16 Volt Digitally Programmable Potentiometer (DPP™) with 128 Taps and an Increment Decrement Interface

HALOGEN FREE LEAD FREE™ RoHS Compliance

FEATURES

- **Single linear DPP with 128 taps**
- **End-to-end resistance of 10kΩ, 50kΩ or 100kΩ**
- **2-wire interface**
- **Fast Up/Down wiper control mode**
- **Non-volatile wiper setting storage**
- **Automatic wiper setting recall at power-up**
- **Digital Supply range (V_{CC}): 2.7V to 5.5V**
- **Analog Supply range (V+): +8V to +16V**
- **Low Standby Current: 15µA**
- **100 Year wiper setting memory**
- **Industrial Temperature range: -40ºC to +85ºC**
- **RoHS-compliant 10-pin MSOP package**

APPLICATION

- **LCD screen Adjustment**
- **Volume Control**
- **Mechanical potentiometer replacement**
- **Gain adjustment**
- **Line impedance matching**
- **VCOM settings adjustment**

For Ordering Information details, see page 9.

DESCRIPTION

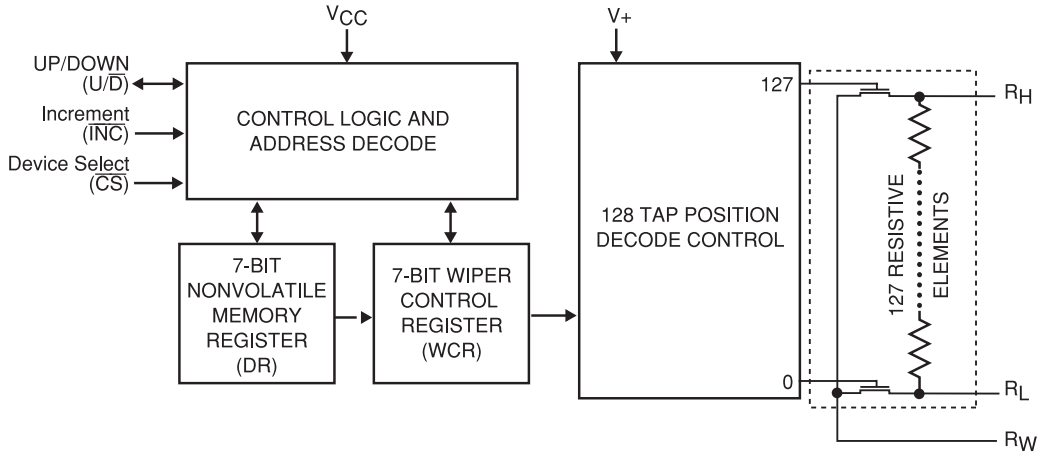
The CAT5133 is a high voltage Digital Programmable Potentiometer (DPP) integrated with EEPROM memory and control logic to operate in a similar manner to a mechanical potentiometer. The DPP consists of a series of resistive elements connected between two externally accessible end points. The tap points between each resistive element are connected to the wiper outputs with CMOS switches. A 7-bit wiper control register (WCR) independently controls the wiper tap switches for the DPP. Associated with the control register is a 7-bit nonvolatile memory data register (DR) used for storing the wiper settings. Changing the value of the wiper control register or storing that value into the nonvolatile memory is performed via a 3-input Increment-Decrement interface.

The CAT5133 comes with 2 voltage supply inputs: V_{CC} (digital supply voltage) input and V+ (analog bias supply) input. Providing separate Digital and Analog inputs allow the potentiometer terminals to be as much as 10 volts above V_{CC} and 16 volts above ground.

The CAT5133 can be used as a potentiometer or as a two terminal, variable resistor. It is designed for circuit level or system level adjustments in a wide variety of applications.

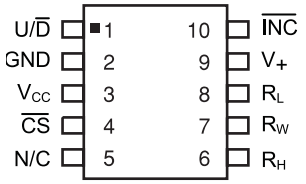
On power-up, the contents of the nonvolatile data register (DR) are transferred to the wiper control register (WCR) and the wiper is positioned to that location. The CAT5133 is shipped with the DR programmed to position 64.

BLOCK DIAGRAM



PIN CONFIGURATION

MSOP Package (GZ)



PIN DESCRIPTIONS

Pin	Name	Function
1	U/$\overline{D}$	Up/Down Data Input – Determines the direction of movement of the wiper
2	GND	Ground
3	V_{CC}	Logic Supply Voltage (2.7V to 5.5V)
4	$\overline{CS}$	Chip Select – The chip is selected when the input is low.
5	N/C	No Connect
6	R_H	High Reference Terminal for the Potentiometer
7	R_W	Wiper Terminal for the Potentiometer
8	R_L	Low Reference Terminal for the Potentiometer
9	V_+	Analog Bias Voltage Input (+8.0V to +16.0V)
10	$\overline{INC}$	Increment Input – Moves the wiper in the direction determined by the Up/Down input on each negative edge

DEVICE OPERATION

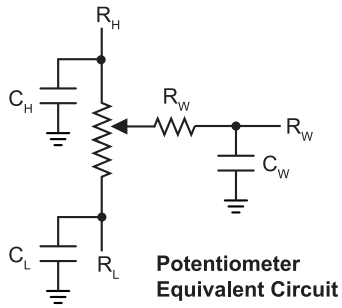
The CAT5133 operates like a digitally controlled potentiometer with R_H and R_L equivalent to the high and low terminals and R_W equivalent to the mechanical potentiometer's wiper. There are 128 available tap positions including the resistor end points, R_H and R_L. There are 127 resistor elements connected in series between the R_H and R_L terminals. The wiper terminal is connected to one of the 128 taps and controlled by three inputs, $\overline{INC}$, U/$\overline{D}$ and $\overline{CS}$. These inputs control a 7-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 CAT5133 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 7-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 $\overline{CS}$ transitions HIGH while the $\overline{INC}$ input is also HIGH. When the CAT5133 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 CAT5133 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.

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



Potentiometer Equivalent Circuit

POWER-ON AND POTENTIOMETER CHARACTERISTICS

The CAT5133 is a 128-position, digital controlled potentiometer. When applying power to the CAT5133, V_{CC} must be supplied prior to or simultaneously with V+. At the same time, the signals on R_H, R_W and R_L terminals should not exceed V+. If V+ is applied before V_{CC}, the electronic switches of the DPP are powered in the absence of the switch control signals, that could result in multiple switches being turned on. This causes unexpected wiper settings and possible current overload of the potentiometer.

When V_{CC} is applied, the device turns on at the mid-point wiper location (64) until the wiper register can be loaded with the nonvolatile memory location previously stored in the device. After the nonvolatile memory data is loaded into the wiper register the wiper location will change to the previously stored wiper position.

At power-down, it is recommended to turn-off first the signals on R_H, R_W and R_L, followed by V+ and, after that, V_{CC}, in order to avoid unexpected transitions of the wiper and uncontrolled current overload of the potentiometer.

The end-to-end nominal resistance of the potentiometer has 128 contact points linearly distributed across the total resistor. Each of these contact points is addressed by the 7 bit wiper register which is decoded to select one of these 128 contact points.

Each contact point generates a linear resistive value between the 0 position and the 127 position. These values can be determined by dividing the end-to-end value of the potentiometer by 127. The 10kΩ potentiometer has a resistance of ~79Ω between each wiper position. However in addition to the ~79Ω for each resistive segment of the potentiometer, a wiper resistance offset must be considered. Table 8 shows the effect of this value and how it would appear on the wiper terminal.

This offset will appear in each of the CAT5133 end-to-end resistance values in the same way as the 10kΩ example. However resistance between each wiper position for the 50kΩ version will be ~395Ω and for the100kΩ version will be ~790Ω.

Potentiometer Resistance and Wiper Resistance Offset Effects

Position	Typical R_W to R_L Resistance for 10kΩ DPP	
0	70Ω or	0Ω + 70Ω
01	149Ω or	79Ω + 70Ω
63	5,047Ω or	4,977Ω + 70Ω
127	10,070Ω or	10,000Ω + 70Ω

Position	Typical R_W to R_H Resistance for 10kΩ DPP	
00	10,070Ω or	10,000Ω + 70Ω
64	5,047Ω or	4,977Ω + 70Ω
126	149Ω or	79Ω + 70Ω
127	70Ω or	0Ω + 70Ω

ABSOLUTE MAXIMUM RATINGS(1)

Parameters	Ratings	Units
Temperature Under Bias	-55 to +125	°C
Storage Temperature	-65 to +150	°C
Voltage on any U/$\overline{D}$, $\overline{INC}$,& $\overline{CS}$ Pins with Respect to V_{CC}(2)	-0.3 to +V_{CC}+0.3	V
Voltage on R_H, R_L, & R_W Pins with Respect to V_{CC}	V+	V
V_{CC} with Respect to Ground	-0.3 to +6.0	V
V+ with respect to Ground	-0.3 to +16.5	V
Wiper Current	±6	mA
Lead Soldering temperature (10 seconds)	+300	°C

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) Latch-up protection is provided for stresses up to 100mA on the digital from -0.3V to V_{CC} +0.3V.

RECOMMENDED OPERATING CONDITIONS

V_{CC} = +2.7V to +5.5V

V+ = +8.0V to +16.0V

Operating Temperature Range: -40°C to +85°C

POTENTIOMETER CHARACTERISTICS

(Over recommended operating conditions unless otherwise stated.)

Symbol	Parameter	Test Conditions	Limits			Units
			Min	Typ	Max	
R_{POT}	Potentiometer Resistance (10kΩ)			10		kΩ
R_{POT}	Potentiometer Resistance (50kΩ)(7)			50		kΩ
R_{POT}	Potentiometer Resistance (100kΩ)(7)			100		kΩ
R_{TOL}	Potentiometer Resistance Tolerance				±20	%
	Power Rating	25ºC			50	mW
I_W	Wiper Current				±3	mA
R_W	Wiper Resistance	I_W = +1mA @ V+ = 12V		70	150	Ω
		I_W = +1mA @ V+ = 8V		110	200	Ω
V_{TERM}	Voltage on R_W , R_H or R_L	GND = 0V; V+ = 8V to 16V	GND		V+	V
RES	Resolution			0.78		%
A_{LIN}	Absolute Linearity(2)	$V_{W(n)(actual)} - V_{W(n)(expected)}$ (5), (6)			±1	LSB(4)
R_{LIN}	Relative Linearity(3)	$V_{W(n+1)} - [V_{W(n)} + LSB]$ (5), (6)			±0.5	LSB(4)
TC_{RPOT}	Temperature Coefficient of R_{POT}	(1)		±300		ppm/°C
TC_{Ratio}	Ratiometric Temperature Coefficient	(1)			30	ppm/°C
$C_H/C_L/C$	Potentiometer Capacitances	(1)		10/10/25		pF
fc	Frequency Response	R_{POT} = 50kΩ		0.4		MHz

Notes:

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

(2) Absolute linearity is utilized to determine actual wiper voltage versus expected voltage as determined by wiper position when used as a potentiometer.

(3) Relative linearity is utilized to determine the actual change in voltage between two successive tap positions when used as a potentiometer.

(4) LSB = $(R_{HM} - R_{LM})/127$; where R_{HM} and R_{LM} are the highest and lowest measured values on the wiper terminal.

(5) n = 1, 2, ..., 127.

(6) V^+ @ R_H; 0V @ R_L; V_W measured @ R_W, with no load.

(7) Contact factory for availability on this version of the CAT5133.

DC ELECTRICAL CHARACTERISTICS

V_{CC} = +2.7V to +6.0V, unless otherwise specified.

Symbol	Parameter	Test Conditions	Min	Max	Units
I_{CC1}	Power Supply Current	V_{CC} = 5.5V, f_{INC} = 1MHz, Input = GND		1	mA
I_{CC2}	Power supply Current Nonvolatile WRITE	V_{CC} = 5.5V, f_{INC} = 1MHz, Input = GND		3.0	mA
$I_{SB(VCC)}$	Standby Current (V_{CC} = 5V)	V_{IN} = GND or V_{CC}, INC = VCC		5	µA
$I_{SB(V+)}$	V+ Standby Current	V_{CC} = 5V, V+ = 16V		10	µA
I_{LI}	Input Leakage Current	V_{IN} = GND to V_{CC}		10	µA
I_{LO}	Output Leakage Current	V_{OUT} = GND to V_{CC}		10	µA
V_{IL}	Input Low Voltage		-1	V_{CC} x 0.3	V
V_{IH}	Input High Voltage		V_{CC} x 0.7	V_{CC} + 1.0	V
V_{OL1}	Output Low Voltage (V_{CC} = 3.0V)	I_{OL} = 3 mA		0.4	V

CAPACITANCE

T_A = 25ºC, f = 1.0MHz, V_{CC} = 5.0V

Symbol	Parameter	Test Conditions	Min	Max	Units
$C_{I/O}$	Input/Output Capacitance (SDA)	$V_{I/O}$ = 0V(1)		8	pF
C_{IN}	Input Capacitance (A0, A1, SCL)	V_{IN} = 0V(1)		6	pF

POWER UP TIMING(1)(2)

Symbol	Parameter	Min	Max	Units
t_{PUR}	Power-up to Read Operation		1	ms
t_{PUW}	Power-up to Write Operation		1	ms

WIPER TIMING

Symbol	Parameter	Min	Max	Units
t_{WRPO}	Wiper Response Time After Power Supply Stable	5	10	µs
t_{WRL}	Wiper Response Time After Instruction Issued	5	10	µs

WRITE CYCLE LIMITS

Symbol	Parameter	Min	Max	Units
t_{WR}	Write Cycle Time		5	ms

RELIABILITY CHARACTERISTICS

(Over recommended operating conditions unless otherwise stated.)

Symbol	Parameter	Reference Test Method	Min	Max	Units
N_{END}(1)	Endurance	MIL-STD-883, Test Method 1033	100,000		Cycles/Byte
T_{DR}(1)	Data Retention	MIL-STD-883, Test Method 1008	100		Years

Notes:

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

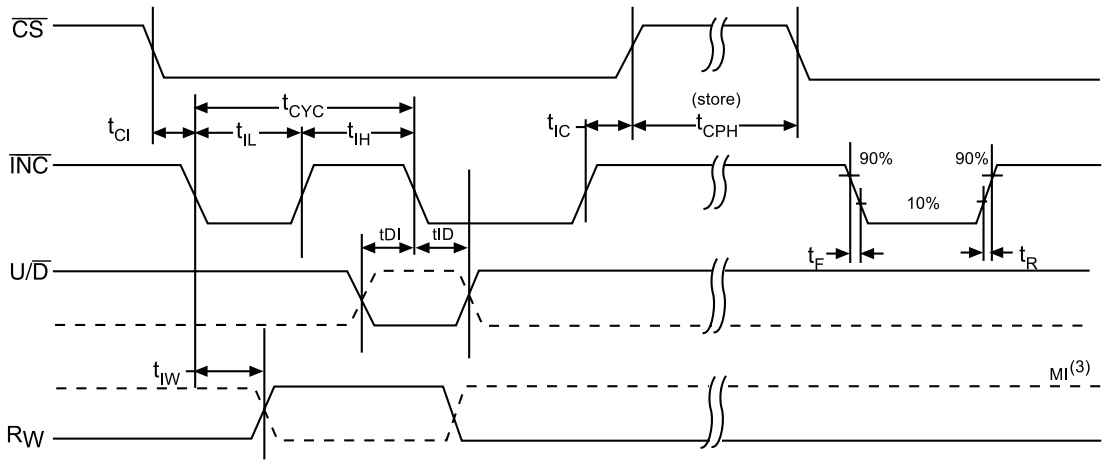
(2) t_{PUR} and t_{PUW} are the delays required from the time V_{CC} is stable until the specified operation can be initiated.

A.C. OPERATIONG 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 INC Setup	100			ns
t_{DI}	U/D to $\overline{INC}$ Setup	50			ns
t_{ID}	U/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 VOUT 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



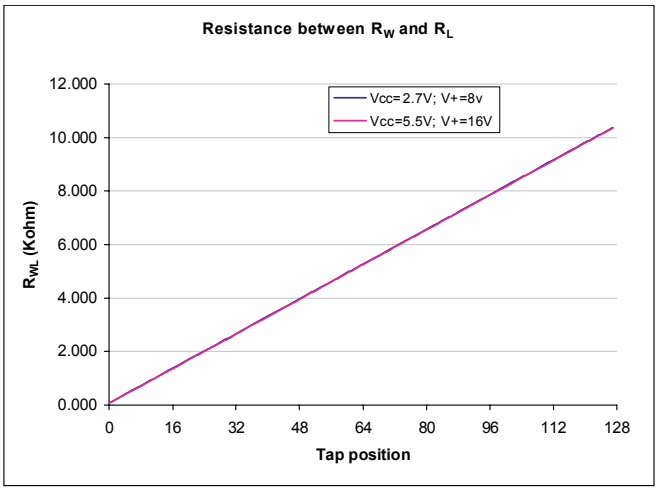
Notes:

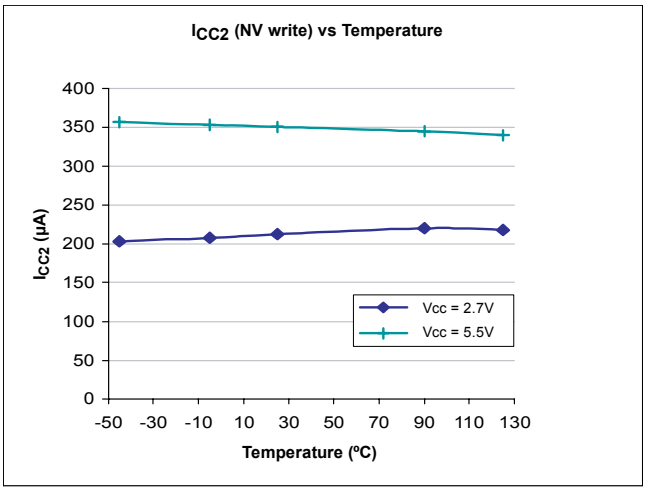
(1) Typical values are for T_A=25ºC and nominal supply voltage.

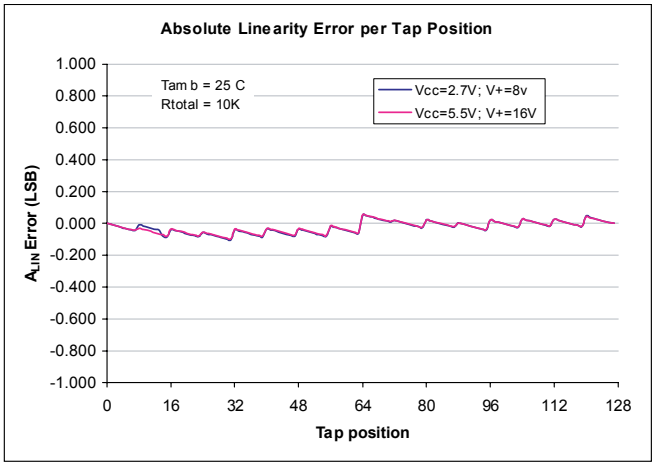
(2) This parameter is periodically sampled and not 100% tested.

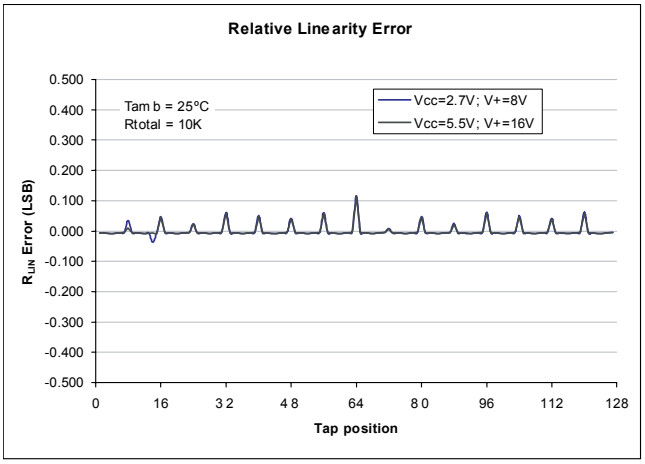
(3) MI in the A.C. Timing diagram refers to the minimum incremental change in the W output due to a change in the wiper position.

TYPICAL PERFORMANCE CHARACTERISTICS



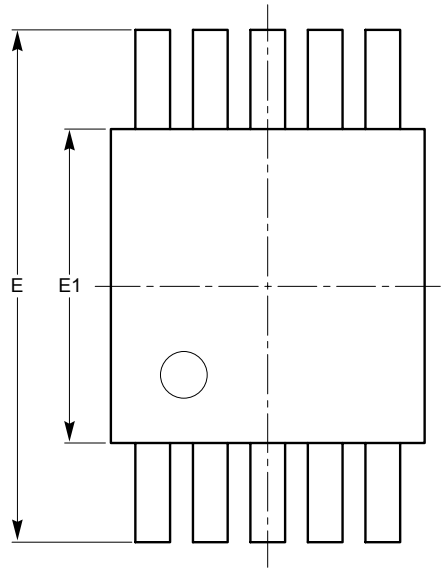






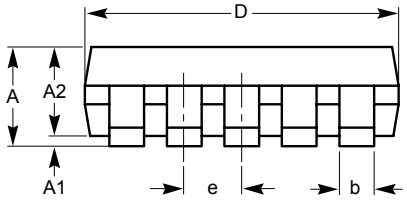
PACKAGE OUTLINE DRAWINGS

MSOP 10-Lead 3.0 x 3.0mm (Z) (1)(2)

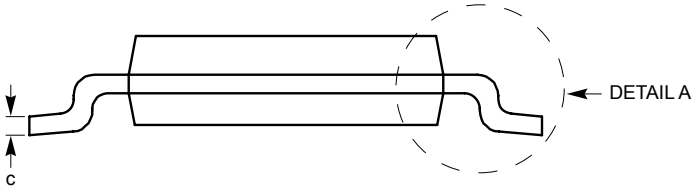


TOP VIEW

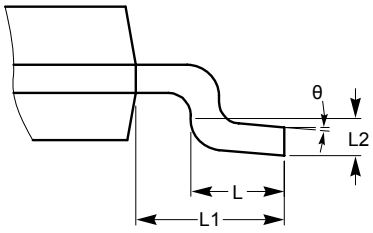
SYMBOL	MIN	NOM	MAX
A			1.10
A1	0.00	0.05	0.15
A2	0.75	0.85	0.95
b	0.17		0.27
c	0.13		0.23
D	2.90	3.00	3.10
E	4.75	4.90	5.05
E1	2.90	3.00	3.10
e		0.50 BSC	
L	0.40	0.60	0.80
L1		0.95 REF	
L2		0.25 BSC	
θ	0°		8°



SIDE VIEW



END VIEW

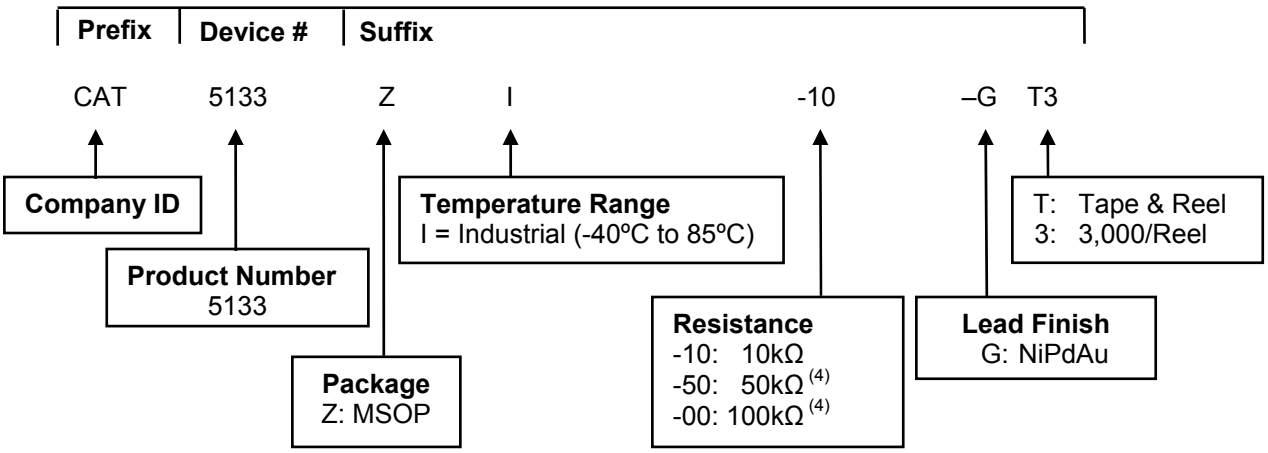


DETAIL A

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 MO-187.

EXAMPLE OF ORDERING INFORMATION



ORDERING PART NUMBER

CAT5133ZI-10-GT3
CAT5133ZI-50-GT3(4)
CAT5133ZI-00-GT3(4)

For Product Top Mark Codes, click here:
http://www.catsemi.com/techsupport/producttopmark.asp

Notes:
(1) All packages are RoHS-compliant (Lead-free, Halogen-free).
(2) The standard lead finish is NiPdAu.
(3) The device used in the above example is a CAT5133ZI-10-GT3 (MSOP, Industrial Temperature range, 10kΩ, NiPdAu, Tape & Reel, 3,000/Reel).
(4) For additional package and temperature options, please contact your nearest Catalyst Semiconductor Sales office.

REVISION HISTORY

Date	Rev.	Reason
04/28/06	A	Initial Issue
11/03/06	B	Update Ordering Information
03/14/2008	C	Update Package Outline Drawing Add MD- to Document Number Add Link to Top Mark Codes

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