2.50	2.60
E2	1.20	1.30	1.40
e	0.50 TYP		
L	0.20	0.30	0.40



DETAIL A



FRONT VIEW

**Notes:**

- (1) All dimensions are in millimeters.
- (2) Complies with JEDEC MO-229.

# CAT5115

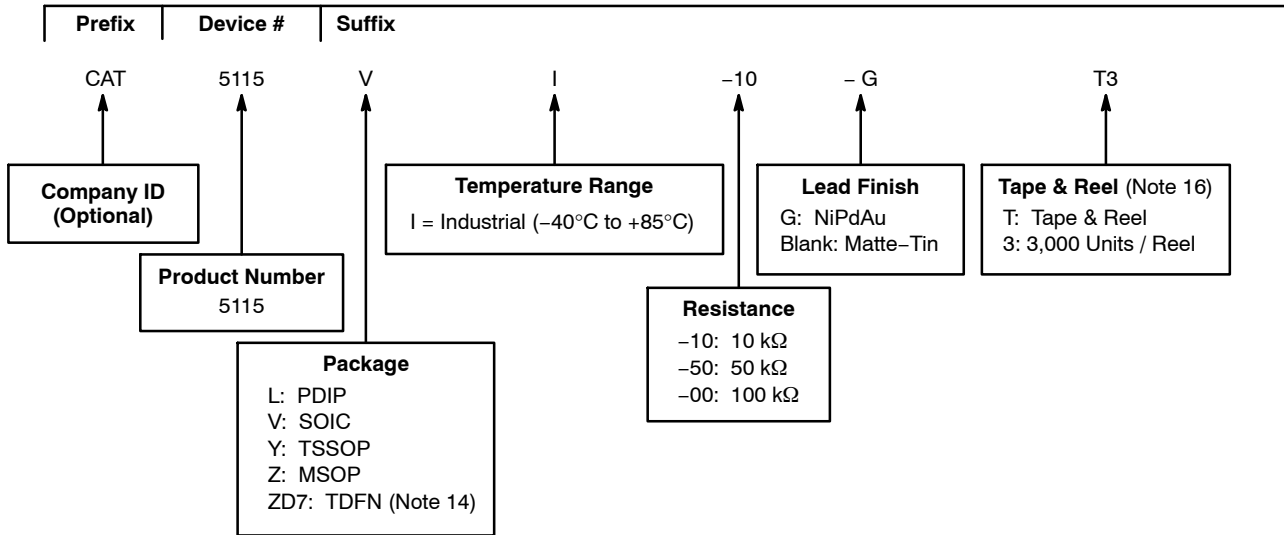
**Table 8. ORDERING INFORMATION**

Orderable Part Numbers	Reset Threshold Voltage	Package-Pin	Lead Finish
CAT5115LI-10-G	10	PDIP-8	NiPdAu
CAT5115LI-50-G	50		
CAT5115LI-00-G	100		
CAT5115VI-10-GT3	10	SOIC-8	NiPdAu
CAT5115VI-50-GT3	50		
CAT5115VI-00-GT3	100		
CAT5115YI-10-GT3	10	TSSOP-8	NiPdAu
CAT5115YI-50-GT3	50		
CAT5115YI-00-GT3	100		
CAT5115ZI-10-GT3	10	MSOP-8	NiPdAu
CAT5115ZI-50-GT3	50		
CAT5115ZI-00-GT3	100		
CAT5115ZD7I-10-T3 (Note 10)	10	TDFN-8 2 x 2.5 mm	Matte-Tin
CAT5115ZD7I-50-T3 (Note 10)	50		
CAT5115ZD7I-00-T3 (Note 10)	100		

10. Contact factory for package availability.

# CAT5115

## Example of Ordering Information (Note 15)



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

12. The standard lead finish is NiPdAu.


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

14. TDFN is not available in NiPdAu (-G) version.

15. The device used in the above example is a CAT5115VI-10-GT3 (SOIC, Industrial Temperature, 10 kΩ, NiPdAu, Tape & Reel, 3,000/Reel).

16. 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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**CAT5115/D**