

WS72321
Low-Power Rail-to-Rail Input Output Operational Amplifiers
Descriptions

The WS72321 series is a single low-voltage operational amplifier with rail-to-rail input/output swing. Ultra low quiescent current makes this amplifier ideal for portable, battery operated equipment. The common mode input range includes ground making the device useful for low-side current-shunt measurements. The ultra small packages allow for placement on the PCB in close proximity to the signal source thereby reducing noise pickup.

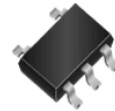
The WS72321 is available in SOT353(SC70-5L), SOT23-5L, DFN1x1-4L and DFN0.8x0.8-4L packages. Standard products are Pb-Free and halogen-Free.

Applications

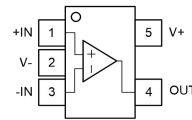
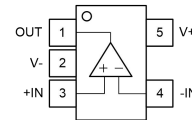
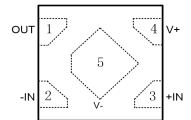
- Active Filters
- Smoke/Gas Sensors
- Battery Powered Electronic Equipments
- Personal Medical Care

Features

- Single Supply Voltage : 1.8~5.5V
- Quiescent Current : 48μA Typical
- GBWP : 1.5MHz
- Slew Rate : 1.1V/μs
- Offset Voltage : 3mV Maximum
- Offset Voltage Temp. Drift : 1μV / °C
- THD+N : -102dB@1kHz,
-90dB@10kHz
- CMRR/PSRR : 104dB/111dB
- Output Short-Circuit Curr. : 43mA
- -40°C to 125°C Operation Range
- Drives 2kΩ Resistive Loads
- No Output Crossover Distortion
- No Phase Reversal from Overdriven Input
- Rail-to-Rail Input/Output Swing

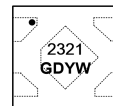
[Http://www.omnivision-group.com](http://www.omnivision-group.com)

SOT353

SOT23-5L

**DFN1x1-4L &
DFN0.8x0.8-4L**

SOT353
(WS72321B-5/TR)

SOT23-5L
(WS72321EO-5/TR)

DFN1x1-4L
((WS72321D-4/TR)
**&
SOT23-5L
(WS72321E-5/TR)**
**&
DFN0.8x0.8-4L
(WS72321DA-4/TR)**
Pin configuration (Top view)

SOT353
WS72321B-5/TR

SOT23-5L
WS72321E-5/TR

SOT23-5L
WS72321EO-5/TR

DFN1x1-4L
WS72321D-4/TR

DFN0.8x0.8-4L
WS72321DA-4/TR
Marking
2321 = Device code
EG017 = Device code
GA, N5, B5, GD, A = Special code
Y = Year code
W = Week code
*** = Year and week code**
Order Information

Device	Package	Shipping
WS72321B-5/TR	SOT353	3000/Reel &Tape
WS72321E-5/TR	SOT23-5L	3000/Reel &Tape
WS72321EO-5/TR	SOT23-5L	3000/Reel &Tape
WS72321D-4/TR	DFN1x1-4L	3000/Reel &Tape
WS72321DA-4/TR	DFN0.8 x 0.8-4L	3000/Reel &Tape

Pin Descriptions (WS72321B-5/TR & WS72321E-5/TR)

Pin Number	Symbol	Descriptions
1	+IN	Non-inverting input
2	V-	Negative supply
3	-IN	Inverting input
4	OUT	Output
5	V+	Positive supply

Pin Descriptions (WS72321EO-5/TR)

Pin Number	Symbol	Descriptions
1	OUT	Output
2	V-	Negative supply
3	+IN	Non-inverting input
4	-IN	Inverting input
5	V+	Positive supply

Pin Descriptions (WS72321D-4/TR & WS72321DA-4/TR)

Pin Number	Symbol	Descriptions
1	OUT	Output
2	-IN	Inverting input
3	+IN	Non-inverting input
4	V+	Positive supply
5	V-	Negative supply

Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Supply Voltage, ([V+] - [V-])	$V_S^{(2)}$	6	V
Input Differential Voltage	$V_{IDR}^{(3)}$	± 6	V
Input Common Mode Voltage Range	V_{ICR}	(V ⁻)-0.2 to (V ⁺)+0.2	V
Output Short-Circuit Duration	t_{SO}	Unlimited	/
Operating Free-Air Temperature Range	T_A	-40 to 125	°C
Storage Temperature Range	T_{STG}	-65 to 150	°C
Junction Temperature Range	T_J	150	°C
Lead Temperature Range	T_L	260	°C

Note:

1. Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are only stress ratings, and functional operation of the device at these or any other conditions beyond those indicated under recommended operating conditions are not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
2. All voltage values, except differential voltage are with respect to network terminal.
3. Differential voltages are at +IN with respect to -IN.

ESD, Electrostatic Discharge Protection

Symbol	Parameter	Condition	Minimum level	Unit
HBM	Human Body Model ESD	MIL-STD-883H Method 3015.8 JEDEC-EIA/JESD22-A114A	±8000	V
MM	Machine Model ESD	JEDEC-EIA/JESD22-A115	±500	V
CDM	Charged Device Model ESD	JEDEC-EIA/JESD22-C101E	±2000	V

Electronics Characteristics
At $T_A = 25^\circ\text{C}$, $V_S = 5\text{V}$, $V_{CM} = V_{OUT} = V_S/2$, $R_{load} = 100\text{k}\Omega$, $C_{load} = 100\text{pF}$, unless otherwise noted.

Symbol	Parameter		Conditions	Min.	Typ.	Max.	Unit
V_{OS}	Input Offset Voltage		$V_{CM} = V_S/2$	-3.0	± 0.1	3.0	mV
α_{VOS}	Input Offset Voltage Temperature Drift				1		$\mu\text{V}/^\circ\text{C}$
I_{IB}	Input Bias Current				1		pA
I_{OS}	Input Offset Current				1		pA
V_n	Input Voltage Noise		$f=0.1\text{ Hz to }10\text{ Hz}$		4		μV_{P-P}
e_n	Input Voltage Noise Density		$f=1\text{ kHz}$		30		$\text{nV}/\sqrt{\text{Hz}}$
			$f=10\text{ kHz}$		23		
CMRR	Common Mode Rejection Ratio		$V_{CM}=0.1\text{ V to }4.9\text{ V}$	80	104		dB
V_{CM}	Common Mode Input Voltage Range			$(V^-)-0.2$		$(V^+)+0.2$	V
PSRR	Power Supply Rejection Ratio			80	111		dB
A_{VOL}	Open Loop Large Signal Gain		$V_{OUT}=0.1\text{ V to }4.9\text{ V}$, $R_{load}=10\text{ k}\Omega$	100	108		dB
V_{OH}	High Level Output Voltage Drop ($V_{OH}=(V^+)-V_{OUT}$)		$R_{load}=2\text{ k}\Omega$		50		mV
			$R_{load}=10\text{ k}\Omega$		5		
V_{OL}	Low Level Output Voltage Drop ($V_{OL}=(V^-)+V_{OUT}$)		$R_{load}=2\text{ k}\Omega$		40		mV
			$R_{load}=10\text{ k}\Omega$		5		
I_{SC}	Output Short-Circuit Current		Source Current		43		mA
			Sink Current		47		
I_Q	Quiescent Current				48	65	μA
PM	Phase Margin		$R_{load}=100\text{ k}\Omega$, $C_{load}=100\text{ pF}$		60		degrees
GM	Gain Margin		$R_{load}=100\text{ k}\Omega$, $C_{load}=100\text{ pF}$		-14		dB
GBWP	Gain-Bandwidth Product		$f=1\text{ kHz}$		1.5		MHz
t_s	Settling Time	1.5 to 3.5V, Unity Gain	0.1%		1.9		μs
		2.45 to 2.55V, Unity Gain	0.1%		0.29		
SR	Slew Rate		$A_V=1$, $V_{OUT}=1.5\text{ V to }3.5\text{ V}$, $R_{load}=100\text{ k}\Omega$, $C_{load}=100\text{ pF}$		1.1		$\text{V}/\mu\text{s}$
FPBW	Full Power Bandwidth		$2V_{P-P}$		180		kHz
THD+N	Total Harmonic Distortion and Noise		$f=1\text{ kHz}$, $A_V=1$, $R_{load}=100\text{ k}\Omega$, $V_{OUT}=2V_{PP}$		-102		dB
			$f=10\text{ kHz}$, $A_V=1$, $R_{load}=100\text{ k}\Omega$, $V_{OUT}=2V_{PP}$		-90		

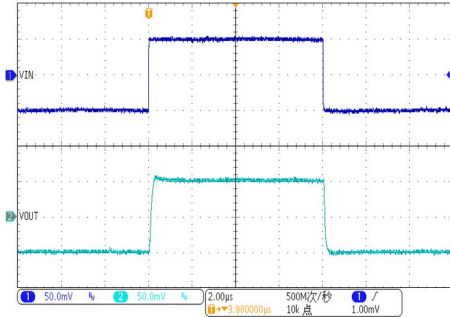
Note:

1. Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.
2. A heat sink may be required to keep the junction temperature below the absolute maximum rating when the output is shorted indefinitely.
3. Thermal resistance varies with the amount of PC board metal connected to the package. The specified values are for short traces connected to the leads.
4. Full power bandwidth is calculated from the slew rate $FPBW = SR/(\pi \cdot V_{P-P})$.

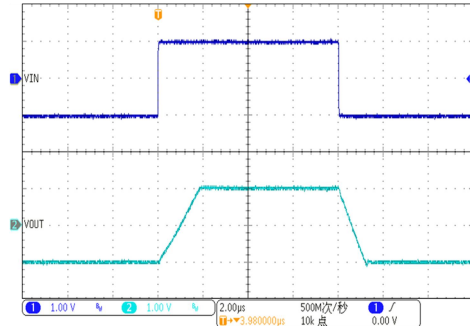
Typical Characteristics

$T_A=25^{\circ}\text{C}$, $V_S=\pm 2.5\text{V}$, $V_{CM}=0\text{V}$, unless otherwise noted.

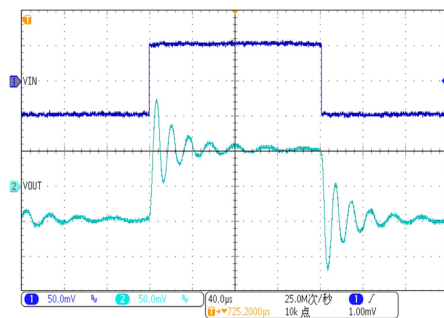
Small-Signal Step Response, 100mV Step



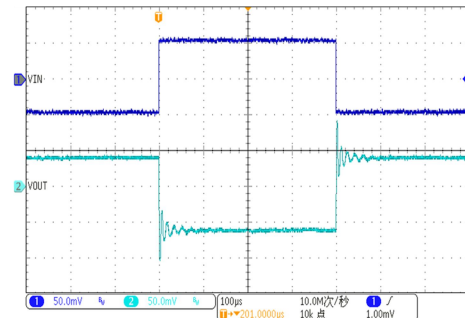
Large-Signal Step Response, 2V Step



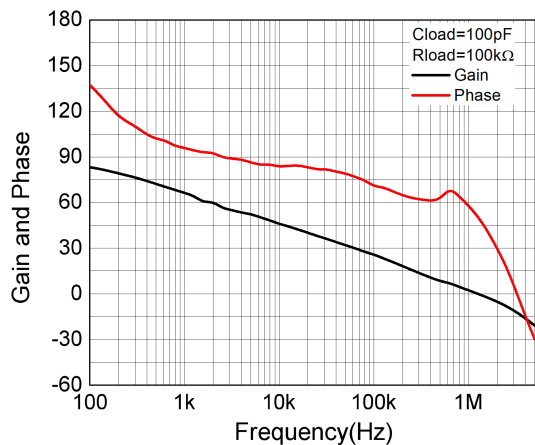
Over Shoot Voltage, $C_{load}=47\text{nF}$,
 $R_{FB}=10\text{k}\Omega$, Gain=+1



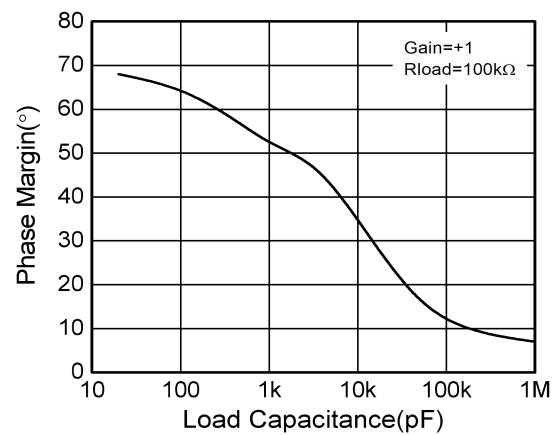
Over Shoot Voltage, $C_{load}=47\text{nF}$,
 $R_{load}=40\text{k}\Omega$, Gain=-1



Open-Loop Gain and Phase



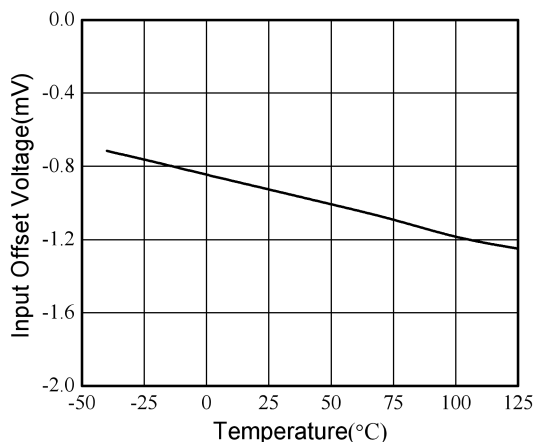
Phase Margin vs. C_{load} (Stable for Any C_{load})



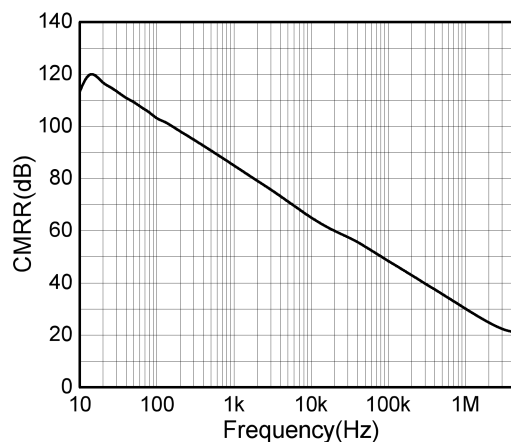
Typical Characteristics (continued)

$T_A=25^{\circ}\text{C}$, $V_S=\pm 2.5\text{V}$, $V_{\text{CM}}=0\text{V}$, unless otherwise noted.

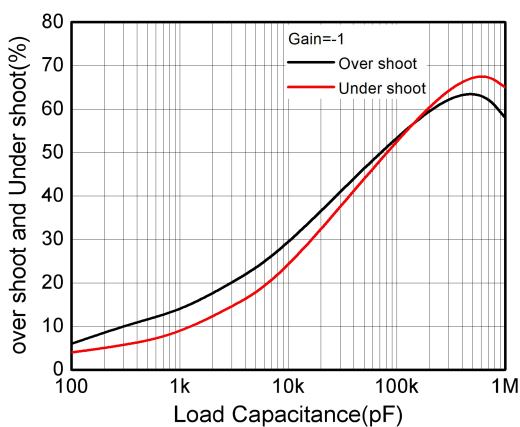
Input Offset Voltage vs. Temperature



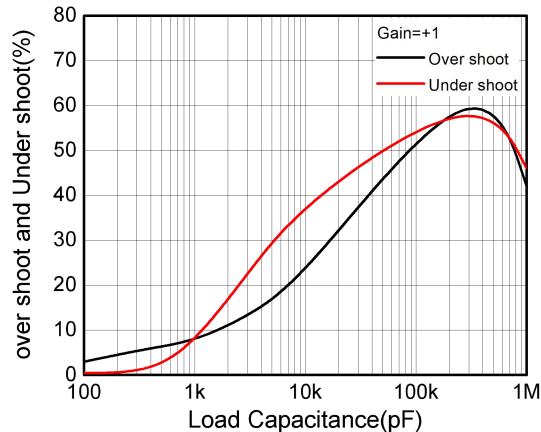
CMRR vs. Frequency



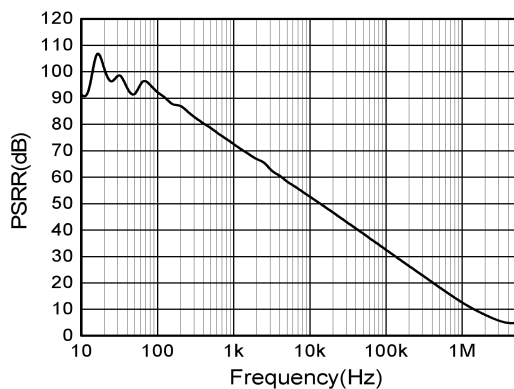
**Over-Shoot % vs. C_{load}
Gain=-1, RFB=20k Ω**



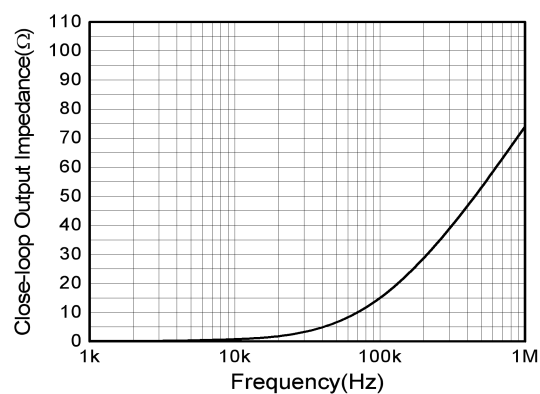
**Over-Shoot % vs. C_{load}
Gain=+1**



PSRR vs. Frequency



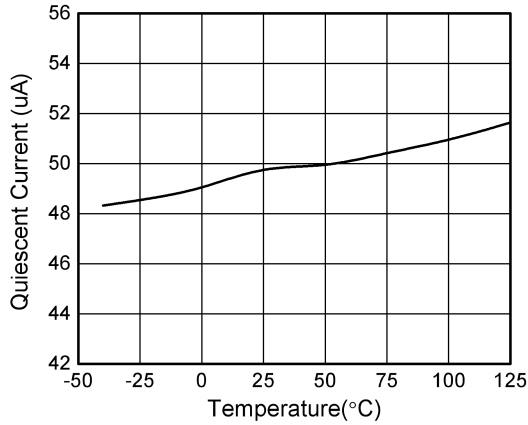
Closed-Loop Output Impedance vs. Frequency



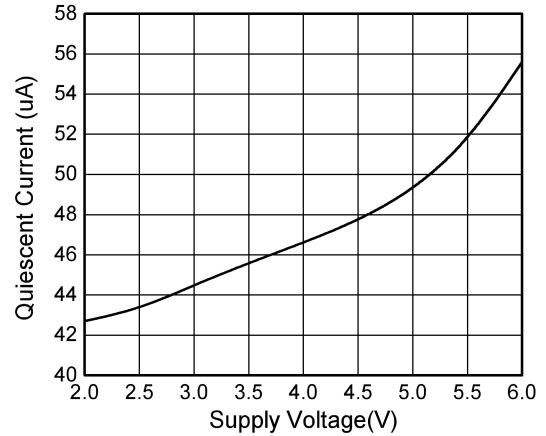
Typical Characteristics (continued)

$T_A=25^{\circ}\text{C}$, $V_S=\pm 2.5\text{V}$, $V_{\text{CM}}=0\text{V}$, unless otherwise noted.

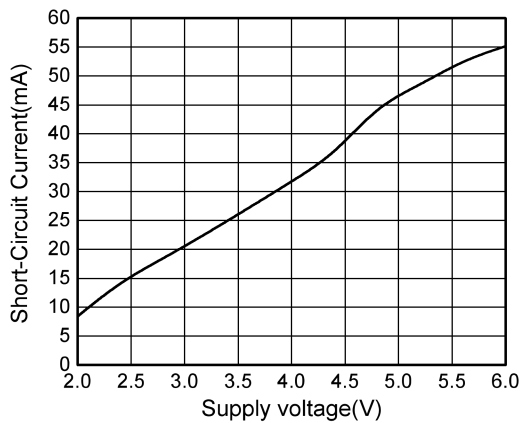
Quiescent Supply Current vs. Temperature



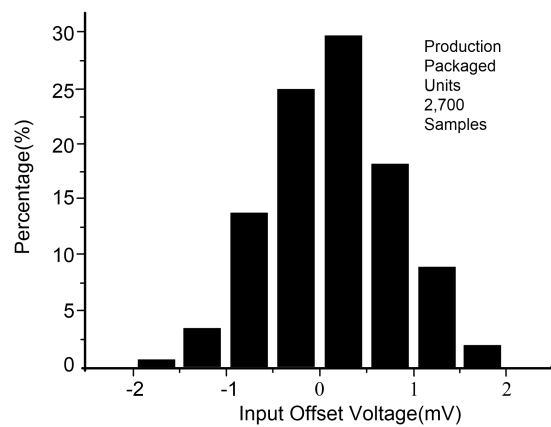
Quiescent Supply Current vs. Supply Voltage



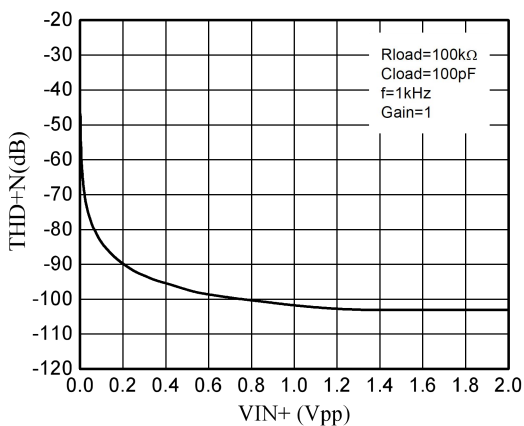
Short-Circuit Current vs. Supply Voltage



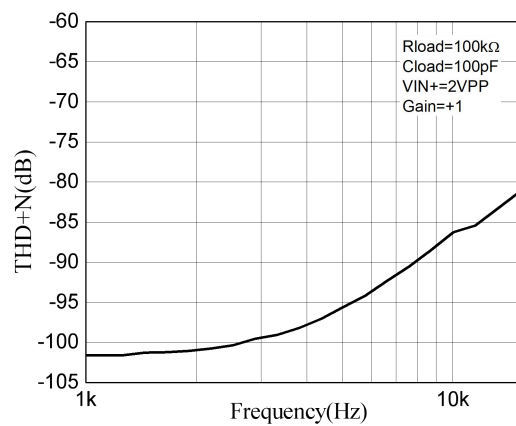
Input Offset Voltage Distribution



THD+Noise vs. Vin+



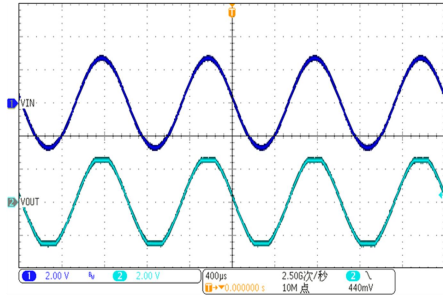
THD+Noise vs. Frequency



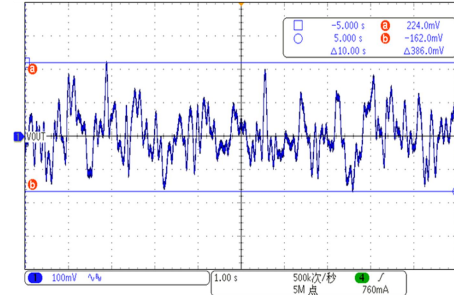
Typical Characteristics (continued)

$T_A=25^{\circ}\text{C}$, $V_S=\pm 2.5\text{V}$, $V_{CM}=0\text{V}$, unless otherwise noted.

VIN=-0.2V to 5.7V, No Phase Reversal

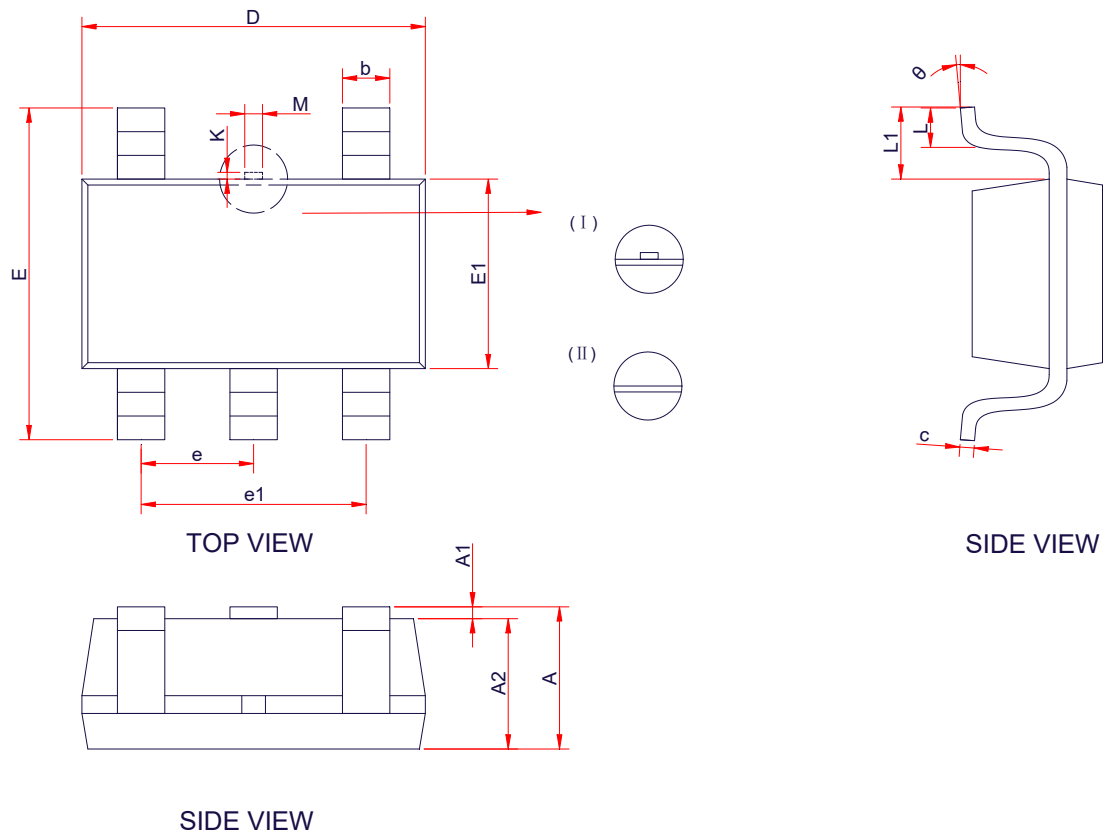


0.1Hz to 10Hz Integrated Input Noise,
Gain = 100000



PACKAGE OUTLINE DIMENSIONS

SOT-353(SC70-5L)

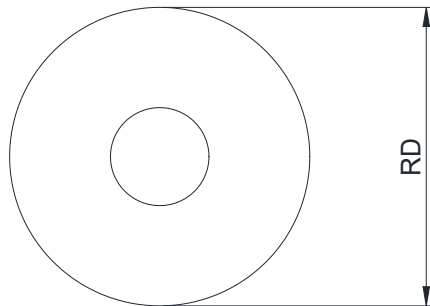


Symbol	Dimensions in Millimeters		
	Min.	Typ.	Max.
A	0.80	0.95	1.10
A1	0.00	-	0.10
A2	0.80	0.90	1.00
b	0.15	0.25	0.35
c	0.08	-	0.20
D	2.00	2.10	2.20
E1	1.15	1.25	1.35
E	2.15	2.30	2.45
e	0.65 Typ.		
e1	1.20	1.30	1.40
L1	0.50 Ref.		
L	0.26	0.36	0.46
M	0.10	0.15	0.25
K	0.00	-	0.25
θ	0 °	-	14 °

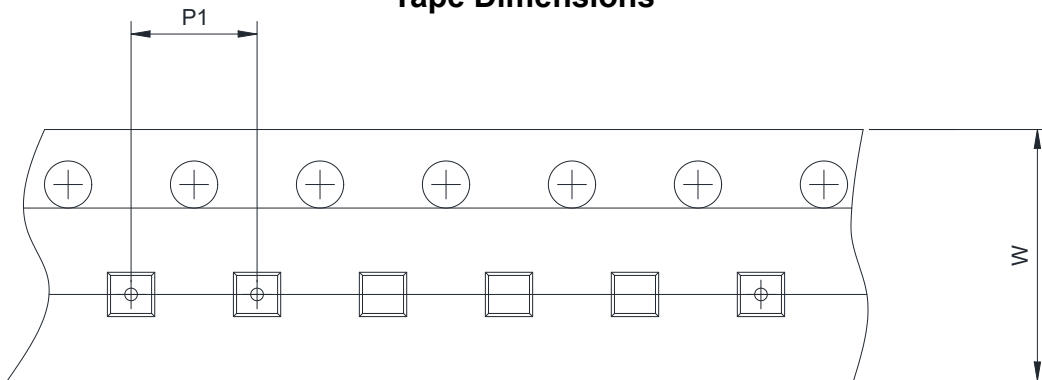
TAPE AND REEL INFORMATION

SOT-353(SC70-5L)

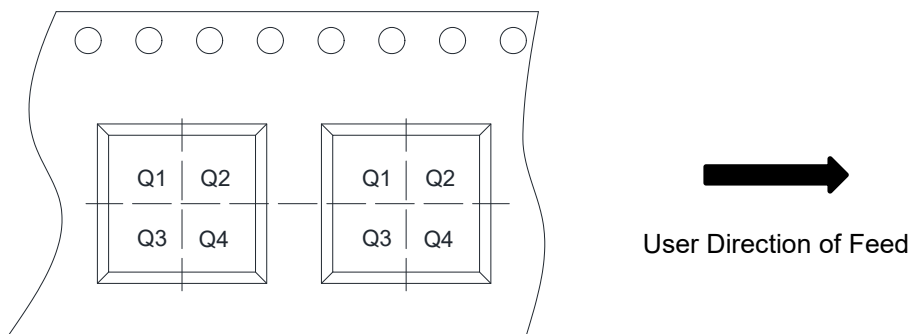
Reel Dimensions



Tape Dimensions



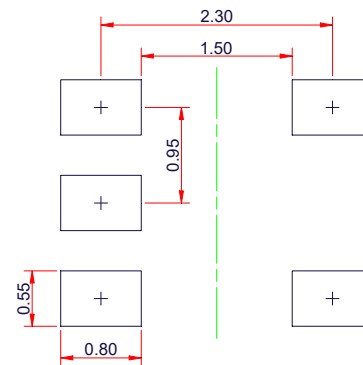
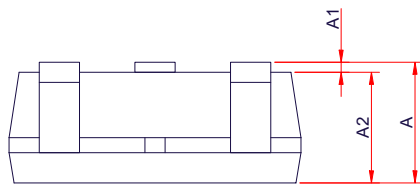
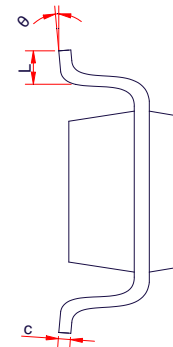
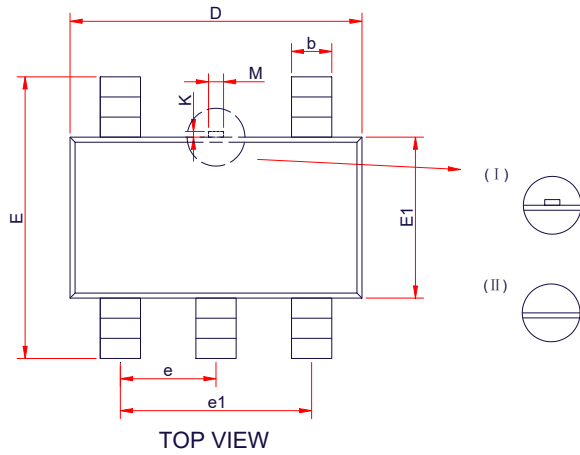
Quadrant Assignments For PIN1 Orientation In Tape



RD	Reel Dimension	<input checked="" type="checkbox"/> 7inch	<input type="checkbox"/> 13inch		
W	Overall width of the carrier tape	<input checked="" type="checkbox"/> 8mm	<input type="checkbox"/> 12mm		
P1	Pitch between successive cavity centers	<input type="checkbox"/> 2mm	<input checked="" type="checkbox"/> 4mm	<input type="checkbox"/> 8mm	
Pin1	Pin1 Quadrant	<input type="checkbox"/> Q1	<input type="checkbox"/> Q2	<input checked="" type="checkbox"/> Q3	<input type="checkbox"/> Q4

PACKAGE OUTLINE DIMENSIONS

SOT-23-5L



SIDE VIEW

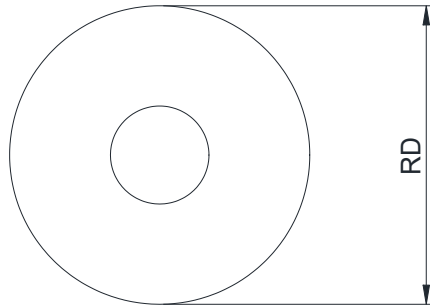
RECOMMENDED LAND PATTERN (unit: mm)

Symbol	Dimensions in Millimeters		
	Min.	Typ.	Max.
A	-	-	1.25
A1	0.00	-	0.15
A2	1.00	1.10	1.20
b	0.30	0.40	0.50
c	0.10	-	0.21
D	2.72	2.92	3.12
E	2.60	2.80	3.00
E1	1.40	1.60	1.80
e	0.95 BSC		
e1	1.90 BSC		
L	0.30	0.45	0.60
M	0.10	0.15	0.25
K	0.00	-	0.25
θ	0°	-	8°

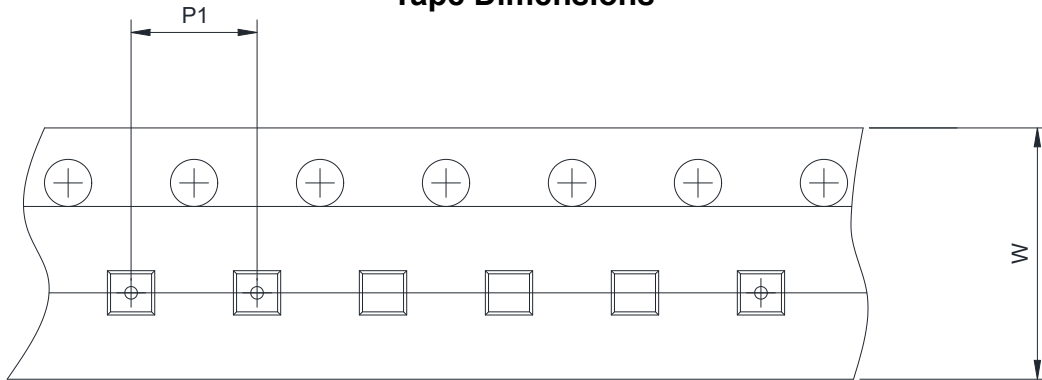
TAPE AND REEL INFORMATION

SOT-23-5L

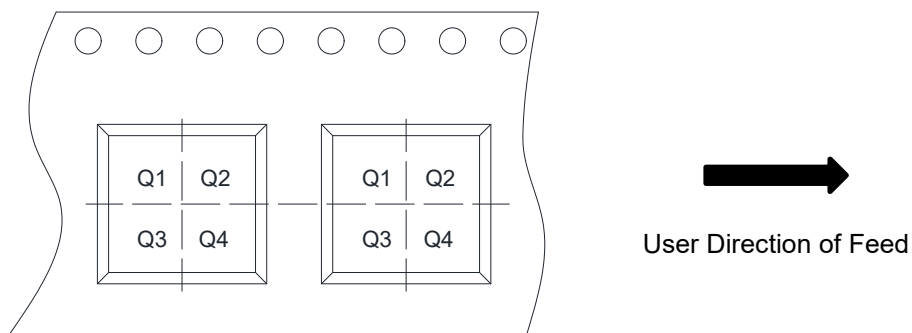
Reel Dimensions



Tape Dimensions



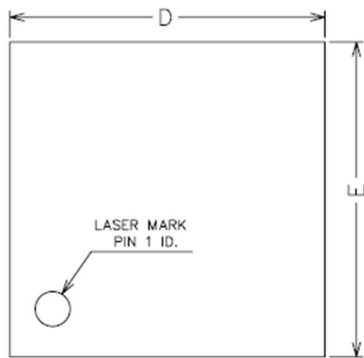
Quadrant Assignments For PIN1 Orientation In Tape



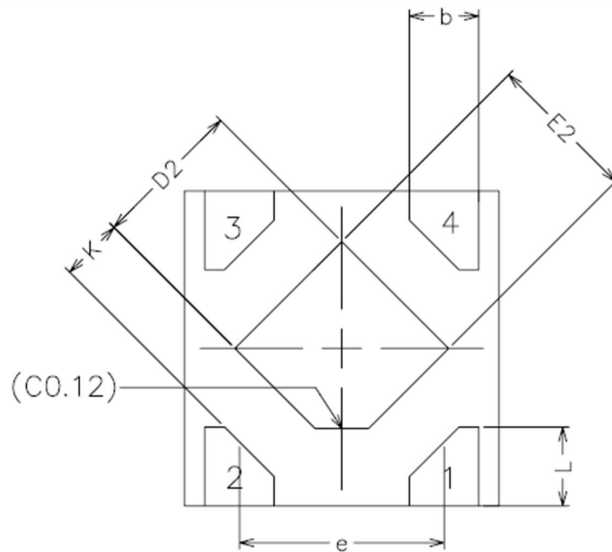
RD	Reel Dimension	<input checked="" type="checkbox"/> 7inch	<input type="checkbox"/> 13inch
W	Overall width of the carrier tape	<input checked="" type="checkbox"/> 8mm	<input type="checkbox"/> 12mm <input type="checkbox"/> 16mm
P1	Pitch between successive cavity centers	<input type="checkbox"/> 2mm	<input checked="" type="checkbox"/> 4mm <input type="checkbox"/> 8mm
Pin1	Pin1 Quadrant	<input type="checkbox"/> Q1	<input type="checkbox"/> Q2 <input checked="" type="checkbox"/> Q3 <input type="checkbox"/> Q4

PACKAGE OUTLINE DIMENSIONS

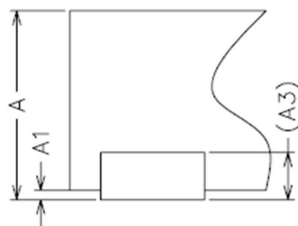
DFN1x1-4L



TOP VIEW



BOTTOM VIEW



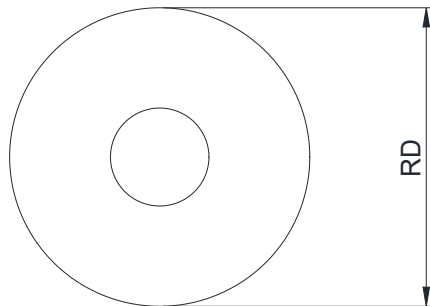
SIDE VIEW

Symbol	Dimensions in Millimeters		
	Min.	Typ.	Max.
A	0.34	0.37	0.40
A1	0.00	0.02	0.05
A3	0.10 REF		
b	0.17	0.22	0.27
D	0.95	1.00	1.05
E	0.95	1.00	1.05
D2	0.43	0.48	0.53
E2	0.43	0.48	0.53
L	0.20	0.25	0.30
e	0.60	0.65	0.70
K	0.15	-	-

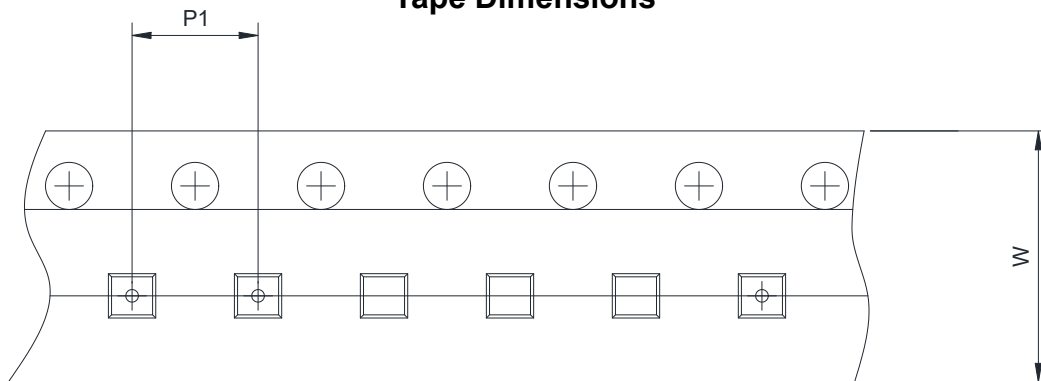
TAPE AND REEL INFORMATION

DFN1x1-4L

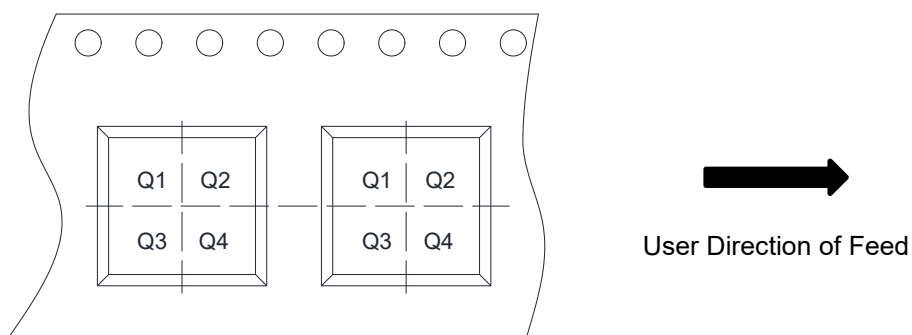
Reel Dimensions



Tape Dimensions



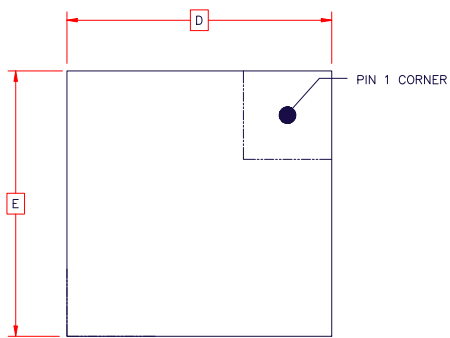
Quadrant Assignments For PIN1 Orientation In Tape



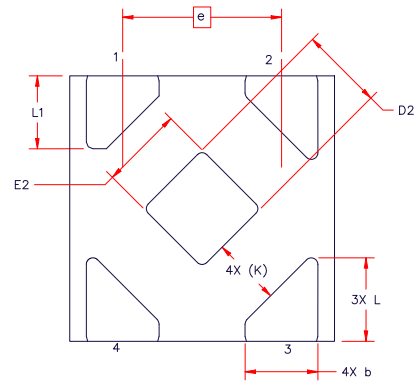
RD	Reel Dimension	<input checked="" type="checkbox"/> 7inch	<input type="checkbox"/> 13inch
W	Overall width of the carrier tape	<input checked="" type="checkbox"/> 8mm	<input type="checkbox"/> 12mm <input type="checkbox"/> 16mm
P1	Pitch between successive cavity centers	<input checked="" type="checkbox"/> 2mm	<input type="checkbox"/> 4mm <input type="checkbox"/> 8mm
Pin1	Pin1 Quadrant	<input type="checkbox"/> Q1	<input checked="" type="checkbox"/> Q2 <input type="checkbox"/> Q3 <input type="checkbox"/> Q4

PACKAGE OUTLINE DIMENSIONS

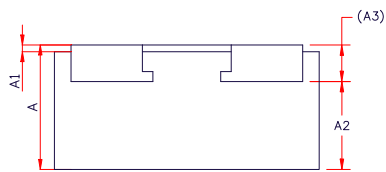
DFN0.8x0.8-4L



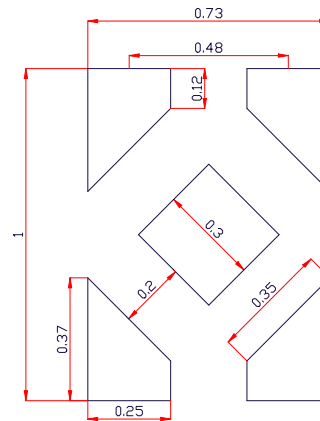
TOP VIEW



BOTTOM VIEW



SIDE VIEW



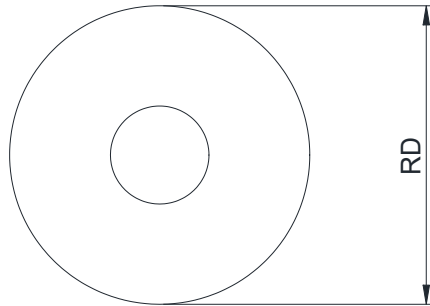
RECOMMENDED LAND PATTERN(unit : mm)

Symbol	Dimensions in Millimeters		
	Min.	Typ.	Max.
A	0.32	0.375	0.40
A1	-0.004	-	0.0005
A2	-	0.265	-
A3	0.11 REF		
D	0.80 BSC		
E	0.80 BSC		
e	0.48 BSC		
D2	0.15	0.25	0.35
E2	0.15	0.25	0.35
b	0.17	0.22	0.27
L	0.152	0.252	0.352
L1	0.12	0.22	0.32
K	0.207 REF		

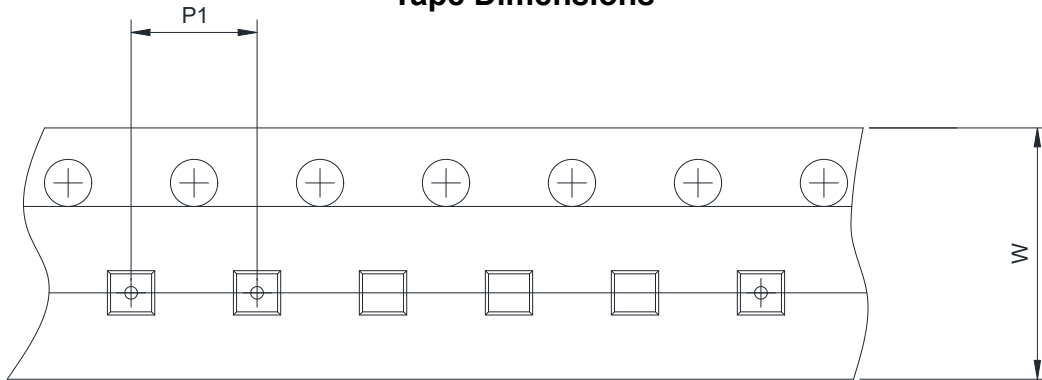
TAPE AND REEL INFORMATION

DFN0.8x0.8-4L

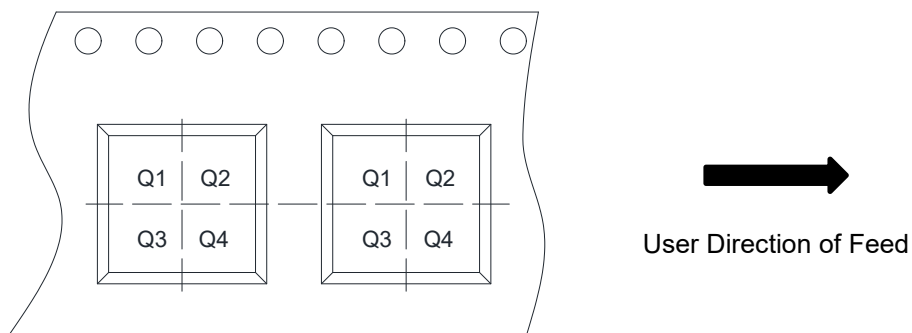
Reel Dimensions



Tape Dimensions



Quadrant Assignments For PIN1 Orientation In Tape



RD	Reel Dimension	<input checked="" type="checkbox"/> 7inch	<input type="checkbox"/> 13inch
W	Overall width of the carrier tape	<input checked="" type="checkbox"/> 8mm	<input type="checkbox"/> 12mm <input type="checkbox"/> 16mm
P1	Pitch between successive cavity centers	<input type="checkbox"/> 2mm	<input checked="" type="checkbox"/> 4mm <input type="checkbox"/> 8mm
Pin1	Pin1 Quadrant	<input type="checkbox"/> Q1	<input checked="" type="checkbox"/> Q2 <input type="checkbox"/> Q3 <input type="checkbox"/> Q4

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[NJM2904CRB1-TE1](#) [UPC4570G2-E1-A](#) [UPC4741G2-E1-A](#) [NJM8532RB1-TE1](#) [EL2250CS](#) [EL5100IS](#) [EL5104IS](#) [EL5127CY](#) [EL5127CZY](#)
[EL5133IW](#) [EL5152IS](#) [EL5156IS](#) [EL5162IS](#) [EL5202IY](#) [EL5203IY](#) [EL5204IY](#) [EL5210CS](#) [EL5210CZY](#) [EL5211IYE](#) [EL5220CY](#)
[EL5223CLZ](#) [EL5223CR](#) [EL5224ILZ](#) [EL5227CLZ](#) [EL5227CRZ](#) [EL5244CS](#) [EL5246CS](#) [EL5246CSZ](#) [EL5250IY](#) [EL5251IS](#) [EL5257IS](#)
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