EMS4000

Dual 2:1 USB2.0 Mux/De-Mux with 20V Over-Voltage Protection

Product datasheet, Rev. 1.7 Jun 20, 2025

1. General Description

The EMS4000 is a bidirectional low-power dual port, high-speed, USB 2.0 analog switch with integrated protection for USB Type-C™ systems. The device is configured as a dual 2:1 or 1:2 switch. It is optimized for use with the USB 2.0 DP/DM lines in a USB Type-C™ system.

The device integrates over-voltage protection on the C0+/- pins can withstand up to DC 7V with automatic shutoff circuitry in order to protect system components behind the switch. GPIO controls of SEL and $\overline{EN}$ are 1.8V logic compatible.

The EMS4000 is available in QFN 1.4x1.8-10L, QFN 1.5x2.0-10L, DFN3x3-10L and MSOP-10L package with Pb-free and Halogen-free making it a perfect candidate for mobile and space constrained applications.

2. Features and Benefits

- Wide Supply Range from 2.5 V to 4.5 V
- Differential 2:1 or 1:2 Switch/Multiplexer
- Up to DC 7V Overvoltage Protection (OVP) on C0+/- Ports
- IEC 64000-4-5 Surge Protection w/o External TVS onto C0+/- Ports: ±20 V
- System Side Clamp Voltage Pulse Less than 8 V, Duration Less than 300 ns
- Power off Protection When V_{DD} = 0 V
- 10 Ω typical ON resistance
- Insertion loss: -1dB@200MHz, -2dB@650MHz, -3dB@1GHz
- 4 pF typical ON capacitance
- 1.8 V Compatible Control Logic Inputs
- Latch-up performance exceeds 250 mA
- ESD protection:
  - HBM ESDA/JEDEC JS-001 Class 2 exceeds 2000 V
  - CDM ANSI/ESDA/JEDEC JS-002 Class C3 exceeds 2000 V

3. Applications

- USB Type-C™, Type A and Micro B devices
- Mobile Phones, Tablets and Notebooks

4.Ordering Information

Table 1. Ordering information

Type number	Topside marking	Package		
		Name	Description	Quantity
EMS4000RSW	4000YYWW	QFN1.4×1.8-10L	QFN package, 10 pins 1.4 mm × 1.8 mm; 0.55 mm (Max) height	3000
EMS4000RSE	4000YYWW	QFN1.5×2.0-10L	QFN package, 10 pins 1.5 mm × 2.0 mm; 0.6 mm (Max) height	3000
EMS4000DRC	4000YYWW	DFN3x3-10L	DFN package, 10 pins 3.0 mm × 3.0 mm; 0.8 mm (Max) height	5000
EMS4000MS	4000YYWW	MSOP-10L	MSOP package, 10 pins 3.0mm × 3.0mm; 1.1 mm (Max) height	3000

MARKING INFORMATION

NOTE: YYWW = Data Code.

YY WW

Data Code -Week

Data Code -Year

5.Functional Diagram

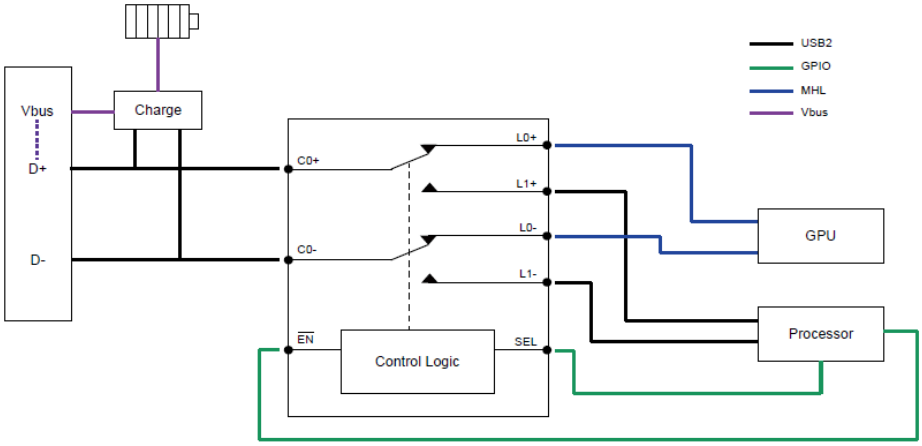


Fig 1. Functional diagram

6.Pinning Information

6.1. Pin map

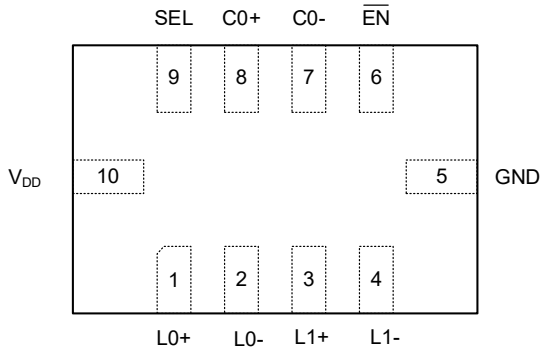


Fig 2. Top view pin configuration QFN 1.5x2.0-10L

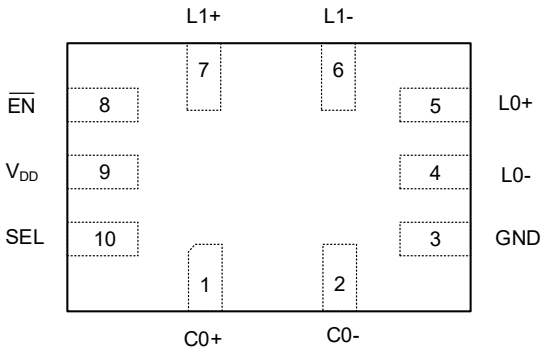


Fig 3. Top view pin configuration QFN 1.4x1.8-10L

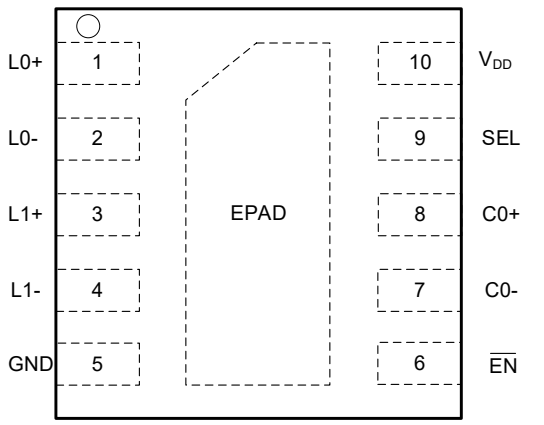


Fig 4. Top view pin configuration DFN-10L

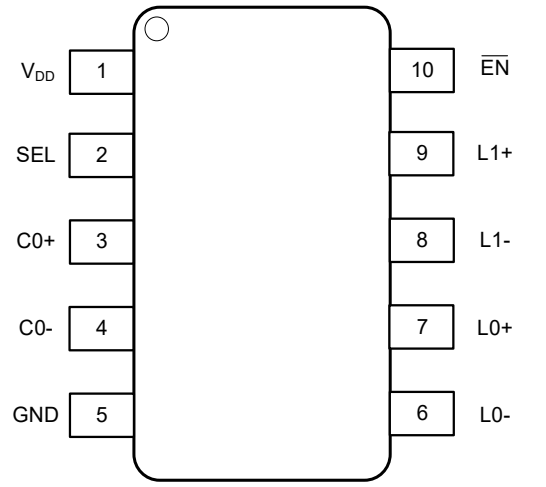


Fig 5. Top view pin configuration MSOP-10L

6.2. Pin description

Table 2. Pin description

Symbol	Pin			Signal Type	Description
	QFN1.4x1.8-10L	QFN1.5x2.0-10L/DFN3x3-10L	MSOP-10L		
C0+	1	8	3	I/O	Signal I/O, Common Port
C0-	2	7	4	I/O	Signal I/O, Common Port
L1+	7	3	9	I/O	Signal I/O, Channle 1
L1-	6	4	8	I/O	Signal I/O, Channle 1
L0+	5	1	7	I/O	Signal I/O, Channle 0
L0-	4	2	6	I/O	Signal I/O, Channle 0
SEL	10	9	2	I	Operation Model Select; (when SEL=0: C0->L0, when SEL=1: C0->L1)
$\overline{EN}$	8	6	10	I	$\overline{EN}$ = 1, Power Down is Enabled
V_{DD}	9	10	1	PWR	Positive Supply Voltage
GND	3	5	5	GND	Power Ground

7.Functional Description

Table 3. Function table
H = HIGH voltage level; L = LOW voltage level; X = Don't care.

Input		Switch
$\overline{EN}$	SEL	
L	L	C0+ to L0+, C0- to L0-
L	H	C0+ to L1+, C0- to L1-
H	X	Switch off

8.Absolute Maximum Ratings

Absolute Maximum Ratings may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification is not implied.

Table 4 Absolute Maximum Ratings

Symbol	Parameter	Conditions	Min	Max	Unit
V_{DD}	supply voltage		-0.3	5.5	V
V_{IN}	control input voltage		-0.3	5.5	V
P_D	power dissipation			250	mW
T_{stg}	storage temperature		-55	150	°C
T_J	junction temperature under bias			125	°C
T_L	lead temperature (soldering, 10 seconds)			260	°C

9.Recommended Operating Conditions

Table 5 Recommend operating ratings

Symbol	Parameter	Conditions	Min	Max	Unit
V_{DD}	supply voltage operating		2.5	4.5	V
V_{IN}	control input voltage		0	4.5	V
T_A	operating temperature		-40	125	°C

10. Electrical Characteristics

Table 4. Electrical characteristics

T_a = 25 ℃, V_{DD} = 3.3 V, unless otherwise specified

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
POWER SUPPLY						
V_{DD}	supply voltage range		2.5	3.3	4.5	V
I_{DD}	supply current	$\overline{EN}$ = 3.5 V V_{DD} = 3.5 V		10	18	uA
		$\overline{EN}$ = 0 V V_{DD} = 3.5 V		42	60	uA
SEL/_EN DIGITAL INPUT CONTOL						
V_{IH}	control input logic high		1.6		4.5	V
V_{IL}	control input logic low		0		0.5	V
SWITCH ON RESISTANCE AND OFF LEAKAGE						
R_{ON}	on-resistance	V_{IS} = 0 V to 0.4 V I_{OUT} = 8 mA		10	13	Ω
R_{FLAT}	R_{ON} flatness [1]	V_{IS} = 0 V to 0.4 V I_{OUT} = 8 mA		0.2	0.4	Ω
ΔR_{ON}	R_{ON} matching between channels [2]	V_{IS} = 0 V to 0.4 V I_{OUT} = 8 mA		0.1	0.5	Ω
I_{LEAK}	OFF leakage current	$V_{C0+/-}$ = 6 V $V_{L0+/-}$ = $V_{L1+/-}$ = 0 V		52	90	uA
SWITCH DYNAMICS						
C_{ON}	on capacitance	V_{DD} = V_{IS} = 3.3 V, $\overline{EN}$ = 0		4		pF
C_{OFF}	off capacitance	V_{DD} = V_{IS} = 3.3 V, $\overline{EN}$ = 1		4		pF
Off	off isolation	f = 250 MHz, R_L = 50 Ω, C_L = 0 pF		-38		dB
X_{TALK}	crosstalk [3] (Channel-to-Channel)	f = 250 MHz, R_L = 50 Ω, C_L = 0 pF		-41		dB
BW	-3dB bandwidth	R_L = 50 Ω, C_L = 0 pF Signal Power = 0 dBm	0.9	1		GHz
BBM	break-before-make	V_{IS} = 0.4 V, R_L = 50 Ω		640		ns
t_{ON}	turn-on time	V_{IS} = 0.4 V, R_L = 50 Ω $\overline{EN}$ switches from High to Low		80		ns
t_{OFF}	turn-off time	V_{IS} = 0.4 V, R_L = 50 Ω $\overline{EN}$ switches from Low to High		100		ns
t_{PD}	propagation delay	V_{IS} = 0.4 V, R_L = 50 Ω		200		ps
OVER VOLTAGE PROTECTION						

V_{FP}	OVP lockout threshold	$V_{C0+/-}$ Rising Edge	4.6	4.9	5.2	V
V_{HYS}	OVP hysteresis			300		mV
V_{CLAMP}	clamp voltage on L0+/- and L1+/-	10 V shorts to C0+/- with R_L = 1 kΩ			8	V
t_{FP}	OVP response time	10 V shorts to C0+/- with R_L = 1 kΩ		200	300	ns
t_{FPR}	OVP recovery time	$V_{C0+/-}$ from 6 V to 1 V		40		ns

[1] Flatness is defined as the difference between maximum and minimum value of ON-resistance at the specified analog signal voltage points.
[2] R_{ON} matching between channels is calculated by subtracting the channel with the lowest max Ron value from the channel with the highest max R_{ON} value.
[3] Crosstalk is inversely proportional to source impedance.

11. Typical Performance Curves

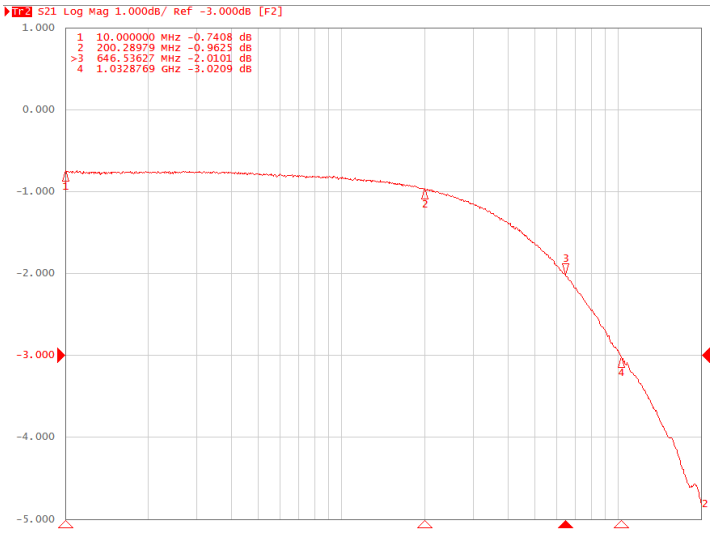


Fig 6. Switch Bandwidth or Insertion Loss

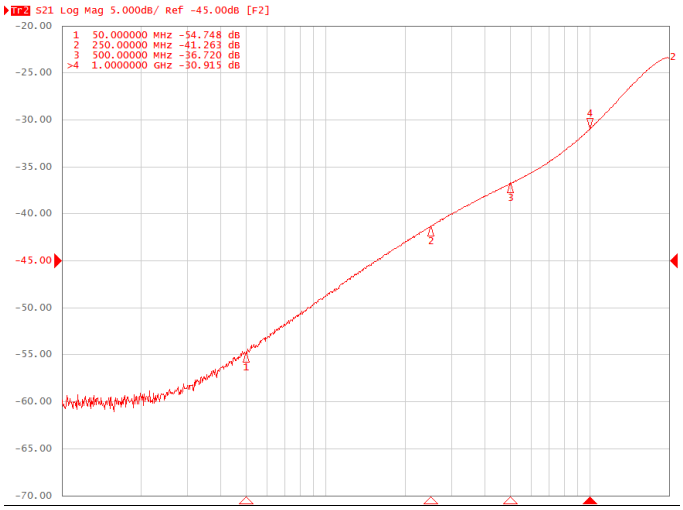


Fig 7. Switch Channel to Channel Cross-Talk

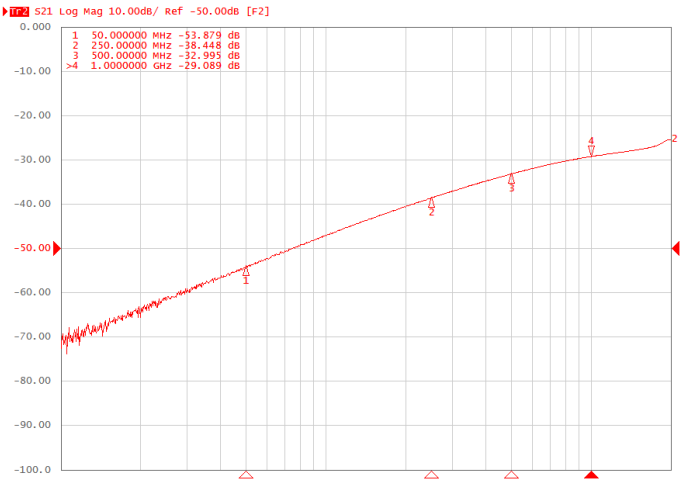
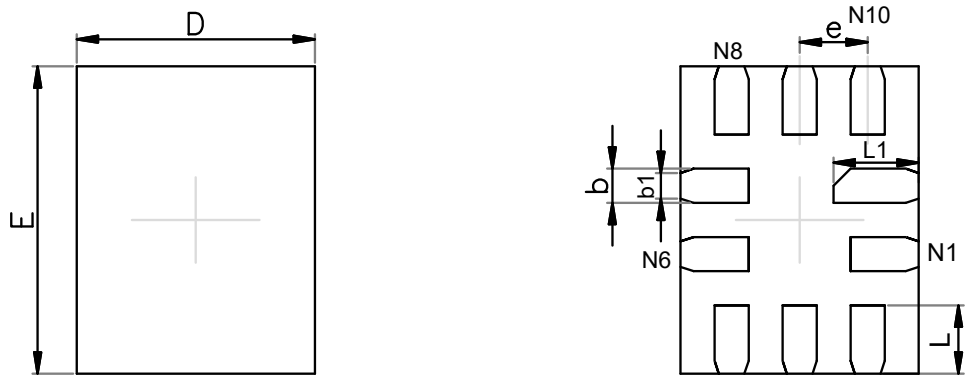
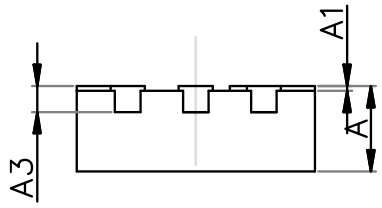


Fig 8. Switch Off Isolation

12. Package Outline

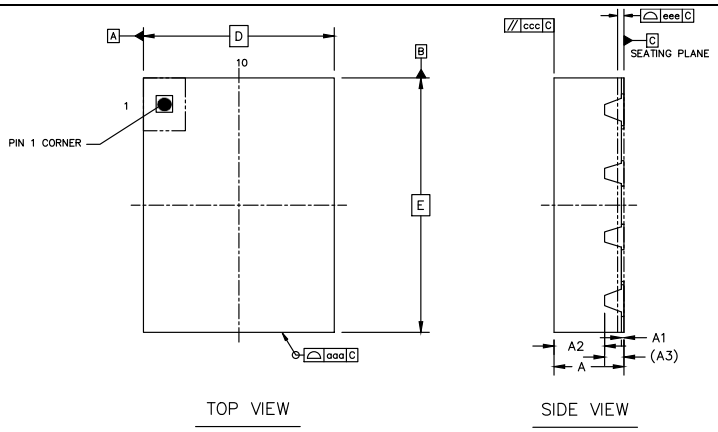
QFN 1.4x1.8 -10L

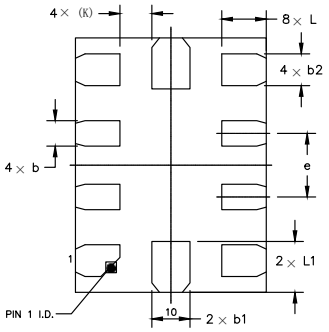




Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.450	0.550	0.018	0.022
A1	0.000	0.050	0.000	0.002
A3	0.152REF.		0.006REF.	
D	1.350	1.450	0.053	0.057
E	1.750	1.850	0.069	0.073
b	0.150	0.250	0.006	0.010
b1	0.100	0.200	0.004	0.008
e	0.400TYP.		0.016TYP.	
L	0.350	0.450	0.014	0.018
L1	0.450	0.550	0.018	0.022

QFN 1.5x2.0 -10L

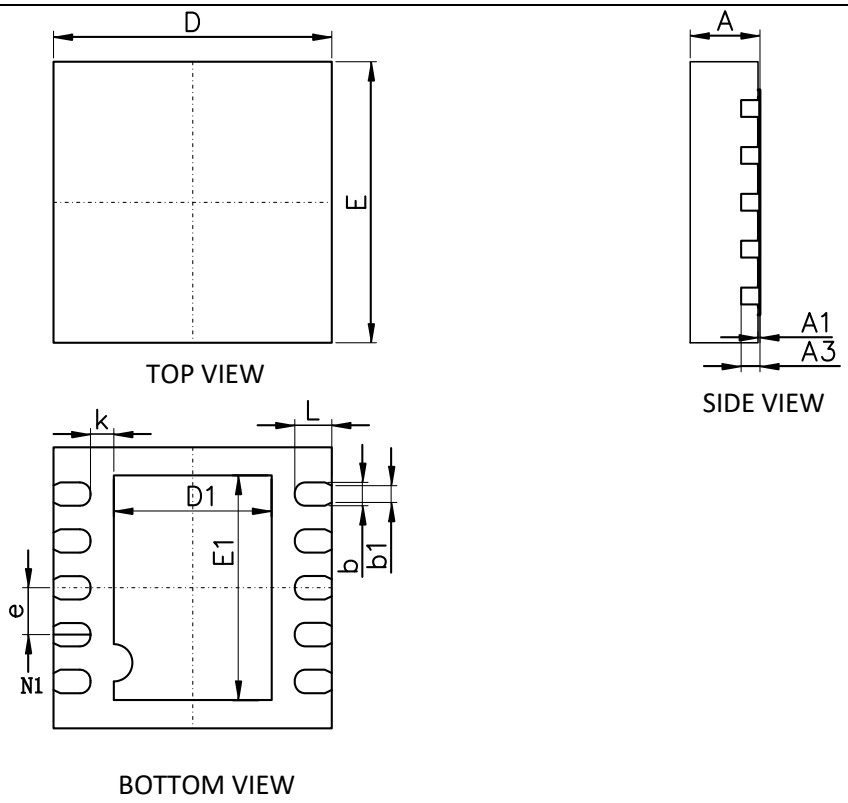




BOTTOM VIEW

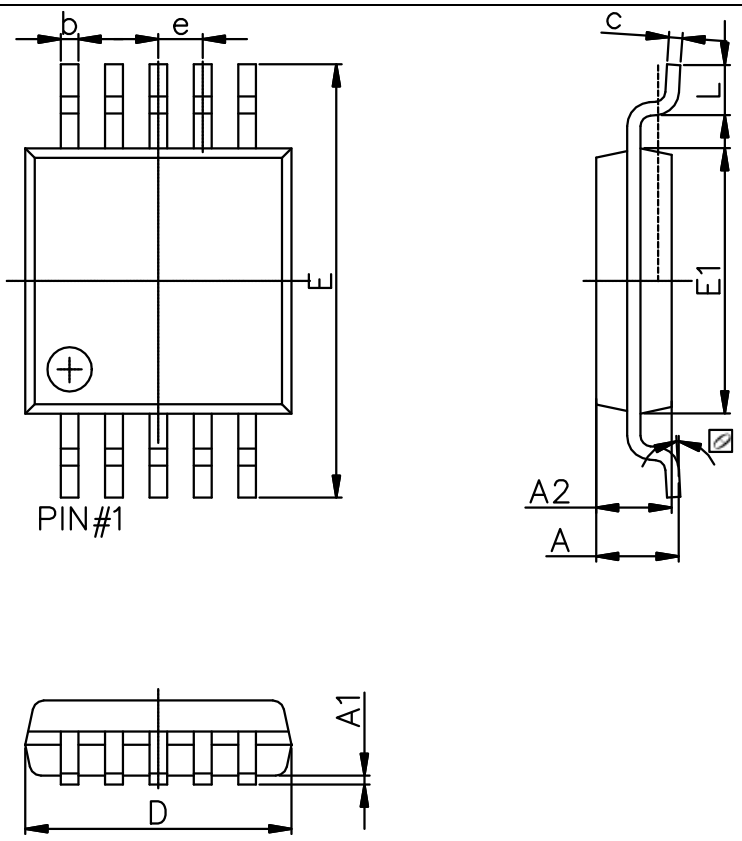
Symbol	Dimensions In Millimeters		
	MIN	NOM	MAX
A	0.5	0.55	0.6
A1	0	0.02	0.05
A2	---	0.398	---
A3	0.152 REF		
D	1.5 BSC		
E	2 BSC		
b	0.15	0.2	0.25
b1	0.25	0.3	0.35
b2	0.2	0.25	0.3
e	0.5 BSC		
L	0.3	0.35	0.4
L1	0.35	0.40	0.45
K	0.25 ref		

DFN 3x3 -10L



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A3	0.203REF.		0.008REF.	
D	2.924	3.076	0.115	0.121
E	2.924	3.076	0.115	0.121
D1	1.600	1.800	0.063	0.071
E1	2.300	2.500	0.091	0.098
b	0.200	0.300	0.008	0.012
b1	0.180REF		0.007REF	
e	0.500BSC.		0.020BSC.	
k	0.250REF		0.010REF	
L	0.324	0.476	0.013	0.019

MSOP - 10L



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	---	1.100	---	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.180	0.330	0.007	0.013
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
e	0.500(BSC)		0.020(BSC)	
E	4.750	5.050	0.187	0.199
E1	2.900	3.100	0.114	0.122
L	0.400	0.800	0.016	0.031
θ	0°	6°	0°	6°

13. Tape and Reel Information

13.1. Carrier tape dimensions

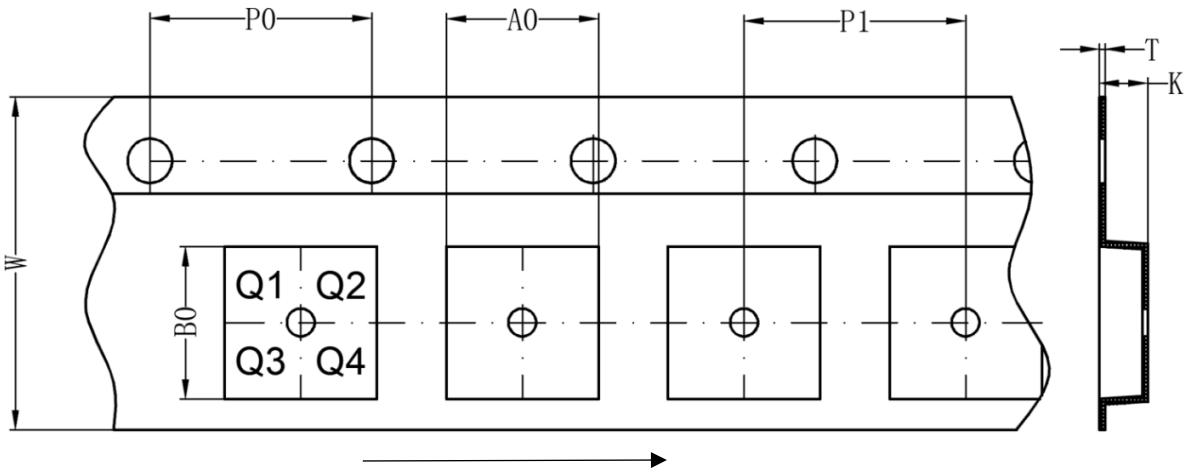


Table 5. Carrier tape dimensions

Package version	A0(mm)	B0(mm)	K0(mm)	T(mm)	P1(mm)	W(mm)	P0(mm)	PIN 1
QFN1.4×1.8-10L	1.6	2.0	0.85	0.2	4	8	4	Q1
DFN3x3-10L	3.35	3.35	1.13	0.25	8	12	4	Q1
QFN1.5x2-10L	1.7	2.3	0.75	0.2	4	8	4	Q1
MSOP-10L	5.3	3.4	1.4	0.25	8	12	4	Q1

13.2. Reel and box dimensions

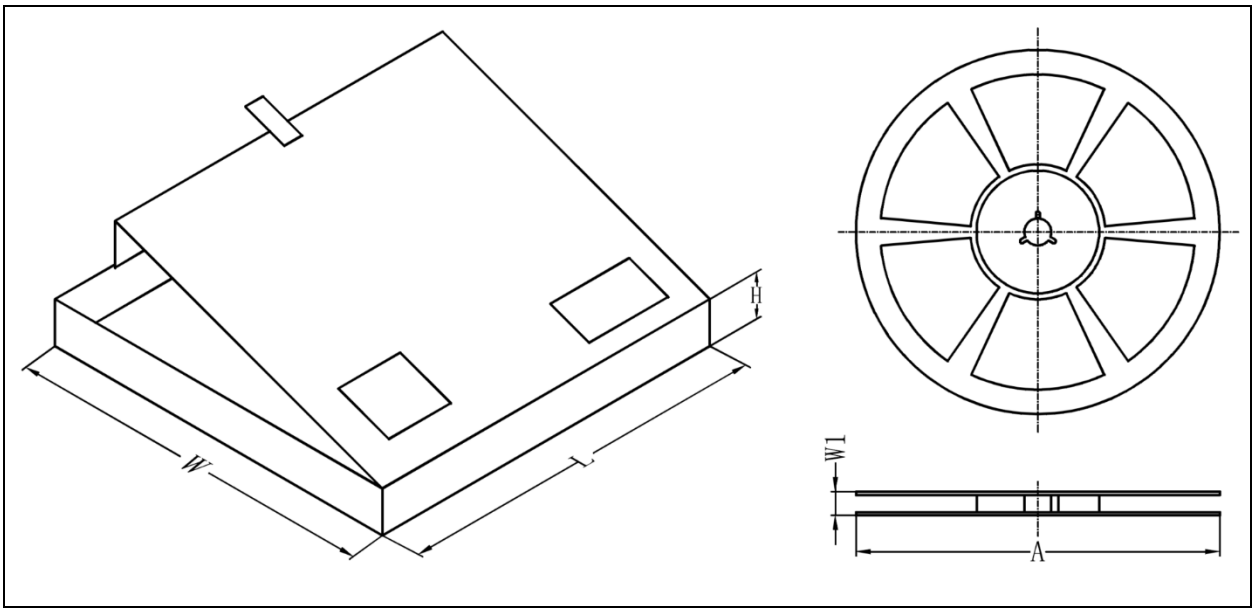


Table 6. Dimensions and quantities

Package version	Type NO. ending	Reel Dimension A (mm)	Reel Width W1 (mm)	SPQ (pcs)[1]	Reels per box	Outer box dimensions L×W×H(mm)[2]
QFN1.4×1.8-10L	1R	180	12.2	3000	1	210x200x40
DFN3x3-10L	1R	330	17.6	5000	1	358x340x50
QFN1.5x2-10L	1R	180	12.2	3000	1	210x200x40
MSOP-10L	1R	330	17.6	3000	1	358x340x50

[1] Packing quantity dependent on specific product type. Please contact your local Energymath representative for ordering.

[2] Dimensions for reference only.

14. Abbreviations

Table 7. Abbreviations

Acronym	Description
ESD	ElectroStatic Discharge
HBM	Human Body Model

15. Revision History

Table 8. Revision history

Document ID	Release Date	Data sheet status	Change notice	Supersedes
EMS4000 Rev. 1.7	Jun 20, 2025	Product datasheet		EMS4000 Rev. 1.6
Modifications	• Added marking, tape and reel information			
EMS4000 Rev. 1.6	May 21, 2025	Product datasheet		EMS4000 Rev. 1.5
Modifications:	• Table 4: On resistance matching between channels updated.			
EMS4000 Rev. 1.5	Apr 18, 2025	Product datasheet		EMS4000 Rev. 1.4
Modifications:	• Table 4: Supply current and off leakage updated.			
EMS4000 Rev. 1.4	Feb 12, 2025	Product datasheet		EMS4000 Rev. 1.3
Modifications:	• Features and Benefits updated. • Table 4: Supply current, on resistance and off leakage updated.			
EMS4000 Rev. 1.3	Nov 22, 2024	Product datasheet		EMS4000 Rev. 1.2
Modifications:	• Added DFN3x3-10L package.			
EMS4000 Rev. 1.2	Nov 8, 2024	Product datasheet		EMS4000 Rev. 1.1
Modifications:	• Table 4: On Capacitance and off Capacitance updated. • Table 4: BBM , OVP Hysteresis and OVP recovery time updated. • Added MSOP-10L package.			
EMS4000 Rev. 1.1	Sep 25, 2024	Product datasheet		EMS4000 Rev. 1.0
Modifications:	• Table 4: Supply and leakage Current updated. • Table 4: On Capacitance, turn on time and propagation delay updated. • Table 4: OVP Hysteresis and OVP recovery time updated.			
EMS4000 Rev. 1.0	Oct 30, 2023	Product datasheet		