One-Time Digitally Programmable 32-Tap Potentiometer

FEATURES

- Wiper position stored after one-time non-volatile programming
- User-defined Power-On wiper position
- 32-tap positions
- Wiper position programmed through simple 2-wire serial interface
- Low 0.35 µA (typ) static supply current
- 2.5 V to 5.5 V single-supply operation
- 10 kΩ, 50 kΩ, and 100 kΩ end-to-end resistances
- 50 ppm/°C end-to-end temperature coefficient and 5 ppm/°C ratiometric temperature coefficient
- TDFN 8-pad (2 x 3 mm) and MSOP 8-lead packages

APPLICATIONS

- Mechanical potentiometer replacement
- Products using one-time factory calibration
- Contrast, brightness, volume controls
- Programmable analog functions

DESCRIPTION

The CAT5126 is a digital programmable potentiometer. The wiper position is controlled with a simple 2-wire digital interface. This digital potentiometer is unique in that it has an optional one-time programmable feature that either sets the wiper's position upon power-on to a user-defined value, or the wiper can be set and the interface also disabled to prevent further adjustment.

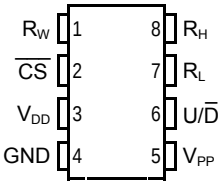
The CAT5126 has an end-to-end resistance of 10 kΩ, 50 kΩ, and 100 kΩ. All CAT5126 devices have 32-wiper positions and operate from a single 2.5 V to 5.5 V supply.

The CAT5126 is available in TDFN 8-pad and MSOP 8-lead packages. Each device is guaranteed over the industrial temperature range of -40°C to +85°C.

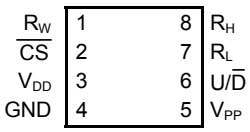
For Ordering Information details, see page 10.

PIN CONFIGURATION

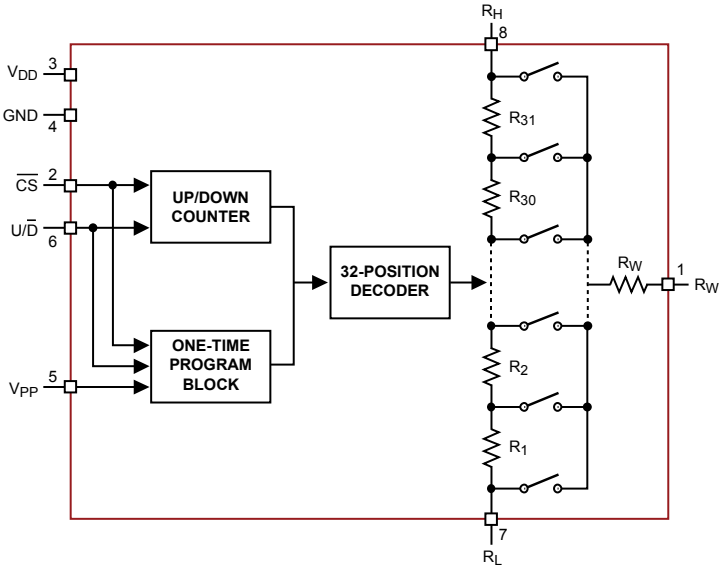
MSOP (Z)
(top view)



TDFN (VP2)
(top view)



FUNCTIONAL DIAGRAM



PIN DESCRIPTION

Pin	Name	Function
1	R_W	Wiper Connection
2	$\overline{CS}$	Chip-Select Input. A high-to-low $\overline{CS}$ transition determines the mode: increment if U/$\overline{D}$ is high, or decrement if U/$\overline{D}$ is low. $\overline{CS}$ is also used for one-time programming (see the One-Time Programming section).
3	V_{DD}	Power-Supply Voltage
4	GND	Ground
5	V_{PP}	Programming Voltage for One-Time Programming. Connect V_{PP} to 10 V supply when one-time programming the device. For normal operation, connect to ground or let float.
6	U/$\overline{D}$	Up/Down Control Input. With $\overline{CS}$ low, a low-to-high transition increments or decrements the wiper position.
7	R_L	Low Terminal of Resistor
8	R_H	High Terminal of Resistor

ABSOLUTE MAXIMUM RATINGS (1)

Parameters	Ratings	Units
V_{DD} to GND	-0.5 to +7.0	V
V_{PP} to GND	-0.5 to +12.0	V
All other pins to GND	-0.5 to V_{DD} +0.5	V
Maximum Continuous Current into H, L, and W	±1.5	mA
Continuous Power Dissipation (T_A = +70°C) MSOP 8-Lead (derate 4.5mW/°C above +70°C) TDFN 8-Pad (derate 24.4mW/°C above +70°C)	 362 1951	 mW mW
Operating Temperature Range	-40 to +85	ºC
Junction Temperature	+150	ºC
Storage Temperature Range	-65 to +150	ºC
Lead Temperature (soldering, 10 s)	+300	ºC

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.

ELECTRICAL CHARACTERISTICS

V_{DD} = 2.5 V to 5.5 V, V_{PP} = GND, R_H = V_{DD}, R_L = GND, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at V_{DD} = 5.0 V, T_A = +25°C, unless otherwise noted.(1)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
DC PERFORMANCE						
RES	Resolution			3.2		%
R_{POT}	End-to-End Resistance	-10 Device	8	10	12	kΩ
		-50 Device	40	50	60	
		-00 Device	80	100	120	
TC_{RPOT}	TC of Pot Resistance			±50	±300	ppm/°C
TC_{RATIO}	Ratiometric Resistance TC			±5	±20	ppm/°C
INL	Integral Nonlinearity	Potentiometer configuration, no load		0.5	1	LSB
DNL	Differential Nonlinearity	Potentiometer configuration, no load		0.25	0.5	LSB
R_W	Wiper Resistance	V_{DD} = 5 V		70	100	Ω
		V_{DD} = 2.5 V		150	200	Ω
DIGITAL INPUTS ($\overline{CS}$, U/$\overline{D}$)						
V_{IH}	Input High Voltage		0.7 x V_{DD}			V
V_{IL}	Input Low Voltage				0.3 x V_{DD}	V
I_{IN}	Input Leakage Current			±0.1	±1	µA
C_{IN}	Input Capacitance			5		pF
POWER SUPPLY						
V_{DD}	Supply Voltage		2.5		5.5	V
I_{DD}	Stand by Current	(Note 2)		0.35	1	µA
I_{DDW}	Programming Current			0.25	1	mA
V_{PP}	Programming Voltage	V_{DD} = 5 V		8.5	10	V
		V_{DD} = 2.5 V		6.0	10	
I_{PP}	V_{PP} Input Current	V_{PP} = 10 V			5	µA

Notes:
(1) All devices are production tested at T_A = +25°C and are guaranteed by design for TA = -40°C to +85°C.
(2) Digital inputs $\overline{CS}$ and U/$\overline{D}$ are connected to GND or V_{DD}.

ELECTRICAL CHARACTERISTICS (continued)

V_{DD} = 2.5 V to 5.5 V, V_{PP} = GND, V_H = V_{DD}, V_L = GND, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at V_{DD} = 5.0 V, T_A = +25°C, unless otherwise noted. (1)

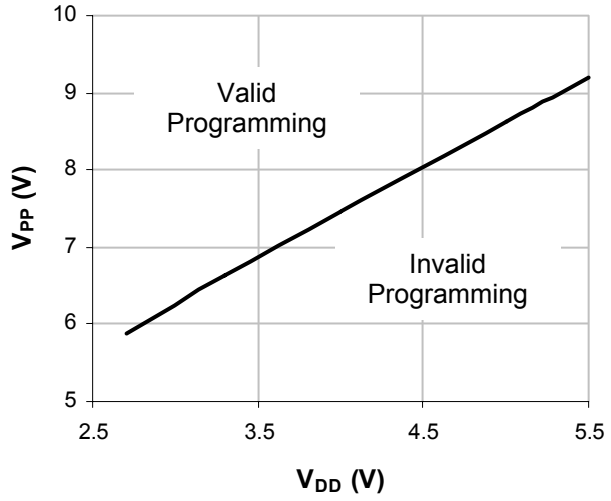
TIMING CHARACTERISTICS (2)						
Symbol	**Parameter**	**Conditions**	**Min**	**Typ**	**Max**	**Units**
t_{CU}	U/$\overline{D}$ Mode to $\overline{CS}$ Setup	Figures 1, 2	50			ns
t_{CI}	$\overline{CS}$ Hold to U/$\overline{D}$ Mode	Figures 1, 2	50			ns
t_{IC}	U/$\overline{D}$ Step Hold to $\overline{CS}$	Figures 1, 2	0			ns
t_{IL}	U/$\overline{D}$ Step Low Time	Figures 1, 2	100			ns
t_{IH}	U/$\overline{D}$ Step High Time	Figures 1, 2	100			ns
t_{IW}	Wiper Switching Time	C_L = 0 pF, Figures 1, 2		100		ns
t_{PC}	V_{PP} Rising Edge to $\overline{CS}$ Falling Edge	Figure 3	1			ms
t_{CP}	$\overline{CS}$ Falling Edge to V_{PP} Falling Edge	Figure 3	5			ms
t_{CL}	$\overline{CS}$ Step Low Time	Figure 3	5			ms
t_{CH}	$\overline{CS}$ Step High Time	Figure 3	5			ms
t_{PH}	V_{PP} Falling Edge to $\overline{CS}$ Rising Edge	Figure 3	1			ms
$f_{U/\overline{D}MAX}$	U/$\overline{D}$ Frequency				5	MHz
t_{UP}	Power-Up Time	(Note 3)			1	ms
t_{SETTLE}	Output Settling Time	100 kΩ variable resistor configuration, C_L = 10 pF		1		µs
		100 kΩ potentiometer configuration, C_L = 10 pF		0.25		

Notes:
(1) All devices are production tested at TA = +25°C and are guaranteed by design for TA = -40°C to +85°C.
(2) Digital timing is guaranteed by design, not production tested.
(3) Power-up time is the period of time from when the power supply is applied until the serial interface is ready for writing.

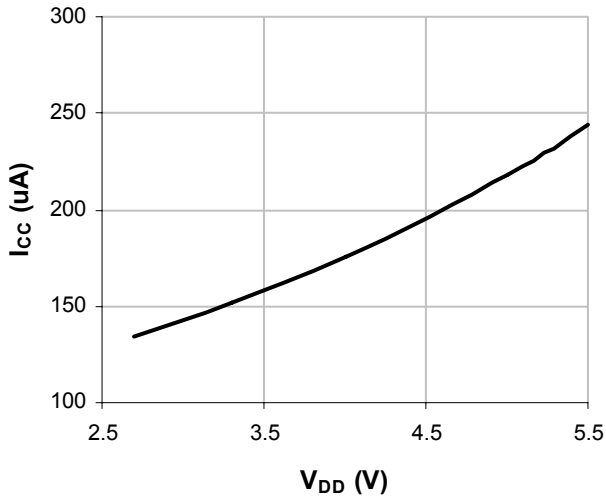
TYPICAL OPERATING CHARACTERISTICS

V_{DD} = 2.5 V to 5.5 V, V_{PP} = GND, V_H = V_{DD}, V_L = GND, T_A = +25°C.

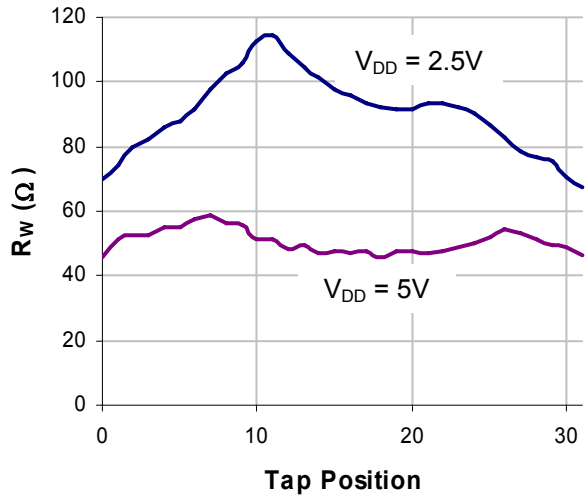
V_{PP} vs. V_{DD}



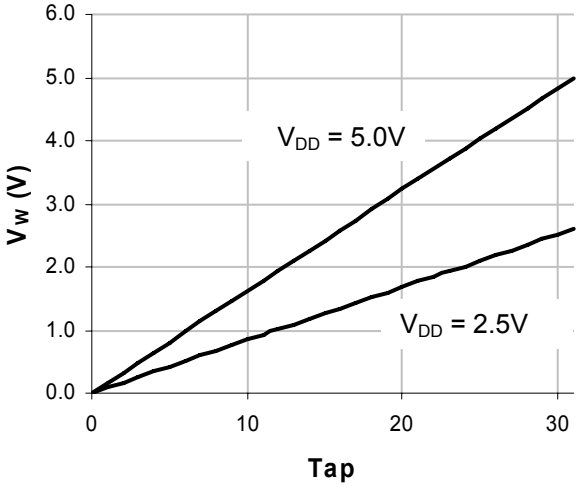
I_{DD} programming vs. V_{DD}



Wiper Resistance vs. Tap Position @ 25°C



Wiper Voltage vs. Tap Position



DETAILED DESCRIPTION

The CAT5126 devices are 10 kΩ/50 kΩ/100 kΩ (end-to-end resistance) digitally controlled potentiometers. They have 32-tap positions that are accessible to the wiper along the resistor array between R_H and R_L.

The wiper (R_W) position is adjusted sequentially through the tap positions using a simple I^2C interface. These digital potentiometers have an optional one-time programmable feature that sets the POR position of the wiper. The I^2C interface can then be disabled, permanently preventing unwanted adjustment.

DIGITAL INTERFACE OPERATION

The CAT5126 devices have two modes of operation when the serial interface is active: increment mode and decrement mode. The serial interface is only active when $\overline{CS}$ is low.

The $\overline{CS}$ and U/$\overline{D}$ inputs control the position of the wiper along the resistor array. When $\overline{CS}$ transitions from high to low, the part goes into increment mode if U/$\overline{D}$ is high (Figure 1), and into decrement mode if U/$\overline{D}$ is low (Figure 2). Once the mode is set, the device remains in that mode until $\overline{CS}$ goes high. A low-to-high transition at the U/$\overline{D}$ increments or decrements the wiper position depending on the current mode.

The value of the counter is then stored and the wiper position is maintained till the device is Powered down.

The wiper performs a make-before-break transition, ensuring that there is never an open circuit during a transition from one resistor tap to another. When the wiper is at either end (max/min) of the resistor array, additional transitions in the direction of the endpoint do not change the counter value (the counter does not wrap around).

One-Time Programming

The factory-set default position of the wiper on power-up is tap 16. However, the power-up position can be changed once using the one-time programming feature. After the wiper is moved to the desired position, the programming sequence is initiated by setting U/$\overline{D}$ high, applying 10 V to V_{PP}, and then taking $\overline{CS}$ low. Five pulses on $\overline{CS}$ (consisting of $\overline{CS}$ starting from low and going high for t_{CH} and then low for t_{CL}) program the device (Figure 3). The programming voltage should then be taken to zero. After the device is programmed, V_{PP} can be set to zero or be allowed to float. The wiper position is still adjustable, but always returns to this programmed position on power-up.

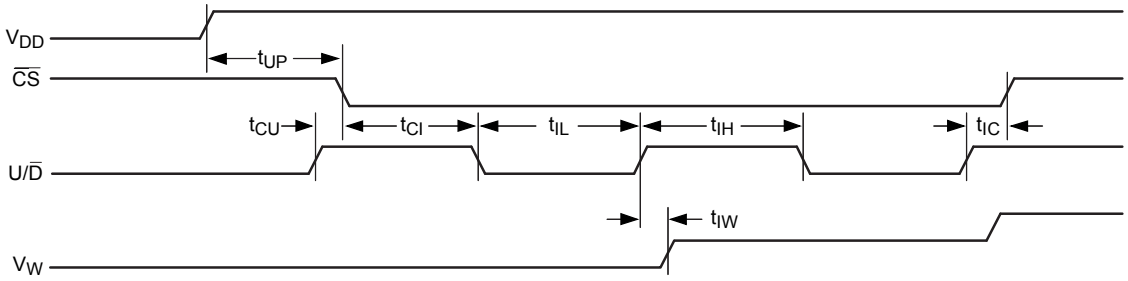


Figure 1. Increment Mode Serial Interface Timing Diagram

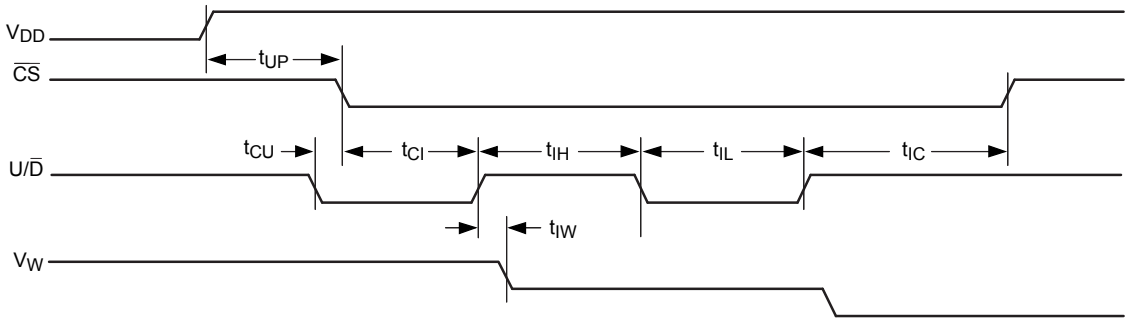


Figure 2. Decrement Mode Serial Interface Timing Diagram

If the intent is to program the device to a specific wiper position and not to allow further adjustments, then six programming pulses are required (as opposed to five), as shown in Figure 3. The sixth pulse locks the wiper position and disables the serial interface. This also allows U/$\overline{D}$ and $\overline{CS}$ to float without any increase in supply current. Once the lockout bit is set, no further adjustment to the potentiometer is possible, effectively changing the potentiometer into a fixed resistor-divider (Table 1).

It is recommended that the user either use six $\overline{CS}$ pulses (convert to a fixed voltage-divider) or five pulses (program the initial power-up value of the device, but still be able to adjust the wiper). If the device is programmed with five pulses and later it is desired to disable the interface (convert to a fixed voltage-divider), then care must be taken to ensure that the wiper is in the same position as it was originally set to (when programmed with five pulses). The full six programming pulses must be applied. Note that once the six-pulse program occurs, no further programming is possible.

Table 1. One-Time Programming Mode

Mode	Power Up Position	Interface	Operation
Factory Default	At midscale	Active	Programming allowed
Programming with 5 pulses at the midscale position	At midscale	Active	Programming allowed
Programming with 5 pulses different from midscale position – **only once**	At the new programmed position	Active	No further change in power-up position allowed
Programming with 5 pulses if the power up position was changed before	At the previous programmed position	Active	None
Programming with 6 pulses if the tap position is at midscale	Midscale position forever	I^2C interface active till power down	I^2C interface disable after next power-up
Programming ONLY with 6 pulses if the tap position is different from midscale position	At the new programmed position	I^2C interface active till power down	I^2C interface disable after next power-up

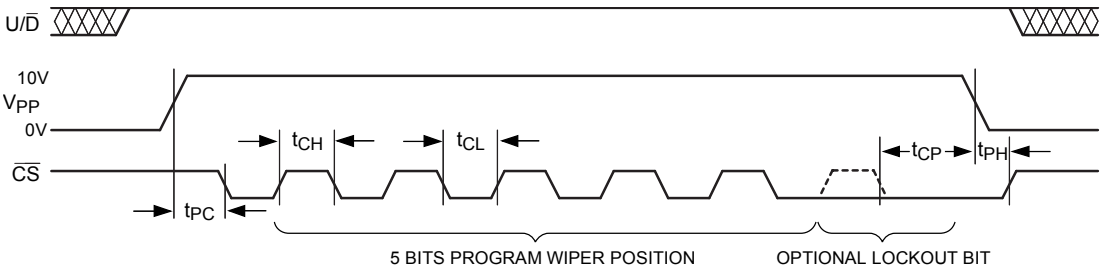
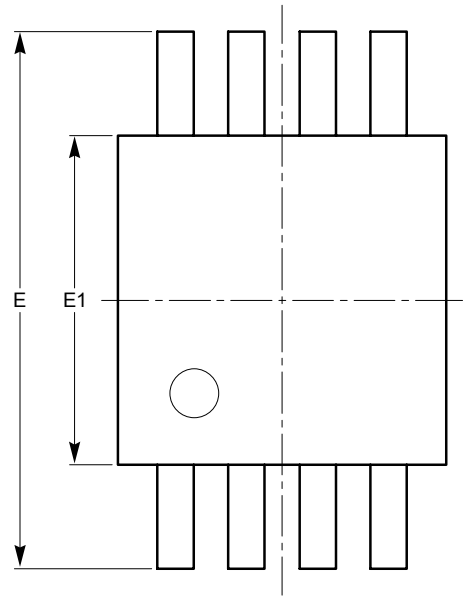


Figure 3. One Time Program Mode Serial Interface Timing Diagram

Notes:
(1) If CAT5126 is Programmed with less than 5 pulses, it does not change the Power-up recall position.
(2) During internal power-up the wiper is forced to miscale; thereafter the wiper is set at the stored position.

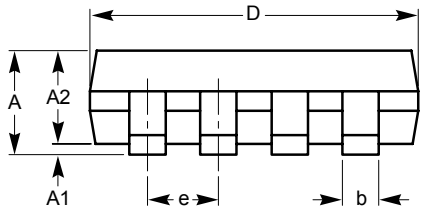
PACKAGE OUTLINE DRAWINGS

MSOP 8-Lead 3 x 3 mm (Z) (1)(2)

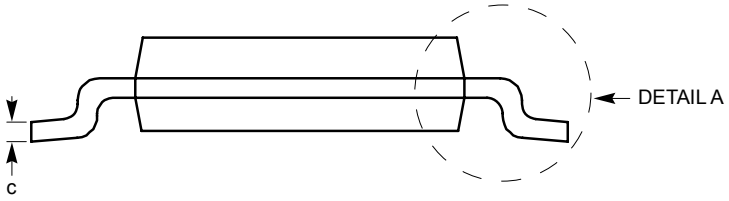


TOP VIEW

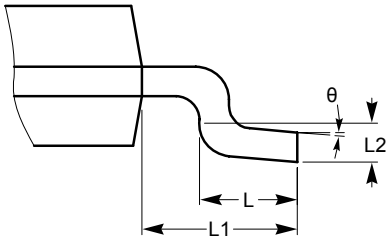
SYMBOL	MIN	NOM	MAX
A			1.10
A1	0.05	0.10	0.15
A2	0.75	0.85	0.95
b	0.22		0.38
c	0.13		0.23
D	2.90	3.00	3.10
E	4.80	4.90	5.00
E1	2.90	3.00	3.10
e		0.65 BSC	
L	0.40	0.60	0.80
L1		0.95 REF	
L2		0.25 BSC	
θ	0º		6º



SIDE VIEW



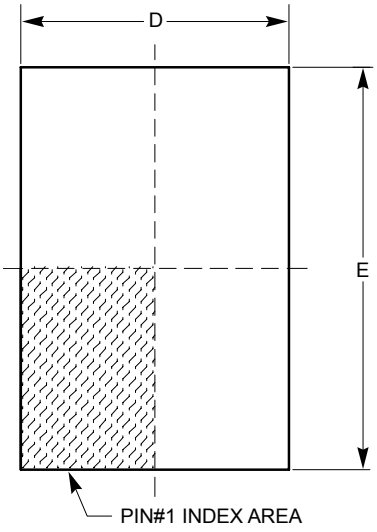
END VIEW



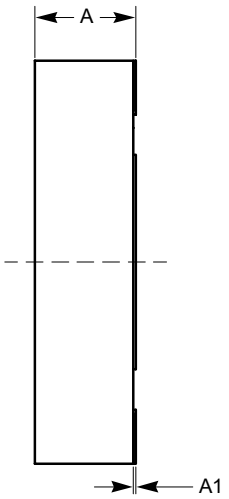
DETAIL A

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

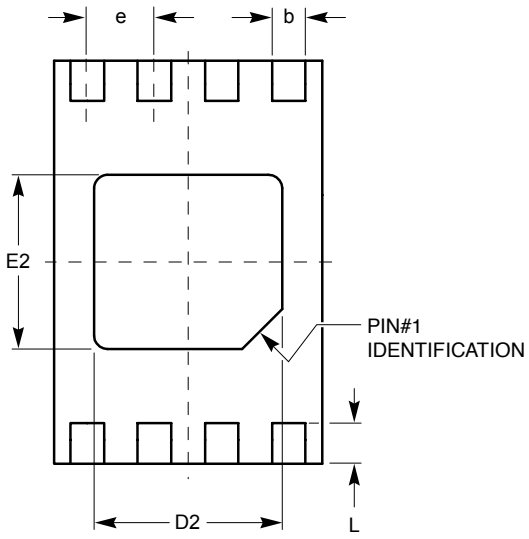
TDFN 8-Pad 2 mm x 3 mm (VP2) [(1)(2)]



TOP VIEW

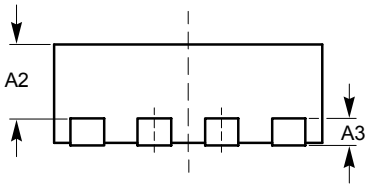


SIDE VIEW



BOTTOM VIEW

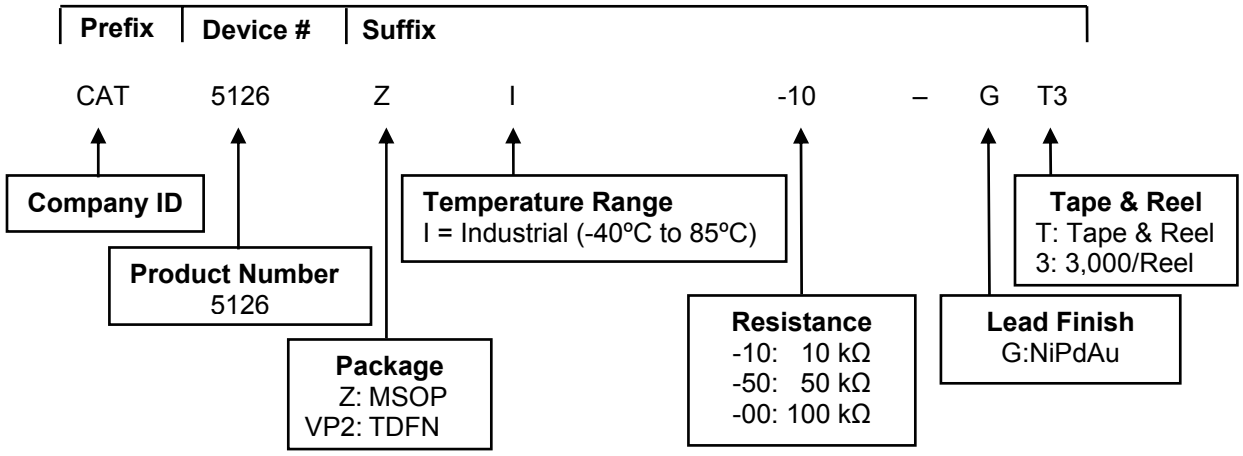
SYMBOL	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A2	0.45	0.55	0.65
A3		0.20 REF	
b	0.20	0.25	0.30
D	1.90	2.00	2.10
D2	1.30	1.40	1.50
E	2.90	3.00	3.10
E2	1.20	1.30	1.40
e		050 TYP	
L	0.20	0.30	0.40



FRONT VIEW

Notes:
(1) All dimensions are in millimeters. Angles in degrees.
(2) Complies with JEDEC Specification MO-229.

EXAMPLE OF ORDERING INFORMATION



ORDERING INFORMATION

Orderable Part Number	Resistor [kΩ]	Package-Pin	Part Per Reel
CAT5126VP2I10GT3*	10	TDFN	3000
CAT5126VP2I50GT3 (4)*	50	TDFN	3000
CAT5126VP2I00GT3 (4)*	100	TDFN	3000
CAT5126ZI-10-GT3	10	MSOP	3000
CAT5126ZI-50-GT3 (4)	50	MSOP	3000
CAT5126ZI-00-GT3 (4)	100	MSOP	3000

* Part number is not exactly the same as the “Example of Ordering Information” shown above. For part numbers marked with * there are NO hyphens in the orderable part numbers.

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 CAT5126ZI-10-GT3 (MSOP, Industrial Temperature range, 10 kΩ, NiPdAu, Tape & Reel, 3,000/Reel).
(4) For additional package and temperature options, please contact your nearest ON Semiconductor Sales office.

REVISION HISTORY

Date	Rev.	Description
14-Mar-07	A	Initial Issue
12-Mar-08	B	Add Top Mark Code link Add -MD to document number
21-Nov-08	C	Change logo and fine print to ON Semiconductor
13-Jul-09	D	Update Ordering Information table

PUBLICATION ORDERING INFORMATION
LITERATURE FULFILLMENT:

Literature Distribution Center for ON Semiconductor
P.O. Box 5163, Denver, Colorado 80217 USA
Phone: 303-675-2175 or 800-344-3860 Toll Free USA/Canada
Fax: 303-675-2176 or 800-344-3867 Toll Free USA/Canada
Email: orderlit@onsemi.com

N. American Technical Support: 800-282-9855 Toll Free USA/Canada
Europe, Middle East and Africa Technical Support:
Phone: 421 33 790 2910
Japan Customer Focus Center:
Phone: 81-3-5773-3850

ON Semiconductor Website: www.onsemi.com
Order Literature: http://www.onsemi.com/orderlit

For additional information, please contact your local Sales Representative