MAS6240C

Piezo Driver with Multi-Mode Charge Pump

- **Both Single Ended and Differential Output**
- **Three-Step Volume Adjusting**
- **Up to 18Vpp Output from 3V Supply**
- **One Wire Audio & Shutdown Control**
- **High Efficiency**
- **Solution without Inductors**
- **Low External Part Count**

DESCRIPTION

MAS6240 is a piezo driver device that can drive outputs up to 18Vpp from 3V supply. An internal three-mode charge pump generates boosted supply voltage for piezo driver. For adjusting the piezo element sound volume, the charge pump can operate in either of a 1x, 2x or 3x mode. In 1x mode the output voltage is same to the input voltage, in 2x or 3x mode the input voltage is boosted up accordingly 2 or 3 times. Charge pump mode is selected by control pins EN1 and EN2 (see Table 1 on page 2).

MAS6240 is an easy and low-cost solution for piezo driver, since only 4 small value capacitors are needed in addition to sound element - the use of inductors can be avoided. The inductorless design also causes significantly less disturbance to the surrounding circuits making it an ideal choice for sensitive designs. Its charge pump switches at 1MHz, allowing to using as small as 100nF external capacitors.

Control logic is switching the charge pump on at first rising signal of digital input (DIN) pin. The switch-off signal will be generated while the signal at DIN has been at low mostly for 50ms. The piezo driver is enabled at a second rising edge of a pulse at DIN and the signal is transferred to piezo output VO1. The same signal is inverted into output VO2 for using differential output.

Continuous logic high level at DIN input causes the charge pump to be turned ON but leaves the audio amplifier disabled. In that state the charge pump output can be used to power the external LEDs or any other external circuit. The output voltage is still selectable at three steps.

In "disabled" mode (DIN has been low for 15ms typically) all functional blocks are switched off to achieve the quiescent current less than 1µA.

Two QFN packaged device versions are available. C1 version has short circuit protection which limits input current taken from the supplies. It is suitable for driving piezo in single ended configuration. C2 version does not have input current limitation but it provides maximum output current drive capability and loudest sound pressure level. It is suited for driving piezo in both single ended and differential configurations. In the die form version D1 the input current limitation is selectable by bonding.

FEATURES

Piezo Driver & Charge Pump

- Thin 0.75 mm QFN 12 package
- Three-Step Volume Adjusting
- Both Single Ended and Differential Output
- Up to 18Vpp Output from 3V Supply
- One Wire Audio & Shutdown Control
- Low External Part Count
- Solution without Inductor
- 1 MHz Switching Frequency
- Multi-Mode Charge Pump (1x/2x/3x)

APPLICATIONS

- Wrist Watches
- Alarm Clocks
- Handheld GPS devices
- PDAs
- Portable Device with Sound Feature

BLOCK & APPLICATION DIAGRAM

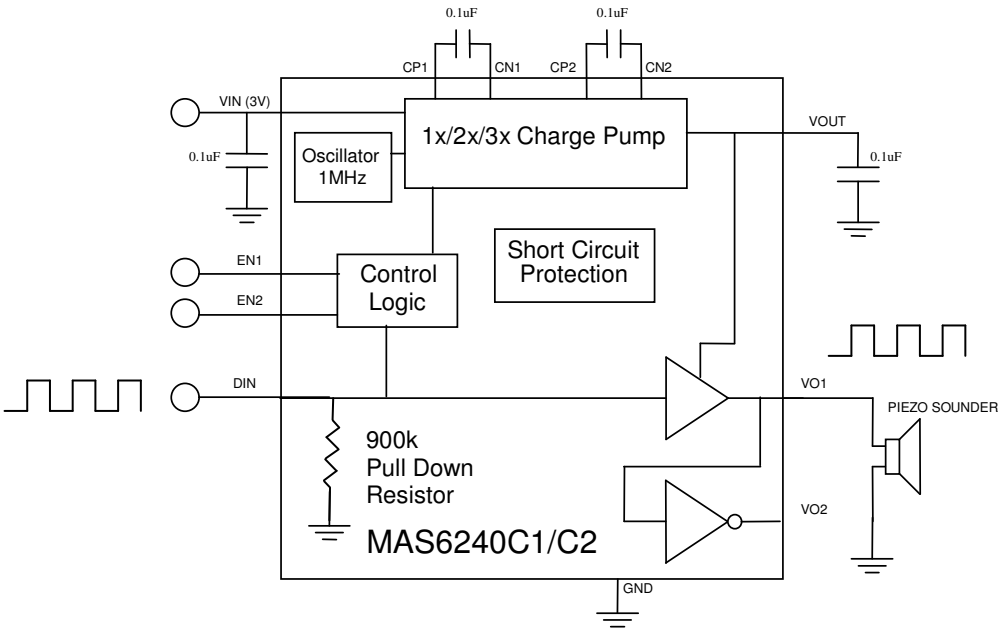


Figure 1: C1 or C2 Version Charge Pump + Single End Piezo Driver (max 9Vpp)

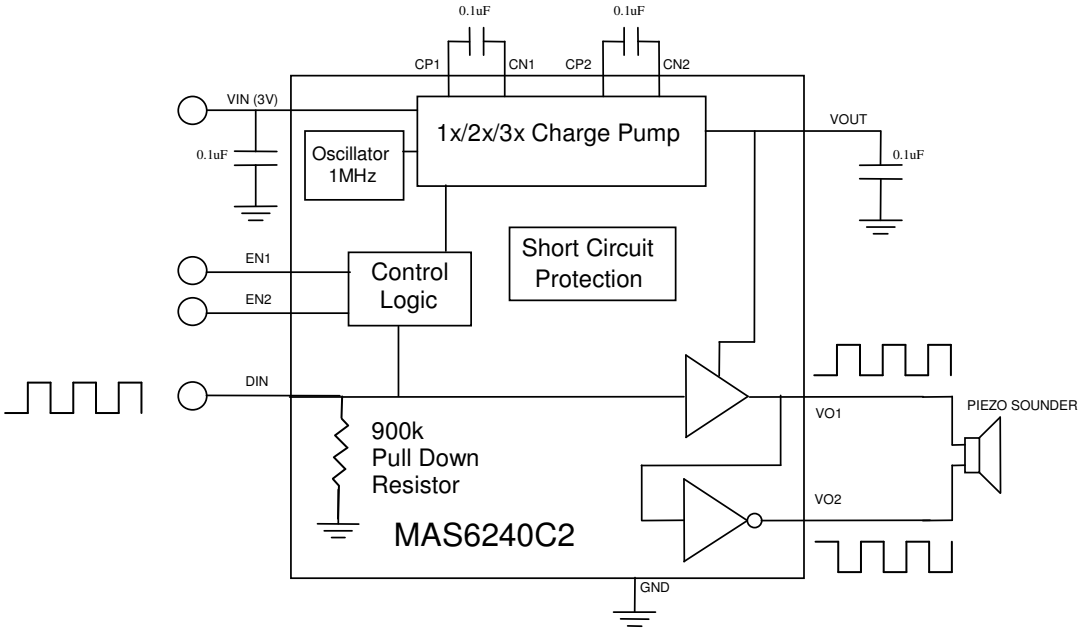


Figure 2: C2 Version Charge Pump + Differential Piezo Driver (max 18Vpp)

Table 1 Charge Pump boosting mode selection

DIN	EN1	EN2	Charge Pump
0	-	-	OFF
1	0	0	OFF
1	0	1	1x Mode (VIN)
1	1	0	2x Mode (2xVIN)
1	1	1	3x Mode (3xVIN)

Note: Pulsed signal at digital input DIN is taken as “1” if pulse low time is less than 5 ms!

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Conditions	Min	Max	Unit
Supply Voltage	VIN	Charge pump in 1x mode. Charge pump in 2x or 3x mode.	-0.3 -0.3	5.5 4.0	V
Outputs and Flying Capacitors Pins Voltages	VOUT, CP2, VO1, VO2		-0.3	12	V
	CP1, CN2,		-0.3	8	V
Voltage Range for Input Pins	DIN, EN1, EN2, CN1		-0.3	VIN + 0.3	V
VOUT Short-Circuit Duration	t_{SC}	Valid for C1 version which has short circuit limitation.		Indefinite	
Storage Temperature			-55	+150	°C
ESD Rating		Human Body Model (HBM)	±2		kV

Note: Stresses beyond the values listed may cause a permanent damage to the device. The device may not operate under these conditions, but it will not be destroyed.

RECOMMENDED OPERATING CONDITIONS

All voltages with respect to ground.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Operating Junction Temperature	T_J		-40		+125	℃
Operating Ambient Temperature	T_A		-40	+27	+85	℃
Operating Supply Voltage	V_{IN}		2.2	3.0	3.3	V

ELECTRICAL CHARACTERISTICS

T_A = -40°C to +85°C, typical values at T_A = 27°C, V_{IN} = 3.0 V, C_1 = 100 nF, C_2 = 100 nF, C_{OUT} = 100 nF, C_{IN} = 100 nF, C_{piezo} = 15 nF, digital input DIN=4kHz; unless otherwise specified

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output Voltage	VOUT	VOUT pin voltage towards ground at VIN = 3 V C1 version: load 0…2 mA C2 version: load 0…5mA 1x Mode 2x Mode 3x Mode	 2.8 5.2 7.2		 3 6 9	 V
Current Consumption	I_{CC}	Charge Pump (no load): 1x Mode 2x Mode 3x Mode		 85 800 2100	 150 1500 3000	 µA
		Single ended application (C_{piezo} = 15nF; f=4kHz): 1x Mode 2x Mode 3x Mode		 0.3 1.7 4.2		 mA
		Differential application (C_{piezo} = 15 nF; f=4kHz): 1x Mode 2x Mode 3x Mode		 0.8 3.5 8.2		 mA
Signal Frequency	F_{AUDIO}		0.2	4	8	kHz
Shutdown Current	I_{SD}	DIN = 0V, **Note 1**			1	µA
Internal Switching Frequency (Charge Pump)	F_{OSC}		0.6	1	1.8	MHz
VOUT Turn-ON Time (From DIN signal HIGH to 90% VOUT steady state)	t_{ON}	C1 version 1x Mode 2x Mode 3x Mode		 10 130 400	 100 300 800	µs
		C2 version 1x Mode 2x Mode 3x Mode		 6 30 60	 100 200 300	µs
Shut Down delay	t_{OFF}	Time before device shutdown after DIN signal goes to LOW	5	15	50	ms
Short Circuit Current Limit	I_{SC}	From VIN pin C1 version C2 version	 5	 10	 50 150	 mA
Control Input Threshold	V_{IH} V_{IL}	EN1, EN2, DIN pins	1.6		 0.55	V V
Control Input Current	I_{IH} I_{IL}	V_{DIN} = 3V, (900kΩ pull down) V_{DIN} = 0V		3.4 0	7 1	µA µA
	 I_{IH} I_{IL}	V_{DIN} = 3V $V_{EN1,EN2}$ = 3V, (900kΩ pull down) $V_{EN1,EN2}$ = 0V		 3.4 0	 7 1	 µA µA
	 I_{IH} I_{IL}	V_{DIN} = 0V, **Note 2** $V_{EN1,EN2}$ = 3V $V_{EN1,EN2}$ = 0V		 0 0	 1 1	 µA µA

Note 1: DIN has been low at least 50 ms.
Note 2: EN1 and EN2 pins are at high-Z state while V_{DIN}=0V.

PIN DESCRIPTION

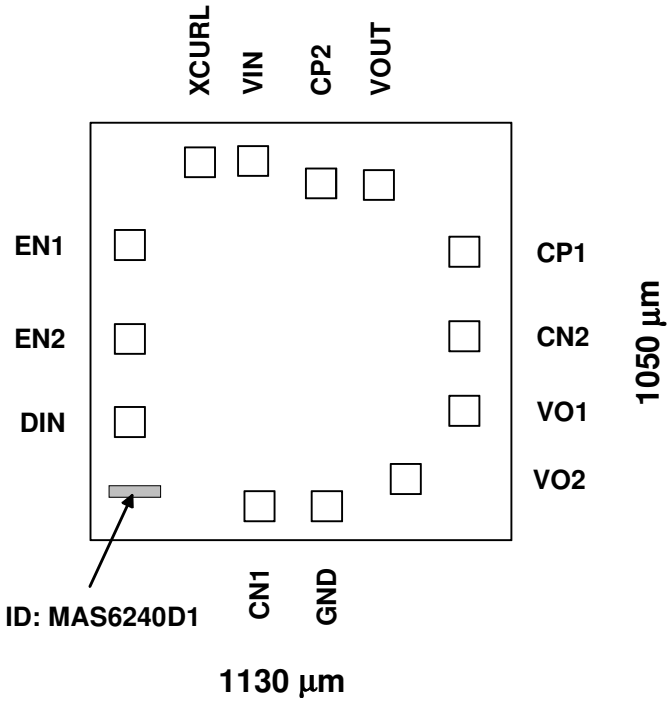
Pin Description	Symbol	Type	X-coordinate	Y-coordinate
Control signal input for setting charge pump mode	EN1	DI	121	695
Control signal input for setting charge pump mode	EN2	DI	121	527
Enable signal + Digital signal input	DIN	DI	121	360
Flying capacitor negative terminal	CN1	I/O	403	121
Supply ground	GND	G	574	121
Digital audio signal output	VO2	DO	765	201
Digital audio signal output	VO1	DO	929	407
Flying capacitor negative terminal	CN2	I/O	929	529
Flying capacitor positive terminal	CP1	I/O	929	682
Charge pump output	VOUT	AO	684	849
Flying capacitor positive terminal	CP2	I/O	570	849
Power supply	VIN	P	393	929
Control signal for current limitation C1 current limitation ON: XCURL=floating or GND C2 current limitation OFF: XCURL=VIN	XCURL	DI	285	929

G = Ground, P = Power, D = Digital, A = Analog, I = Input, O = Output.

Note: Because the substrate of the die is internally connected to GND, the die has to be connected to GND or left floating. Please make sure that GND is the first pad to be bonded. Pick-and-place and all component assembly are recommended to be performed in ESD protected area.

Note: Pad coordinates are measured from the left bottom corner of the chip to the center of the pads. The coordinates may vary depending on sawing width and location, however, distances between pads are accurate.

IC OUTLINES



DIE size = 1130 x 1050 mm; PAD size = 80 x 80 µm

DETAILED DESCRIPTION

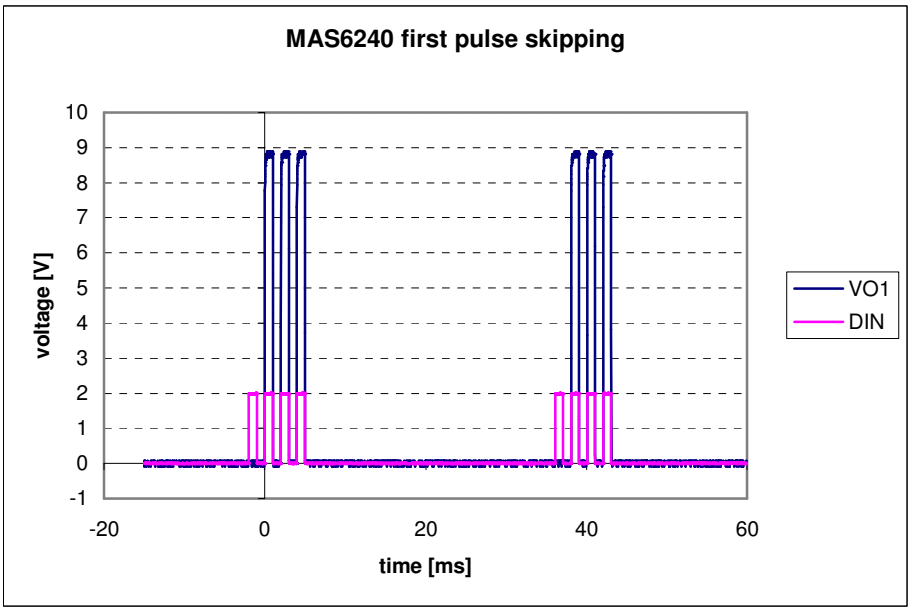


Figure 3: Enabling output VO1

The piezo driver is enabled at the second rising edge of the pulse at DIN, thus the signal is transferred to the piezo output VO1. An output VO2 is enabled at the same time, but it is optional to take it in use. Control logic is switching the charge pump on at first rising signal of digital input DIN pin. If only one continuous pulse is fed to the input DIN, the output VO1 is not enabled. This make it possible to control e.g. a white LED or other device through pin VOUT while charge pump is enabled, without enabling the piezo output VO1.

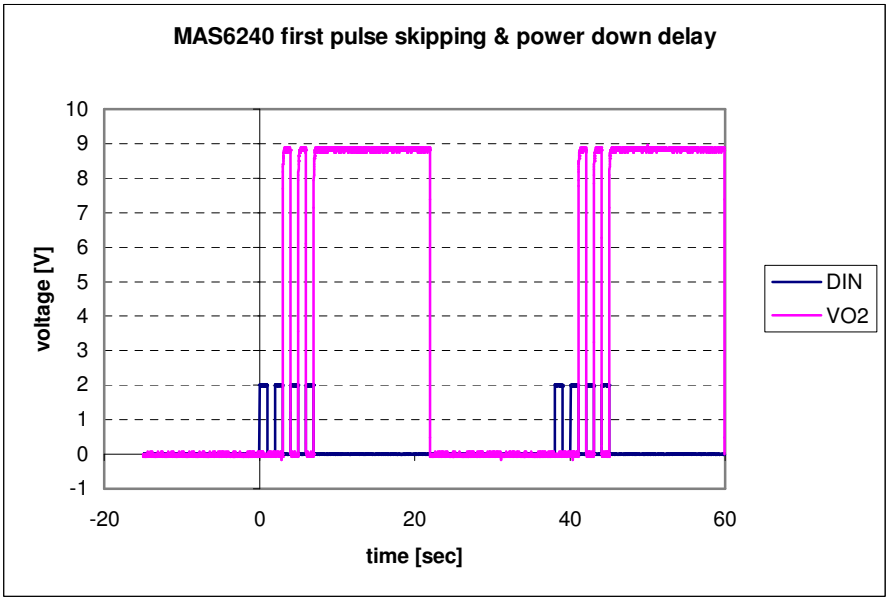
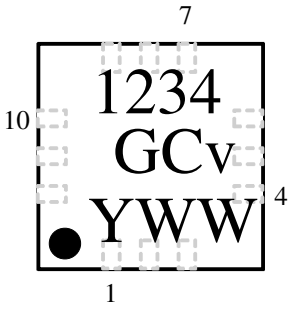


Figure 4: Disabling VO2

Figure 4 is drawn in the case of VO2. The switch-off signal will be generated after the signal at DIN has been low at mostly for 50 ms. In the figure 4 the switch-off delay is about 15 ms. Again when new pulses are fed into DIN, the charge pump and piezo driver will be enabled.

DEVICE OUTLINE CONFIGURATION

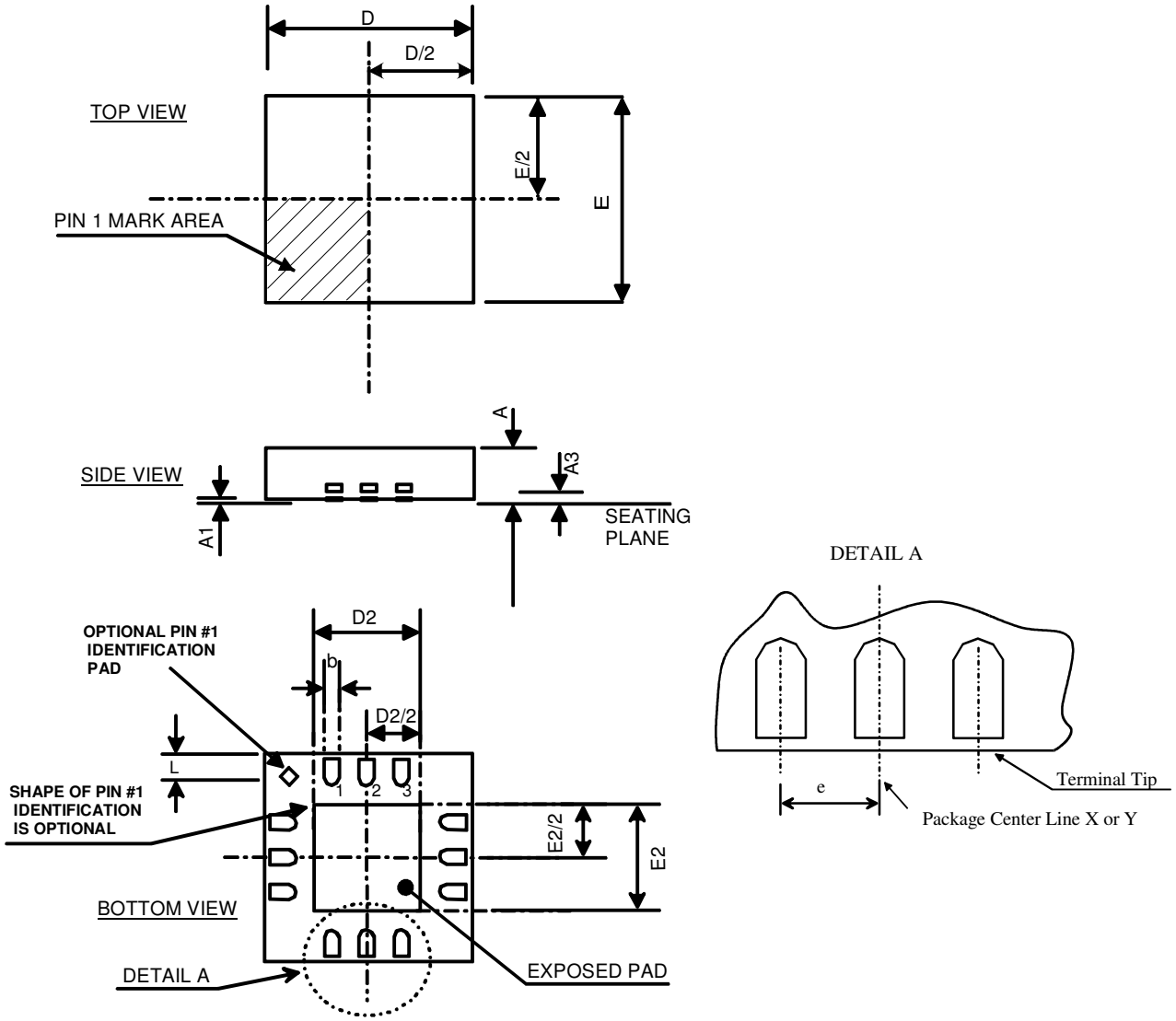
QFN 3x3 12ld



Top Marking Information:
1234 = Product Number
Cv = Version Number
G = Lead Free, RoHS Compliant Package
YWW = Year Week

Pin nr.	Pin Name	Pin nr.	Pin Name	Pin nr.	Pin Name	Pin nr.	Pin Name
1	EN1	4	CN1	7	VO1	10	VOUT
2	EN2	5	GND	8	CN2	11	CP2
3	DIN	6	VO2	9	CP1	12	VIN

PACKAGE (QFN 3X3x0.75 12ld) OUTLINE



Symbol	Min	Nom	Max	Unit
PACKAGE DIMENSIONS				
A	0.700	0.750	0.850	mm
A1	0.000	0.020	0.050	mm
A3	0.178	---	0.228	mm
b	0.180	---	0.280	mm
D	2.950	3.000	3.050	mm
D2 (Exposed.pad)	1.200	---	1.500	mm
E	2.950	3.000	3.050	mm
E2 (Exposed.pad)	1.200	---	1.500	mm
e	0.500 BSC			mm
L	0.350	---	0.450	mm

Dimensions do not include mold or interlead flash, protrusions or gate burrs.

3000 Components on Each Reel

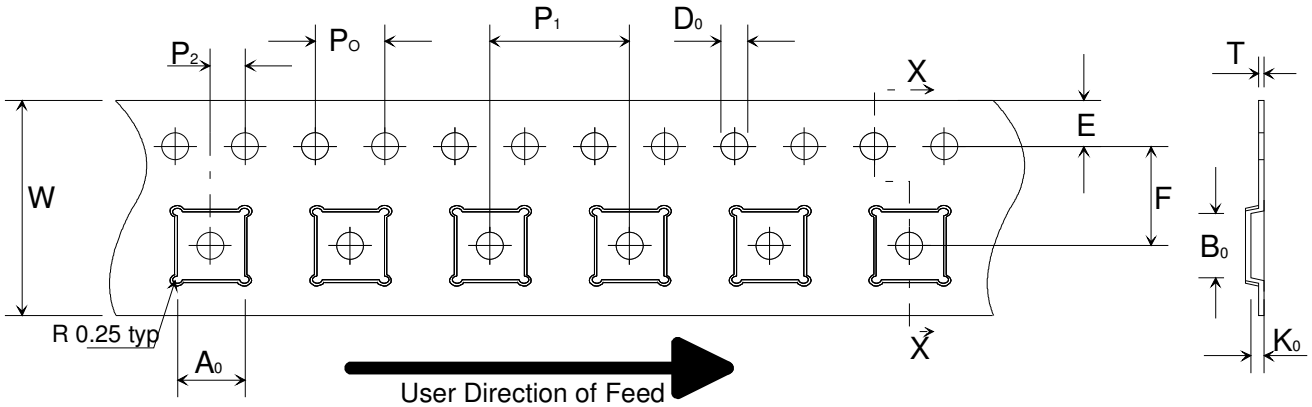
Reel Material: Conductive, Plastic Antistatic or Static Dissipative
Carrier Tape Material: Conductive
Cover Tape Material: Static Dissipative

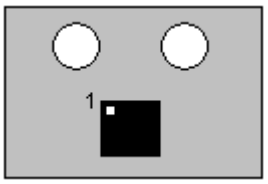
SOLDERING INFORMATION

◆ **For Lead-Free / Green QFN 3mm x 3mm x 0.75mm**

Resistance to Soldering Heat	According to RSH test IEC 68-2-58/20
Maximum Temperature	260°C
Maximum Number of Reflow Cycles	3
Reflow profile	Thermal profile parameters stated in IPC/JEDEC J-STD-020 should not be exceeded. http://www.jedec.org
Lead Finish	7.62 - 25.4 µm, Matte Tin

EMBOSSED TAPE SPECIFICATIONS



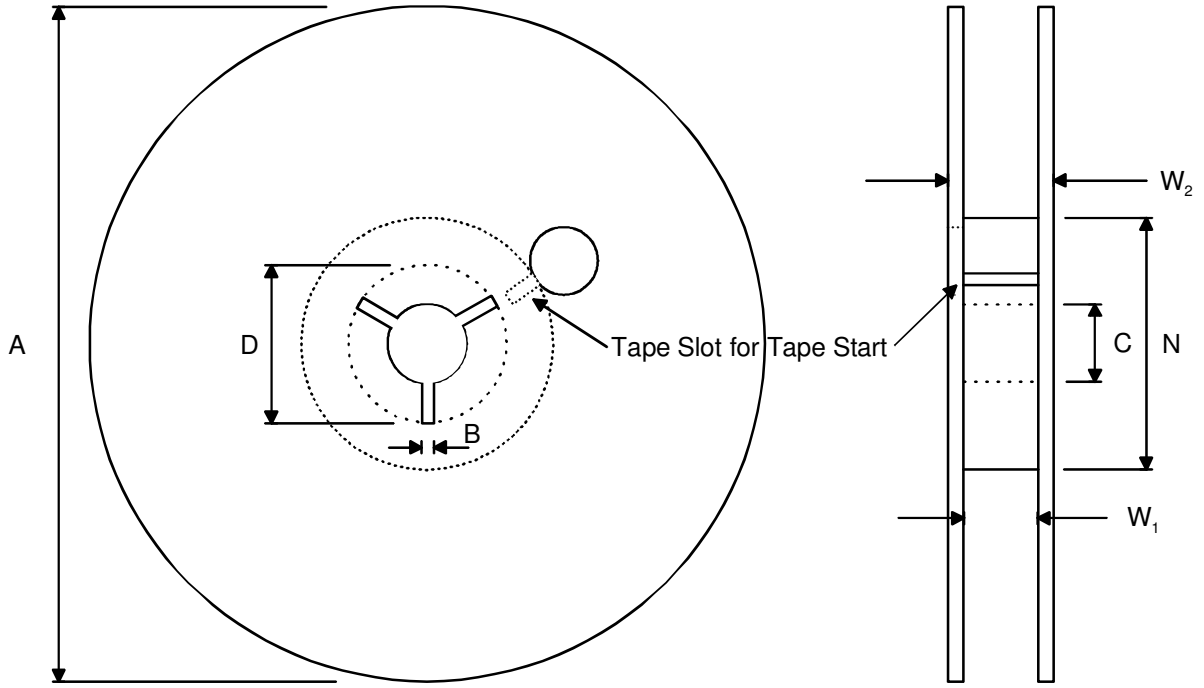


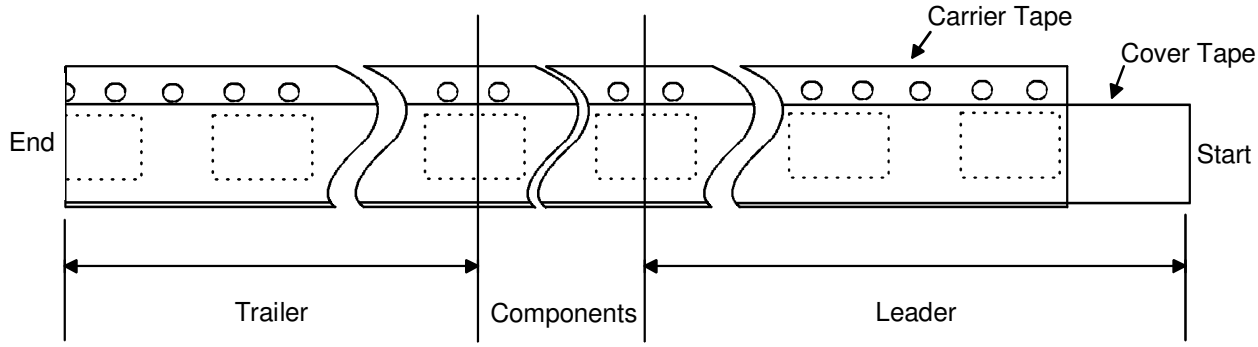
Orientation on tape

Dimension	Min/Max	Unit
A_o	3.30 ±0.10	mm
B_o	3.30 ±0.10	mm
D_o	1.50 +0.1/-0.0	mm
E	1.75	mm
F	5.50 ±0.05	mm
K_o	1.10 ±0.10	mm
P_o	4.0	mm
P_1	8.0 ±0.10	mm
P_2	2.0 ±0.05	mm
T	0.3 ±0.05	mm
W	12.00 ±0.3	mm

All dimensions in millimeters

REEL SPECIFICATIONS





Dimension	Min	Max	Unit
A		330	mm
B	1.5		mm
C	12.80	13.50	mm
D	20.2		mm
N	100		mm
W_1 (measured at hub)	12.4	14.4	mm
W_2 (measured at hub)		18.4	mm
Trailer	160		mm
Leader	390, of which minimum 160 mm of empty carrier tape sealed with cover tape		mm

ORDERING INFORMATION

Product Code	Product	Package	Comments
MAS6240C1HP06	Piezo Driver with Multi-Mode Charge Pump with Input Current Limiting	QFN 3x3x0.75 12ld, Pb Free, RoHS Compliant	Tape and Reel 3000 pcs / r
MAS6240C2HP06	Piezo Driver with Multi-Mode Charge Pump without Input Current Limiting	QFN 3x3x0.75 12ld, Pb Free, RoHS Compliant	Tape and Reel 3000 pcs / r
MAS6240D1TC00	Piezo Driver with Multi-Mode Charge Pump, Input Current Limiting Selectable by Bonding	EWS Tested 8" wafers, thickness 395 µm	Die size 1.13 x 1.05 mm
MAS6240D1TC05	Piezo Driver with Multi-Mode Charge Pump, Input Current Limiting Selectable by Bonding	395 µm thick dies in waffle pack	Die size 1.13 x 1.05 mm

◆ The formation of product code

An example for MAS6240C1HP06:

MAS6240	**C**	**1**	**HP**	**06**
Product name	Design version	Product Version	Package: HP = QFN 3 x 3 x 0.75 (Pb free, RoHS compliant)	Delivery format: 00 = Tested Wafer 05 = Tested Dies 06 = Tape and Reel 08 = In Tube

LOCAL DISTRIBUTOR

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