COPAL ELECTRONICS

16-Tap Digital Potentiometers with 2-Wire Interface

Description

DP7120/7121/7122 linear−taper digital potentiometers perform the same function as a mechanical potentiometer or a variable resistor. These devices consist of a fixed resistor and a wiper contact with 16−tap points that are digitally controlled through a 2−wire up/down serial interface.

The DP7120 is configured as a potentiometer. The DP7121 and DP7122 are configured as variable resistors. See *Pin Configurations* for part functionality.

Three resistance values are available: 10 kΩ, 50 kΩ and 100 kΩ. These are available in space−saving 5−pin and 6−pin SC−70 and SOT−23 packages.

Features

- 0.3 μA Ultra−low Standby Current
- Single−supply Operation: 2.7 V to 5.5 V
- Glitchless Switching between Resistor Taps
- Power−on Reset to Midscale
- 2−wire Up/Down Serial Interface
- Resistance Values: 10 kΩ, 50 kΩ and 100 kΩ
- Available in SC−70 and SOT−23 Packages
- These Devices are Pb−Free, Halogen Free/BFR Free and are RoHS Compliant

Applications

- LCD Screen Adjustment
- Volume Control
- Mechanical Potentiometer Replacement
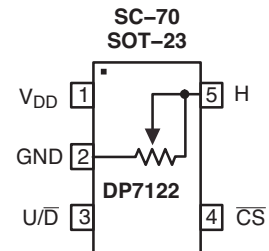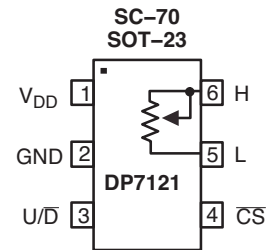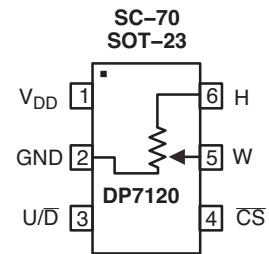- Gain Adjustment
- Line Impedance Matching

SC−70

SOT−23

PIN CONFIGURATIONS

SC−70
SOT−23

V$_{DD}$	1	6	H
GND	2	5	W
U/$\overline{D}$	3	4	$\overline{CS}$

DP7120

SC−70
SOT−23

V$_{DD}$	1	6	H
GND	2	5	L
U/$\overline{D}$	3	4	$\overline{CS}$

DP7121

SC−70
SOT−23

V$_{DD}$	1	5	H
GND	2		
U/$\overline{D}$	3	4	$\overline{CS}$

DP7122

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 11 of this data sheet.
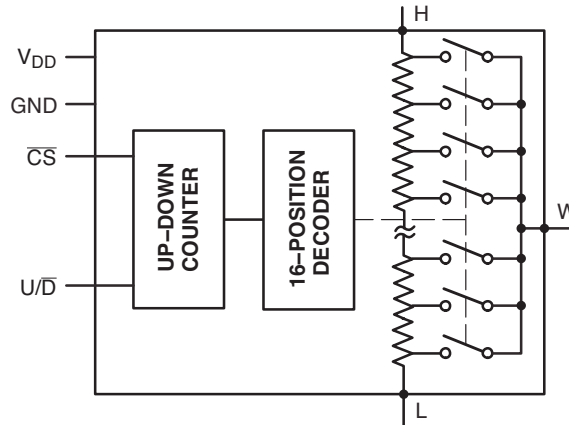
DP7120, DP7121, DP7122

Figure 1. Functional Diagram

Table 1. PIN DESCRIPTIONS

Name	Description
V_{DD}	Power Supply
GND	Ground
U/$\overline{D}$	Up/$\overline{Down}$ Control Input. With $\overline{CS}$ low, a low–to–high transition increments or decrements the wiper position.
$\overline{CS}$	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.
L	Low Terminal of Resistor
W	Wiper Terminal of Resistor
H	High Terminal of Resistor

Table 2. ABSOLUTE MAXIMUM RATINGS

Parameters	Ratings	Units
V_{DD} to GND	−0.3 to +6	V
All Other Pins to GND	−0.3 to (V_{DD} + 0.3)	V
Input and Output Latch–Up Immunity	±200	mA

Maximum Continuous Current into H, L and W
    100 kΩ
    50 kΩ
    10 kΩ
	
	±0.6
	±1.3
	±1.3
		mA

Continuous Power Dissipation (T_A = +70°C)
    5–pin SC–70 (Note 1)
    6–pin SC–70 (Note 1)
	
	247
	245
		mW

Operating Temperature Range	−40 to +85	°C
Junction Temperature	+150	°C
Storage Temperature Range	−65 to +150	°C
Soldering Temperature (soldering, 10 s)	+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.
1. Derate 3.1 mW/°C above T_A = +70°C

Table 3. ELECTRICAL CHARACTERISTICS

(V_{DD} = 2.7 V to 5.5 V, V_H = V_{DD}, V_L = 0, T_A = –40°C to +85°C. Typical values are at V_{DD} = 2.7 V, T_A = 25°C, unless otherwise noted.)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
DC PERFORMANCE						
Resolution			16			Taps
End–to–End Resistance (–00)			75	100	125	kΩ
End–to–End Resistance (–50)			37.5	50	62.5	
End–to–End Resistance (–10)			7.5	10	12.5	
End–to–End Resistance Tempco	TC_R			200		ppm/°C
Ratiometric Resistance Tempco				5		ppm/°C
Integral Nonlinearity	INL				±0.5	LSB
Differential Nonlinearity	DNL				±0.5	LSB
Zero/Full–Scale Error				±0.1	±0.5	LSB
Wiper Resistance	R_W			200	600	Ω
DIGITAL INPUTS						
Input High Voltage	V_{IH}		0.7 x V_{DD}			V
Input Low Voltage	V_{IL}				0.3 x V_{DD}	V
TIMING CHARACTERISTICS (Figures 7, 8)						
U/$\overline{D}$ Mode to $\overline{CS}$ Setup	t_{CU}		25			ns
$\overline{CS}$ to U/$\overline{D}$ Step Setup	t_{CI}		50			ns
$\overline{CS}$ to U/$\overline{D}$ Step Hold	t_{IC}		25			ns
U/$\overline{D}$ Step Low Period	t_{IL}		25			ns
U/$\overline{D}$ Step High Period	t_{IH}		25			ns
Up/$\overline{Down}$ Toggle Rate (Note 2)	f_{TOGGLE}			1		MHz
Output Settling Time (Note 3)	t_{SETTLE}	100 kΩ variable resistor configuration, C_L = 10 pF		1		μs
		100 kΩ potentiometer configuration, C_L = 10 pF		0.25		
POWER SUPPLY						
Supply Voltage	V_{DD}		2.7		5.5	V
Active Supply Current (Note 4)	I_{DD}				25	μA
Standby Supply Current (Note 5)	I_{SB}	V_{DD} = +5 V		0.3	1	μA

2. Up/Down Toggle Rate: f_{TOGGLE} = 1 / t_{SETTLE}
3. Typical settling times are dependent on end–to–end resistance.
4. Supply current measured while changing wiper tap, f_{TOGGLE} = 1 MHz.
5. Supply current measured while wiper position is fixed.

TYPICAL OPERATING CHARACTERISTICS

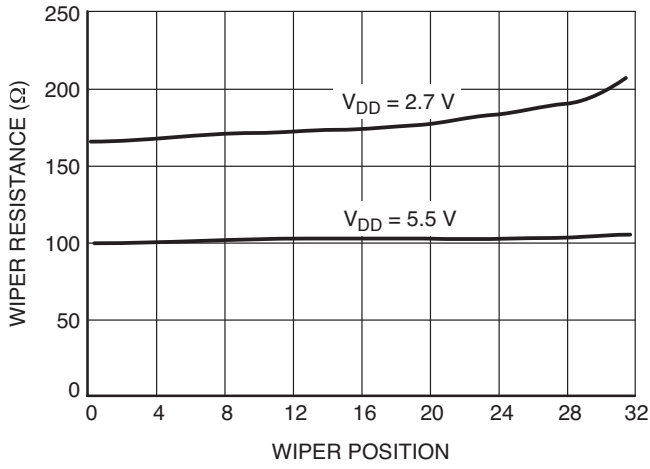(T_A = 25°C, unless otherwise noted.)

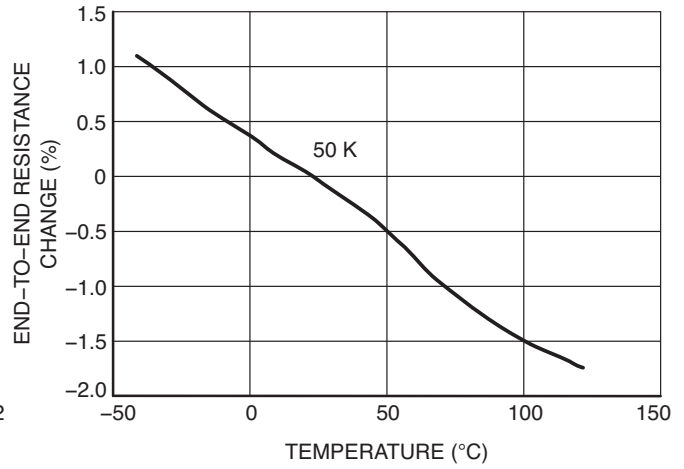**Figure 2. Wiper Resistance vs. Tap Position**

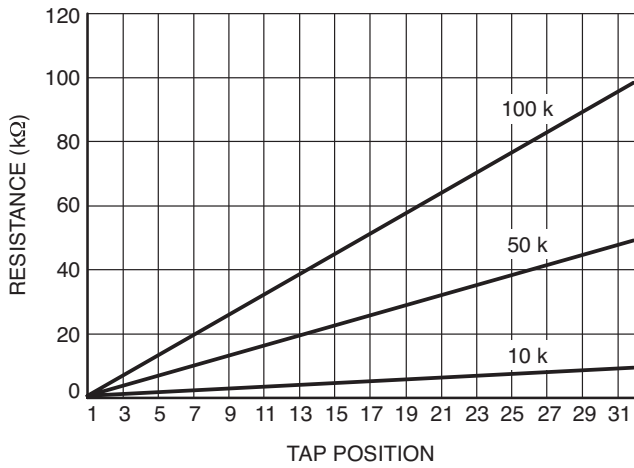**Figure 3. Change in End–to–End Resistance vs. Temperature**

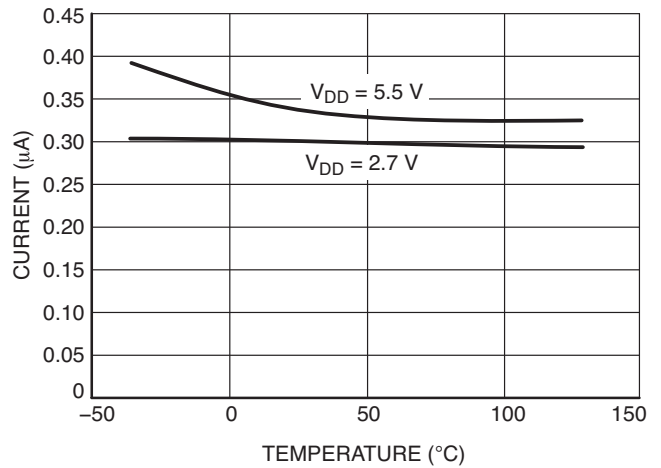**Figure 4. W–to–L Resistance vs. Tap Position**
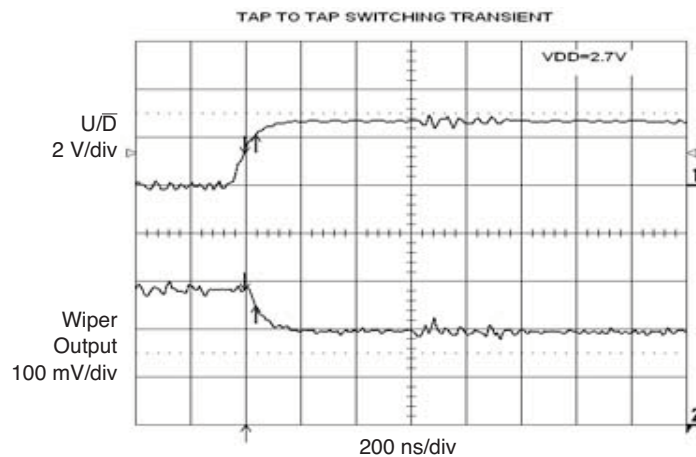

Figure 5. Supply Current vs. Temperature

Figure 6. Tap–to–Tap Switching Transient

DP7120, DP7121, DP7122

Functional Description

The DP7120/7121/7122 consist of a fixed resistor and a wiper contact with 16–tap points that are digitally controlled through a 2–wire up/down serial interface. Three end–to–end resistance values are available: 10 kΩ, 50 kΩ and 100 kΩ.

The DP7120 is designed to operate as a potentiometer. In this configuration, the low terminal of the resistor array is connected to ground (pin 2).

The DP7122 performs as a variable resistor. In this device, the wiper terminal and high terminal of the resistor array is connected at pin 5. The DP7121 is a similar variable resistor, except the low terminal is connected to pin 5.

Digital Interface Operation

The devices have two modes of operation when the serial interface is active: increment 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 will go into increment mode if U/$\overline{D}$ input is high, and into decrement mode when U/$\overline{D}$ input is low. Once the mode is set, the device will remain in that mode until $\overline{CS}$ goes high again. A low–to–high transition at the U/$\overline{D}$ pin will increment or decrement the wiper position depending on the current mode (Figures 7 and 8).

When the $\overline{CS}$ input transitions to high (serial interface inactive), the value of the counter is stored and the wiper position is maintained.

Note that when the wiper reaches the maximum (or minimum) tap position, the wiper will not wrap around to the minimum (or maximum) position.

Power–On Reset

All parts in this family feature power–on reset (POR) circuitry that sets the wiper position to midscale at power–up. By default, the chip is in the increment mode.
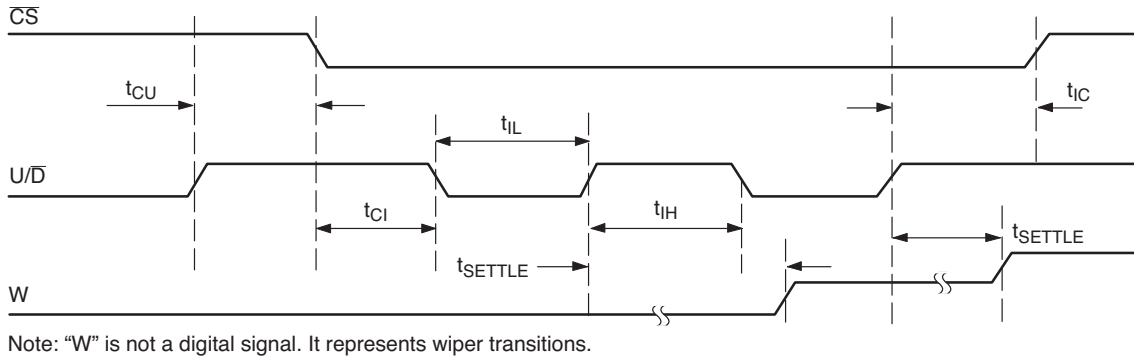

Note: "W" is not a digital signal. It represents wiper transitions.

Figure 7. Serial Interface Timing Diagram, Increment Mode

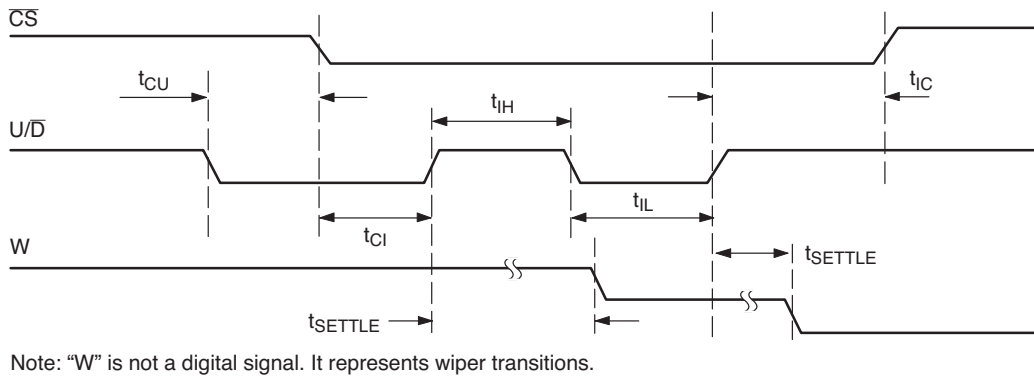Note: "W" is not a digital signal. It represents wiper transitions.

Figure 8. Serial Interface Timing Diagram, Decrement Mode

DP7120, DP7121, DP7122

Applications Information

The devices are intended for circuits requiring digitally controlled adjustable resistance, such as LCD contrast control, where voltage biasing adjusts the display contrast.

Alternative Positive LCD Bias Control

Use an op amp to provide buffering and gain on the output of the DP7120. Connect the mechanical potentiometer to the positive input of a noninverting op amp (Figure 9) to select a portion of the input signal by digitally controlling the wiper terminal. Figure 10 shows a similar circuit for the DP7121.

Adjustable Gain

Figures 11 and 12 show how to use the variable resistor to digitally adjust the gain of a noninverting op amp configuration. Connect the DP7121 in series with a resistor to ground to form the adjustable gain control of a noninverting amplifier. The devices have a low 5 ppm/°C ratiometric tempco that allows for a very stable adjustable gain configuration over temperature.
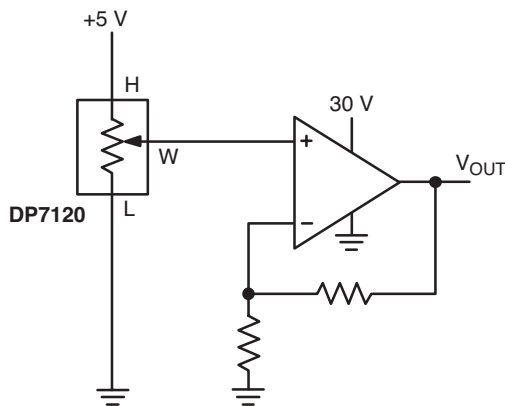
Figure 9. Positive LCD Bias Control
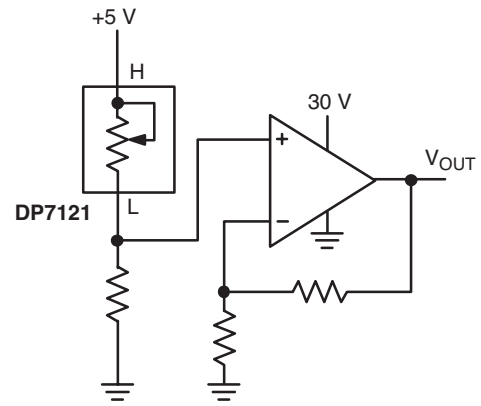
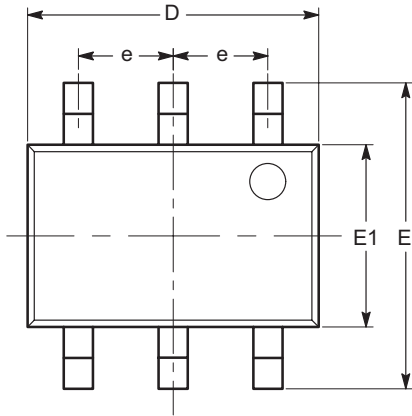**Figure 10. Positive LCD Bias Control**
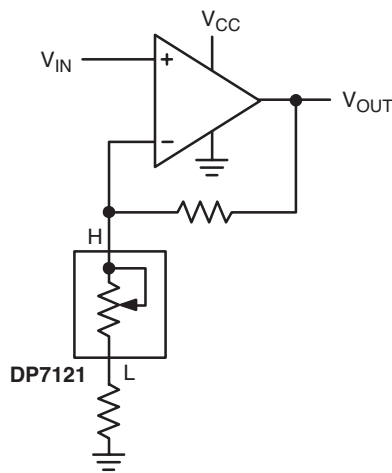
Figure 11. Adjustable Gain Circuit
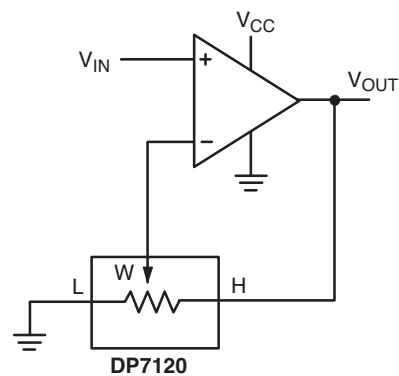
Figure 12. Adjustable Gain Circuit

DP7120, DP7121, DP7122

PACKAGE DIMENSIONS

SC–70, 6 Lead, 1.25x2

TOP VIEW

SYMBOL	MIN	NOM	MAX
A	0.80		1.10
A1	0.00		0.10
A2	0.80		1.00
b	0.15		0.30
c	0.10		0.18
D	1.80	2.00	2.20
E	1.80	2.10	2.40
E1	1.15	1.25	1.35
e		0.65 BSC	
L	0.26	0.36	0.46
L1		0.42 REF	
L2		0.15 BSC	
θ	0º		8º
$\theta1$	4º		10º
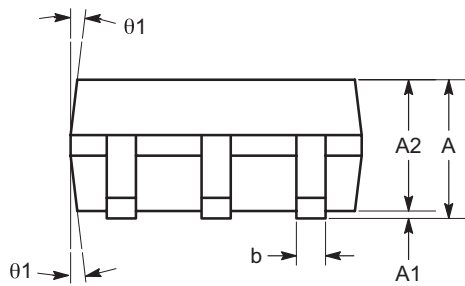
SIDE VIEW
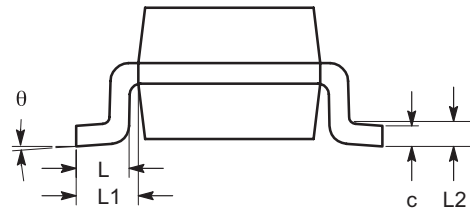
END VIEW

Notes:

(1) All dimensions are in millimeters. Angles in degrees.
(2) Complies with JEDEC MO-203.

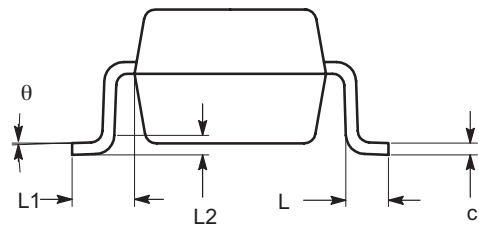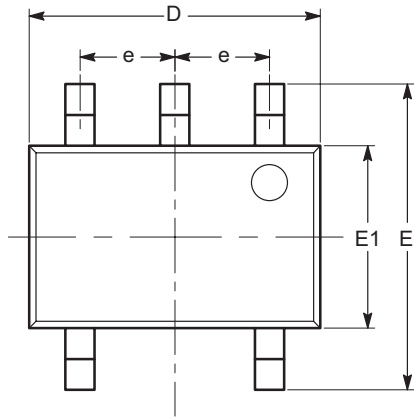# DP7120, DP7121, DP7122
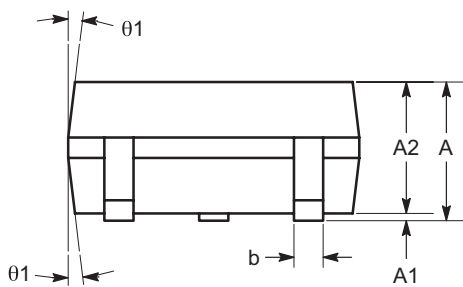
PACKAGE DIMENSIONS

SOT–23, 6 Lead

TOP VIEW

PIN #1 IDENTIFICATION

SYMBOL	MIN	NOM	MAX
A	0.90		1.45
A1	0.00		0.15
A2	0.90	1.15	1.30
b	0.30		0.50
c	0.08		0.22
D		2.90 BSC	
E		2.80 BSC	
E1		1.60 BSC	
e		0.95 BSC	
L	0.30	0.45	0.60
L1		0.60 REF	
L2		0.25 REF	
θ	0°	4°	8°
θ1	5°	10°	15°
θ2	5°	10°	15°

SIDE VIEW

END VIEW

Notes:
(1) All dimensions in millimeters. Angles in degrees.
(2) Complies with JEDEC standard MO-178.

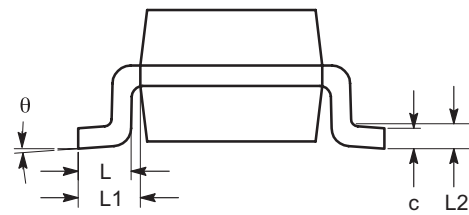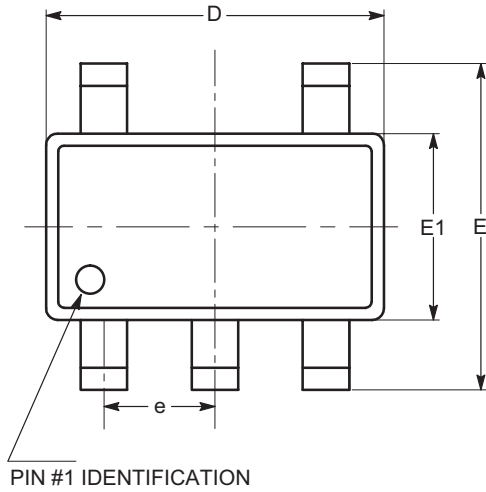# DP7120, DP7121, DP7122

PACKAGE DIMENSIONS

SC–70, 5 Lead, 1.25x2

TOP VIEW

SYMBOL	MIN	NOM	MAX
A	0.80		1.10
A1	0.00		0.10
A2	0.80		1.00
b	0.15		0.30
c	0.10		0.18
D	1.80	2.00	2.20
E	1.80	2.10	2.40
E1	1.15	1.25	1.35
e		0.65 BSC	
L	0.26	0.36	0.46
L1		0.42 REF	
L2		0.15 BSC	
θ	0º		8º
$\theta 1$	4º		10º

SIDE VIEW

END VIEW

Notes:

(1) All dimensions are in millimeters. Angles in degrees.
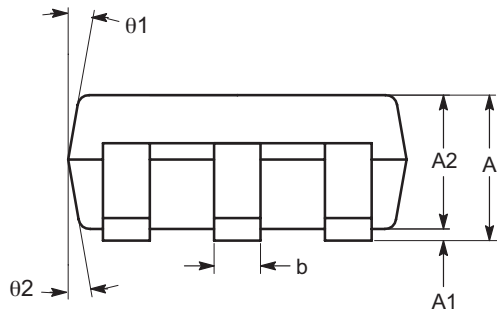(2) Complies with JEDEC MO-203.

DP7120, DP7121, DP7122

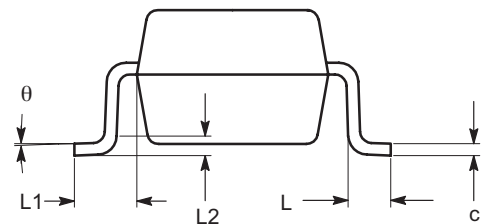## PACKAGE DIMENSIONS

SOT–23, 5 Lead

TOP VIEW

SYMBOL	MIN	NOM	MAX
A	0.90		1.45
A1	0.00		0.15
A2	0.90	1.15	1.30
b	0.30		0.50
c	0.08		0.22
D		2.90 BSC	
E		2.80 BSC	
E1		1.60 BSC	
e		0.95 BSC	
L	0.30	0.45	0.60
L1		0.60 REF	
L2		0.25 REF	
θ	0°	4°	8°
θ1	5°	10°	15°
θ2	5°	10°	15°

SIDE VIEW

END VIEW

Notes:
(1) All dimensions in millimeters. Angles in degrees.
(2) Complies with JEDEC standard MO-178.

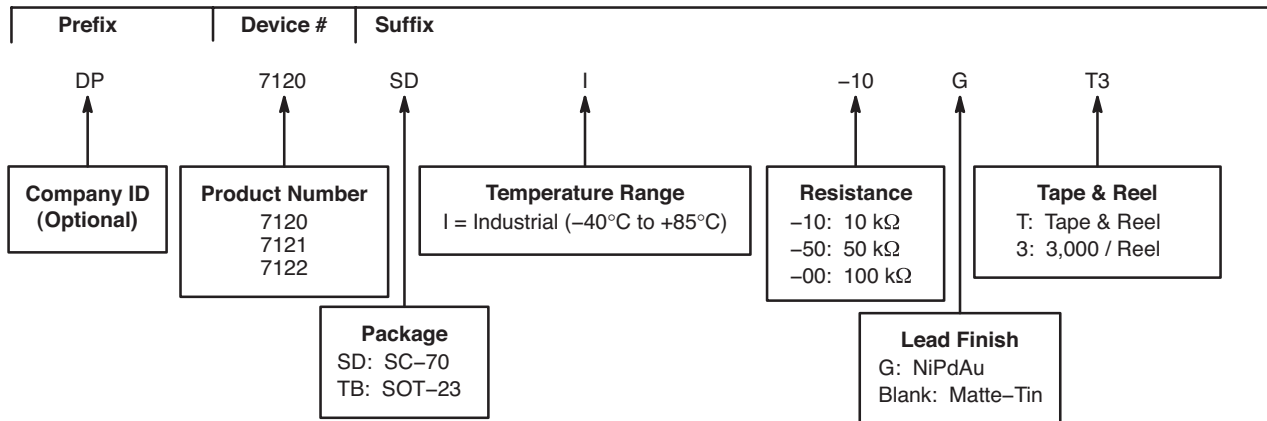**Table 4. ORDERING INFORMATION**

Orderable Part Number	Resistor [kΩ]	Pin Package	Quantity per Reel
DP7120SDI–10-GT3	10	SC70–6	3,000
DP7120TBI–10–T3 (Note 6)	10	SOT23–6	3,000
DP7120TBI–10-GT3	10	SOT23–6	3,000
DP7120SDI–50-GT3	50	SC70–6	3,000
DP7120TBI–50–T3 (Note 6)	50	SOT23–6	3,000
DP7120TBI–50-GT3	50	SOT23–6	3,000
DP7120SDI–00-GT3	100	SC70–6	3,000
DP7120TBI–00–T3 (Note 6)	100	SOT23–6	3,000
DP7120TBI–00-GT3	100	SOT23–6	3,000
DP7121SDI–10-GT3	10	SC70–6	3,000
DP7121TBI–10–T3 (Note 6)	10	SOT23–6	3,000
DP7121TBI–10-GT3	10	SOT23–6	3,000
DP7121SDI–50-GT3	50	SC70–6	3,000
DP7121TBI–50–T3 (Note 6)	50	SOT23–6	3,000
DP7121TBI–50-GT3	50	SOT23–6	3,000
DP7121SDI–00-GT3	100	SC70–6	3,000
DP7121TBI–00–T3 (Note 6)	100	SOT23–6	3,000
DP7121TBI–00-GT3	100	SOT23–6	3,000
DP7122SDI–10-GT3	10	SC70–5	3,000
DP7122TBI–10–T3 (Note 6)	10	SOT23–5	3,000
DP7122TBI–10-GT3	10	SOT23–5	3,000
DP7122SDI–50-GT3	50	SC70–5	3,000
DP7122TBI–50–T3 (Note 6)	50	SOT23–5	3,000
DP7122TBI–50-GT3	50	SOT23–5	3,000
DP7122SDI–00-GT3	100	SC70–5	3,000
DP7122TBI–00–T3 (Note 6)	100	SOT23–5	3,000
DP7122TBI–00-GT3	100	SOT23–5	3,000

6. Contact factory for availability.

Example of Ordering Information (Note 9)

Prefix	Device #	Suffix

DP	7120	SD	I	–10	G	T3

Company ID (Optional)

Product Number
7120
7121
7122

Package
SD: SC–70
TB: SOT–23

Temperature Range
I = Industrial (–40°C to +85°C)

Resistance
–10: 10 kΩ
–50: 50 kΩ
–00: 100 kΩ

Lead Finish
G: NiPdAu
Blank: Matte–Tin

Tape & Reel
T: Tape & Reel
3: 3,000 / Reel

7. All packages are RoHS–compliant (Lead–free, Halogen–free).
8. The standard finish is NiPdAu.
9. The device used in the above example is a DP7120SDI–10-GT3 (SC–70, Industrial Temperature, 10 kΩ, NiPdAu, Tape & Reel, 3,000/Reel).
10. For additional package and temperature options, please contact your nearest COPAL ELECTRONICS Sales office.

DP7120/D