MAS6251

Piezo and LED Driver with Synchronous Boost DC/DC Converter

- **Both Single Ended and Differential Output**
- **Up to 35Vpp Output from min 1.2V Supply**
- **Self-Drive for 3-Terminal Piezo**
- **LED Driver**
- **High Efficiency**
- **External Schottky Diode Not Needed**
- **Small 0806 Size 2.2µH Inductor**

DESCRIPTION

MAS6251 is a piezo and LED driver device that can drive piezo outputs up to 35Vpp and sink up to 15mA LED current using wide range of supply voltage 1.2V…5.5V. An internal high efficiency DC/DC boost converter with adjustable output voltage generates up to 17.5V supply voltage for the piezo driver. Internal over voltage protection (OVP) allows also operating without external feedback resistors and when connecting FB feedback pin to GND. This configuration reduces external part count further and provides highest output voltage 17.5V typically.

MAS6251 uses synchronous type boost DC/DC converter which makes external Schottky diode unnecessary. Thus MAS6251 is a low part count and low-cost solution for a high sound pressure piezo driver.

Two piezo driver outputs (VOB, VOS) allow driving piezo in both single-ended and differential bridge-tied load (BTL) configurations. MAS6251 supports self-drive of a 3-terminal piezo.

The piezo driver is activated by setting DIN pin to logic high (DIN>0.9V). When disabled (logic low DIN<0.4V) the piezo driver outputs (VOB, VOS) are pulled actively to ground (GND).

MAS6251 has ILED pin for sinking up to 15mA current from series connected LEDs. The current sink is enabled by setting CTRL pin to logic high (CTRL>0.9V) which can be also controlled by PWM signal in LED dimming purposes. The DC/DC converter is turned on if either one of DIN or CTRL is at logic high (>0.9V).

The boost DC/DC converter and piezo driver disable signal (shutdown mode) will be generated while the signal at DIN and CTRL has been at low mostly for 15ms.

MAS6251 is available in a small 3x3x0.75 mm QFN-16 package.

FEATURES

- Thin 3x3x0.75 mm QFN-16 package
- Wide Supply Voltage Range 1.2V…5.5V
- Both Single Ended and Differential Output
- Self-Drive for 3-Terminal Piezo
- Up to 15mA LED Driver
- External Schottky Diode Not Needed
- Small 0806 Size 2.2µH Inductor
- Low External Part Count
- Over Voltage Protection (OVP)

APPLICATIONS

- Piezo Buzzers
- Smoke Alarms
- White Goods
- Alarm Clocks
- Handheld GPS devices
- Portable Devices with Sound Feature

ABSOLUTE MAXIMUM RATINGS

All voltages with respect to ground.

Parameter	Symbol	Conditions	Min	Max	Unit
Supply Voltage	VIN		-0.3	6	V
High Voltage Pins	VOUT, VOB, VOS, SW, ILED		-0.3	20	V
	FEED		-20	30	V
Voltage Range for Input Pins	DIN, CTRL		-0.3	6	V
	FB, RLED		-0.3	3	V
VOB, VOS Piezo Buffer Output Short-Circuit Duration	t_{SC}	VOB=VOS=GND **Note 1**		Continuous	
Storage Temperature		**Note 2**	-40	+125	ºC
Junction Temperature			-40	+150	ºC
ESD Rating	V_{HBM}	Human Body Model (HBM) All pins except RLED pin RLED pin **Note 3**		±1000 ±500	V
	V_{CDM}	Charged Device Model (CDM) **Note 4**		±500	V

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.
Note 1: The VOUT pin is not allowed to be shorted to ground.
Note 2: On chip EEPROM memory storing factory trimming values has data retention of minimum 10 years at +125°C.
Note 3: JEDEC document JEP155 states that 500V HBM allows safe manufacturing with a standard ESD control process.
Note 4: JEDEC document JEP157 states that 250V CDM allows safe manufacturing with a standard ESD control process.

RECOMMENDED OPERATING CONDITIONS

All voltages with respect to ground.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Operating Supply Voltage	V_{IN}	**Note 1**	1.2	3.0	5.5	V
Steady State Operating Output Voltage	V_{OUT}	**Note 2**	VIN+1V			V
Operating Ambient Temperature	T_A	**Note 3**	-40	+27	+85	°C
Operating Junction Temperature	T_J	**Note 4**	-40		+125	°C
Inductor Specification	L	Shielded inductor **Note 5**	1.5	2.2	3	µH
	I_{RATED}	L=2.2µH	500	600		mA
	R_{DC}	L=2.2µH		0.18	0.5	Ω
Peak Inductor Current	I_{L_PEAK}	VIN=3.0V, VOUT=15V, L=2.2µH			480	mA
Piezo Resonance Frequency	F_{PIEZO}			3.8	10	kHz
LED PWM Dimming Signal	F_{CTRL}	CTRL signal frequency	150		3000	Hz
	t_{ON_CTRL}	CTRL signal ON-time	30			µs

Note 1: Achieving minimum operating supply voltage 1.2V requires a low loss inductor. See note 5 for two low loss inductor examples. When driving LEDs or resistive load the minimum supply voltage can be higher than specified here. See figures 20-22 for output current drive capability at LED and resistive loading.
Note 2: For stable start-up and good output regulation the steady state output voltage (VOUT) should meet following condition; VOUT≥VIN+1V. When driving one or two LEDs the output voltage may not satisfy this requirement but depending on input voltage. In this case there can be added resistor in series with LED(s) to rise output voltage above the minimum requirement.
Note 3: Ambient temperature plus self-heating should not exceed +125°C in extended periods of time to not degrade EEPROM memory data retention time. Additionally user has to note that the on chip thermal shutdown feature can turn off the device at minimum +140°C rising temperature point.
Note 4: On chip EEPROM memory storing factory trimming values has data retention of minimum 10 years at +125°C.
Note 5: For small PCB footprint a 2x1.6x0.7mm (0806) size 2.2µH inductor is available from Murata (LQM2MPN2R2MEH#). For high efficiency a 3x3x1.2mm size 2.2µH inductor is available from Taiyo Yuden (NR3012T2R2M).

ELECTRICAL CHARACTERISTICS

T_A = -40°C to +85°C, typical values at T_A = 27°C, V_{IN} = 3.0 V, L = 2.2 µH, C_{IN} = 10 µF, C_{OUT} = 100 nF, C_{LOAD} = 15 nF, f_{PIEZO} = 3.8 kHz; unless otherwise specified

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Thermal Shutdown Temperature	T_{TSD}	Rising temperature (device off) Falling temperature (device on) **Note 1**	+140 +125	+150 +135	+160 +145	°C
Undervoltage-Lockout Threshold Levels	$UVLO_{RISE}$ $UVLO_{FALL}$	Turn on level at VDD rising Turn off level at VDD falling	1.10 1.05	1.15 1.10	1.20 1.15	V
Over Voltage Protection Voltage	VOVP	VOUT without feedback resistors	17	17.5	18	V
Output Voltage at Current Load	VOUT	VIN=3V, VOUT=15V (R2/R1=36.5) I_{LOAD}=15mA (R_{LOAD}=1kΩ)		15		V
Output Voltage at Capacitive Load	VOB, VOS	VIN=3V, VOUT=10V (R2/R1=24) VOS: C_{LOAD}=15nF VOB-VOS: C_{LOAD}=15nF VOS: C_{LOAD}=75nF, C_{OUT}=470nF VOB-VOS: C_{LOAD}=75nF, C_{OUT}=470nF		10 20 10 20		Vpp
		VIN=1.2V, VOUT=10V (R2/R1=24) VOB: C_{LOAD}=15nF VOB-VOS: C_{LOAD}=15nF VOB: C_{LOAD}=75nF, C_{OUT}=470nF VOB-VOS: C_{LOAD}=75nF, C_{OUT}=470nF		9.8 19.6 9.5 19		Vpp
Feedback Voltage	VFB		0.38	0.4	0.42	V
LED Current Resistor Voltage	VRLED		0.19	0.2	0.21	V
Shutdown Current	I_{SD}	CTRL=DIN=LOW, VOUT=17.5V (no external feedback resistors). **Note 2**		0.11	2	µA
Quiescent Current	I_Q	CTRL=LOW, DIN=HIGH, no load VOUT=15V (R2/R1=36.5). **Note 3** VIN=3.0V, VIN=4.2V		400 140		µA
Current Consumption at Shorted Piezo Driver Outputs	I_{SC_VIN}	VIN=3.0V, VOP=VON=GND		176		mA
Current Consumption	I_{IN}	VIN=3V, VOUT=10V (R2/R1=24) VOS: C_{LOAD}=15nF VOB-VOS: C_{LOAD}=15nF VOS: C_{LOAD}=75nF, C_{OUT}=470nF VOB-VOS: C_{LOAD}=75nF, C_{OUT}=470nF		3.3 6.7 12.7 23.4		mA
		VIN=1.2V, VOUT=10V (R2/R1=24) VOB: C_{LOAD}=15nF VOB-VOS: C_{LOAD}=15nF VOB: C_{LOAD}=75nF, C_{OUT}=470nF VOB-VOS: C_{LOAD}=75nF, C_{OUT}=470nF		12.7 23.4 43 90		mA
		LED loading I_{LED}=10mA (RLED=20Ω) VIN=3V, VOUT=6.4V (two 3V LEDs) VIN=3V, VOUT=9.4V (three 3V LEDs) VIN=3V, VOUT=12.4V (four 3V LEDs)		31 46 66		mA
Efficiency	η_{LED}	LED loading VIN=3V, VOUT=6.4V (two 3V LEDs) I_{LED}=10mA. **Note 4**		71		%

Note 1: Tested at room temperature. Min and max limits guaranteed by design.

Note 2: DIN has been low at least 15 ms. This shutdown current value is valid for case when no external feedback resistors are connected. When using external VOUT adjusting feedback resistors (R1, R2) the shutdown current will increase by amount of I_{EXT_FB} = VIN/(R1+R2) since VOUT follows VIN voltage when the device is in shutdown. To keep the shutdown current low the external feedback resistance (R1+R2) should be kept above 10MΩ level.

Note 3: Current consumption when boost converter is active but outputs are not loaded

Note 4: 3x3x1.2mm size 2.2µH inductor from Taiyo Yuden (NR3012T2R2M)

ELECTRICAL CHARACTERISTICS

T_A = -40°C to +85°C, typical values at T_A = 27°C, V_{IN} = 3.0 V, L = 2.2 µH, C_{IN} = 10 µF, C_{OUT} = 100 nF, C_{LOAD} = 15 nF, f_{PIEZO} = 3.8 kHz; unless otherwise specified

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Boost DC/DC Converter Switch ON-Resistance	$R_{DS(ON)\_LS}$	Low side switch VIN=3V, VOUT=15V, TA = 27°C		0.55	1.0	Ω
	$R_{DS(ON)\_HS}$	High side switch VIN=3V, VOUT=15V, TA = 27°C		1.1	2.5	
DC/DC Converter Startup-Up Time	$t_{START-UP}$	VOUT=10V (R2/R1=24) VIN=3.0V VIN=1.2V		 200 340		µs
Output Rise/Fall Time	t_{SLEW}	VIN=3V, VOUT=10V (R2/R1=24) VOB: C_{LOAD}=15nF VOB-VOS: C_{LOAD}=15nF VOB: C_{LOAD}=75nF, C_{OUT}=470nF VOB-VOS: C_{LOAD}=75nF, C_{OUT}=470nF		 10 20 50 100		µs
Shutdown Delay	t_{OFF}	Time before device off mode after both DIN and CTRL have gone to LOW	7	10	15	ms
Control Input Threshold	VIH	DIN and CTRL pins. **Note 1**	0.9			V
	VIL	DIN and CTRL pins			0.4	V
Control Input Current	IIH	DIN, CTRL = 3V DIN, CTRL = 0.4V. **Note 2**		0.01 1	1	µA
	IIL	DIN, CTRL = 0V		0.01	1	µA

Note 1: Control inputs can be driven even from low supply voltage controller due to low 0.9V VIH min threshold.
Note 2: DIN and CTRL pins have active pull-down by 400kΩ which disabled to save current when inputs are pulled high.

BLOCK AND APPLICATION DIAGRAMS

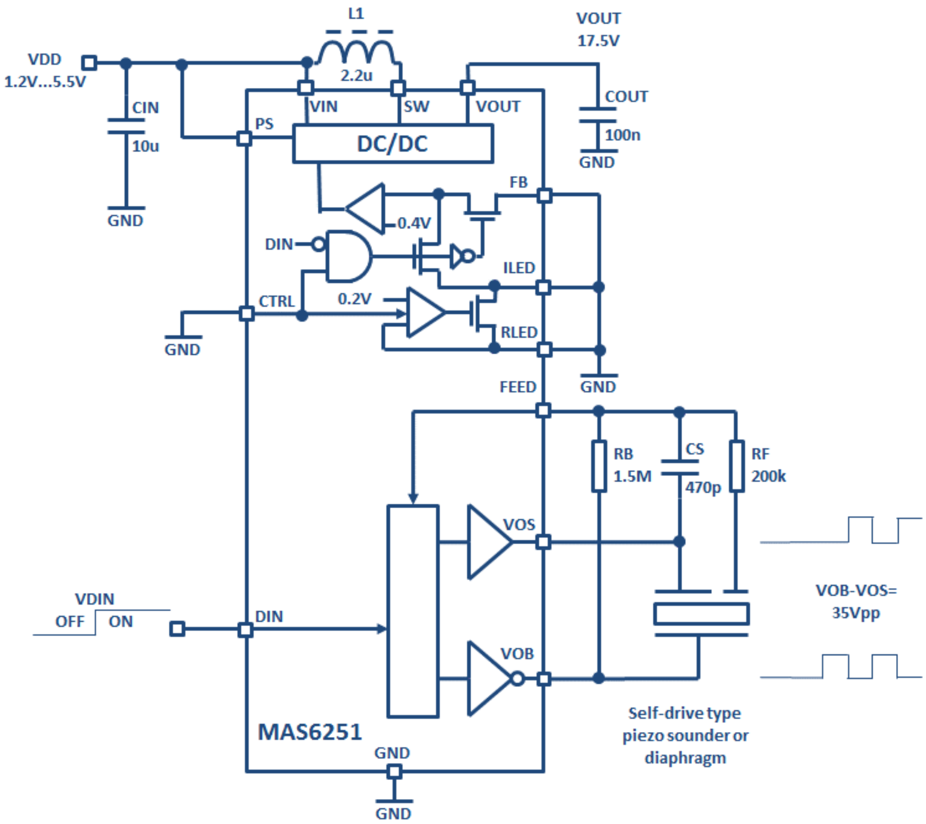


Figure 1. 35Vpp piezo drive in differential configuration by DIN control

In figure 1 there is utilized output over voltage protection (OVP) feature of MAS6251 which limits the output voltage to 17.5V when the feedback resistors are left out which also reduces external part count.

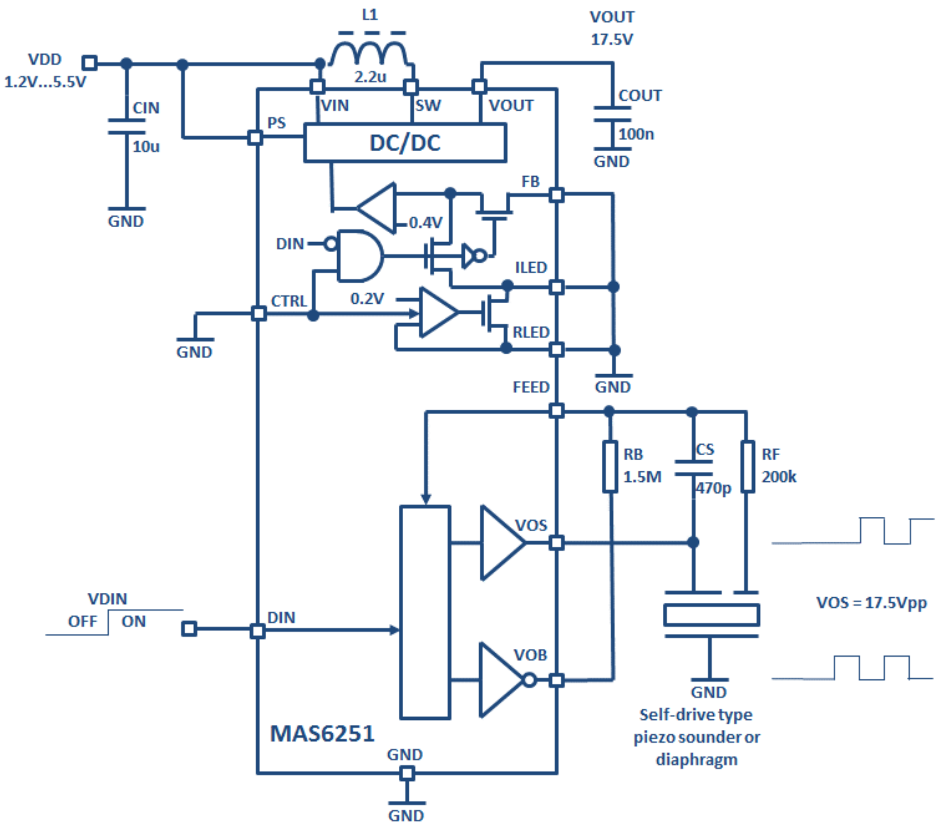


Figure 2. 17.5Vpp piezo drive in single-ended configuration by DIN control

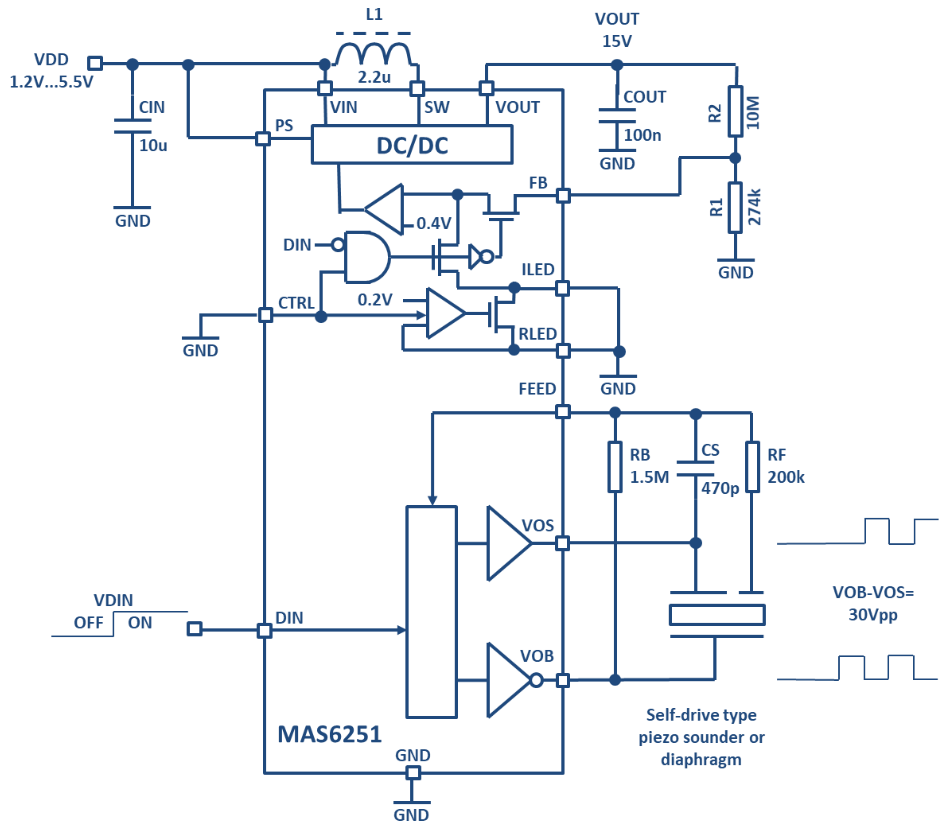


Figure 3. 30Vpp piezo drive in differential configuration by DIN control

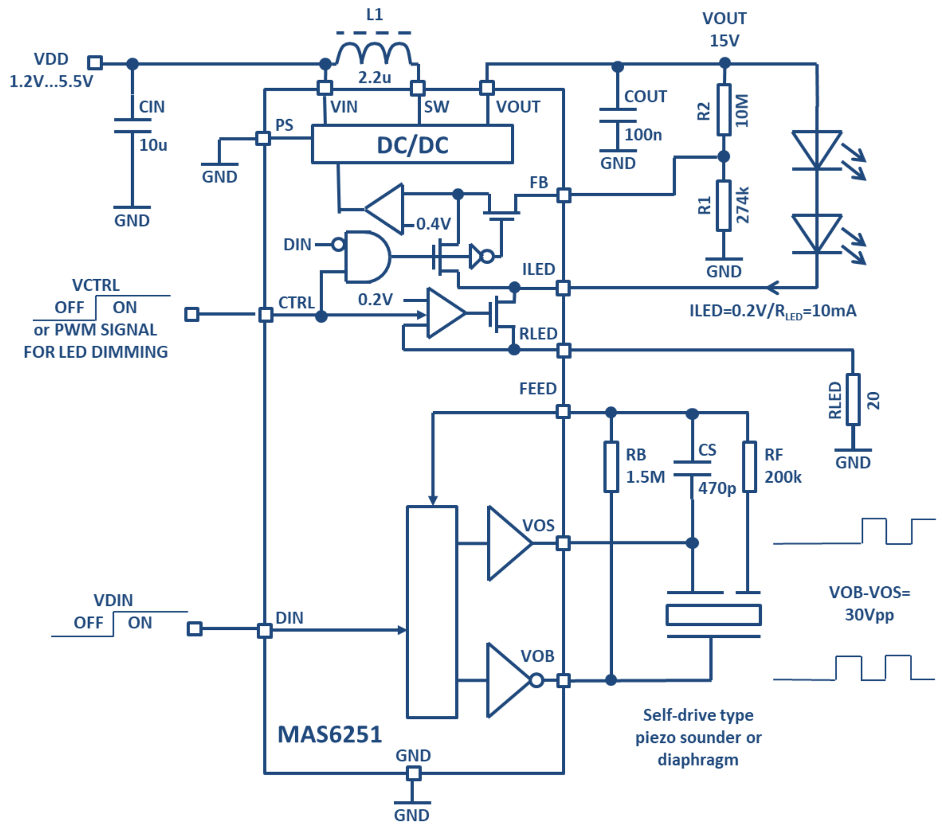


Figure 4. 30Vpp piezo drive in differential configuration and two series 10mA LEDs by DIN and CTRL controls

Normally the PS pin is connected to VIN. In case the VOUT voltage is below 7V the PS pin should be connected GND for best efficiency. For example when driving only one or two 3V LEDs the PS pin should be connected to GND. See figure 4.

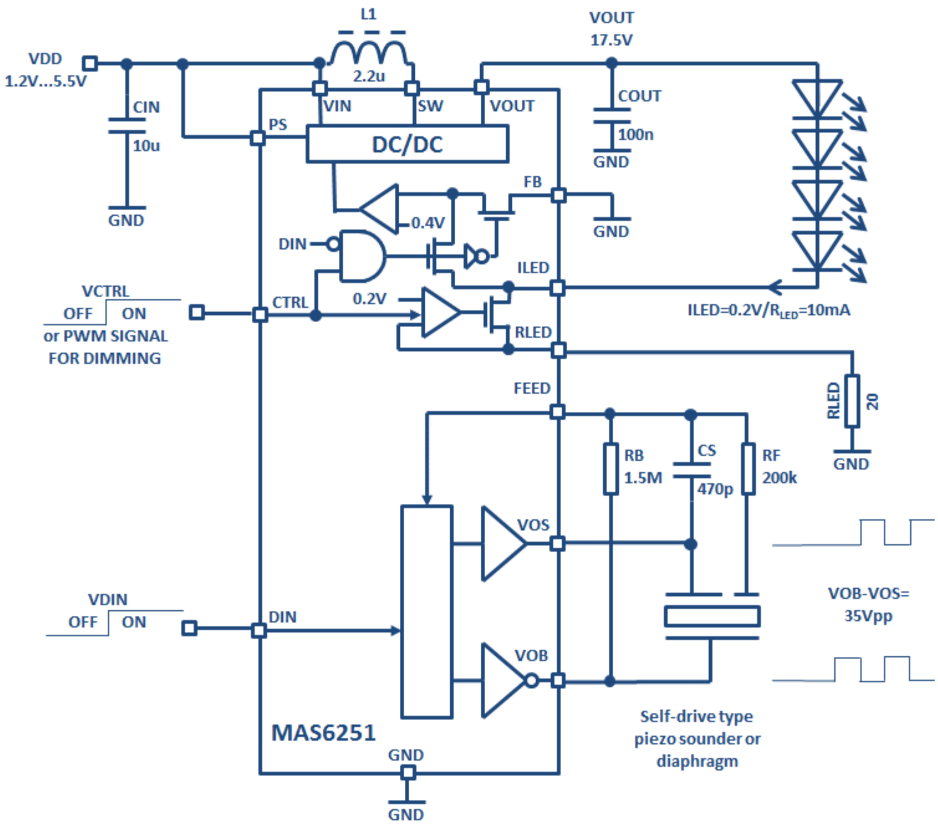


Figure 5. 35Vpp piezo drive in differential configuration and four series 10mA LEDs by DIN and CTRL controls

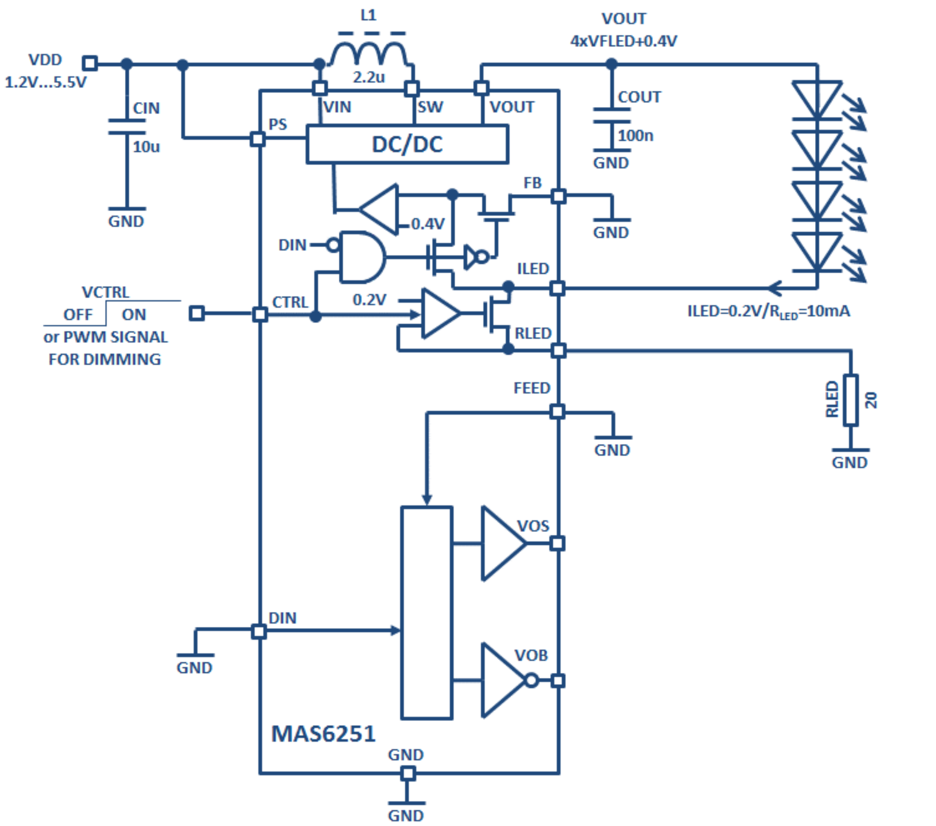


Figure 6. MAS6251 circuit for driving only series connected LEDs by CTRL control

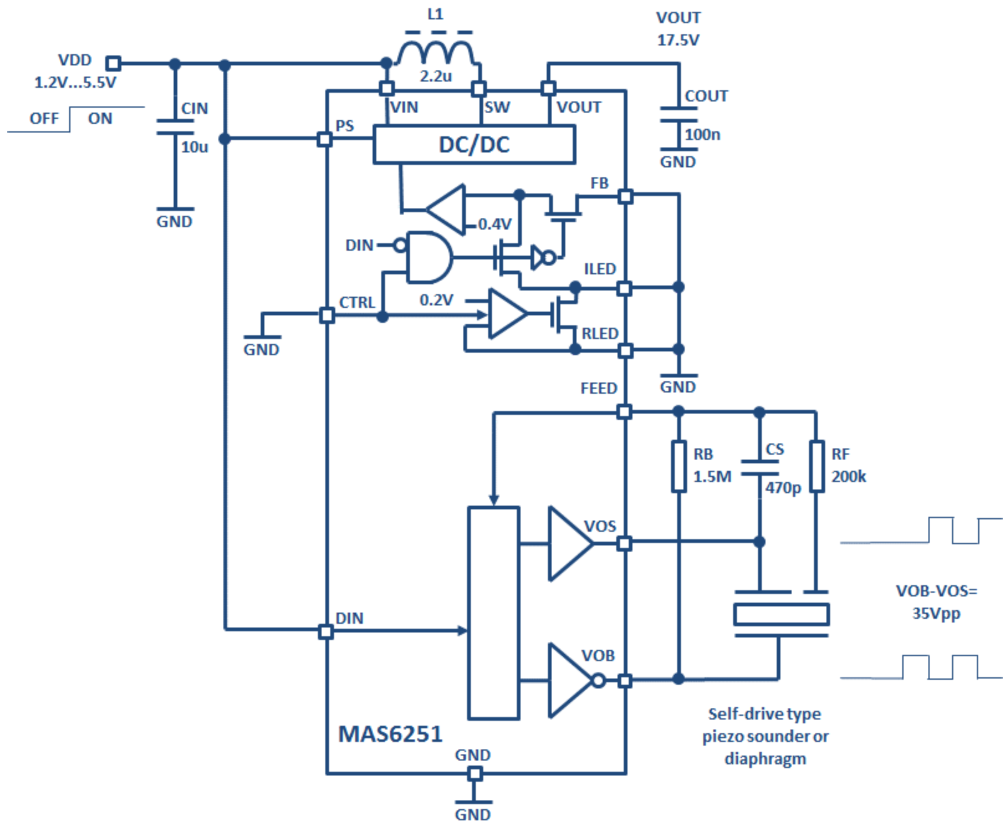


Figure 7. 35Vpp piezo drive in differential configuration by VDD on/off control

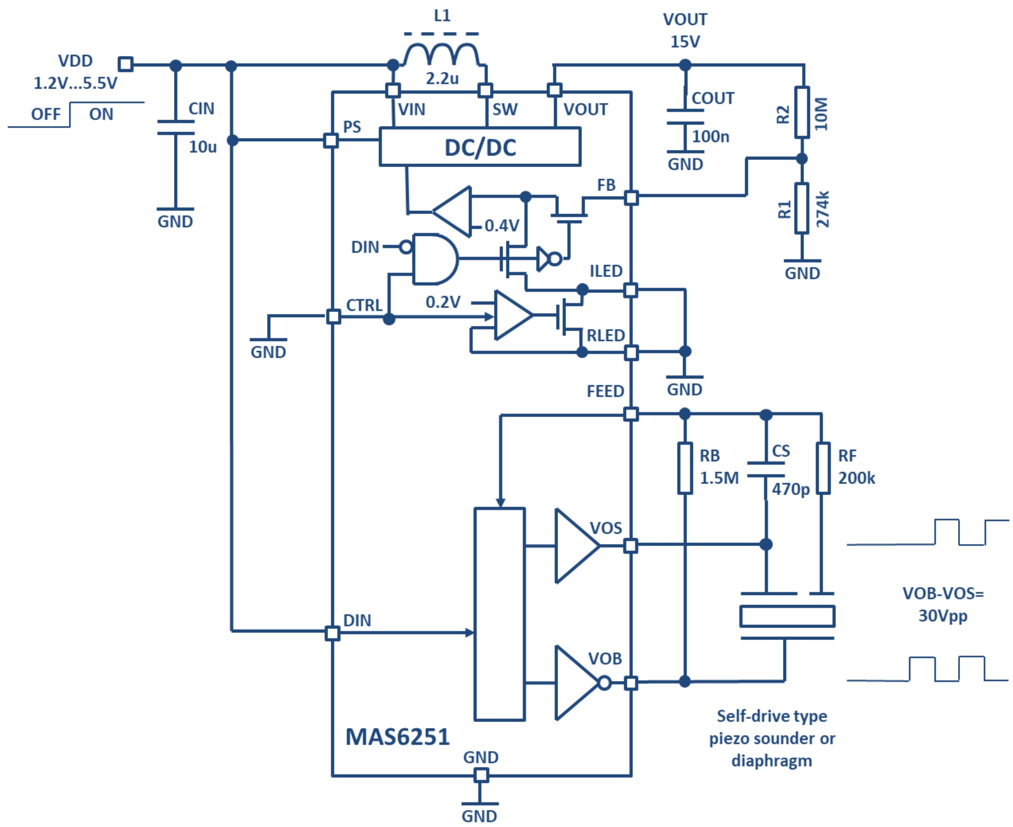


Figure 8. 30Vpp piezo drive in differential configuration by VDD on/off control

DETAILED DESCRIPTION

MAS6251 operating modes are controlled by DIN and CTRL pins as follows.

Table 1. Operating modes

CONTROL INPUTS		OPERATING MODES					
DIN	**CTRL**	**DC/DC**	**OSC**	**PIEZO**	**LED**	**FB FET**	**MODE**
LOW 1)	LOW 1)	OFF	OFF	OFF 2)	OFF	OFF	SHUTDOWN
LOW 1)	HIGH	ON	OFF	OFF 2)	ON	ON 3)	LED
HIGH	LOW 1)	ON	OFF	ON	OFF	OFF	PIEZO
HIGH	HIGH	ON	OFF	ON	ON	OFF	PIEZO+LED

Note 1: For DIN and CTRL "LOW" means being low at least max 15ms
Note 2: Piezo "OFF" is disable mode in which both piezo outputs are pulled to ground (VOB=VOS=GND)
Note 3: Feedback switch between FB and ILED is activated when only LED is driven

Both DIN and CTRL pins have internal pull-down by 400kΩ which is disabled to save current when the inputs are pulled high. When selecting DIN=CTRL=GND the device is in shutdown mode and consumes only very small leakage current.

Capacitor and resistor values

The external CIN and COUT capacitors must be low loss (low ESR) ceramic capacitors. Recommended capacitor and resistor values are shown in the table 2.

Table 2. Recommended capacitor and resistor values

Capacitor	Nominal value
CIN	10µF
COUT	100nF
CS	470pF
RB	1.5M
RF	200k

Note: the voltage ripple at VOUT output is approximately proportional to ratio of piezo load capacitance (C_{LOAD}) and boost DC/DC converter output capacitor (COUT). Thus the output ripple can be reduced by choosing output capacitor value which is much larger relative to piezo capacitance value. However note that large output capacitor also lengthens output voltage rise time.

In piezo driving mode (DIN=HIGH or switching) the boost DC/DC converter output voltage can be controlled by external voltage division resistors R1 and R2. See figures 3-4 and 8. The output voltage is regulated to level which sets the FB feedback pin voltage to 0.4V typically. Table 3 shows example resistors values for different output voltages. Note that the feedback resistors are not always necessary since when not connected the output voltage will be regulated to over voltage protection (OVP) voltage 17.5V typically. See figures 1-2 and 5-7. When driving only LEDs (CTRL=HIGH or PWM signal, DIN=LOW) the maximum output voltage (VOUT) is limited to OVP voltage regardless of the FB pin connection.

Table 3. Feedback resistor (R1, R2) and DC/DC boost output voltage (VOUT) examples

R1 [kΩ]	R2 [MΩ]	VOUT [V]
200	4.3	9
150	3.6	10
162	4.7	12
274	10	15
-	-	17.5

Note: VOUT=VFB*(1+R2/R1), VFB=0.4V

Note that use of external VOUT adjusting feedback resistors increases shutdown current by amount of I_{EXT_FB} = VIN/(R1+R2) since VOUT follows VIN voltage when the device is in shutdown. To keep the shutdown current low the external feedback resistance (R1+R2) path should be kept near 10MΩ level. For good feedback regulation the max R1 should not exceed 400kΩ.

When driving LEDs they are connected in series from VOUT to ILED which is the current sink pin. Additionally LED current setting resistor RLED needs to be connected from RLED pin to GND. See figures 4-6. The table 4 shows example RLED resistor values and corresponding LED current levels. Additionally PWM signal can be applied to the CTRL pin for LED dimming to reduce average LED current from level defined with the RLED resistor.

Table 4. LED current setting resistor examples

RLED [Ω]	**ILED [mA]**
40.2	5.0
20	10.0
13.3	15.0

Note: ILED=VRLED/RLED, VRLED=0.2V typ

TYPICAL CHARACTERISTICS

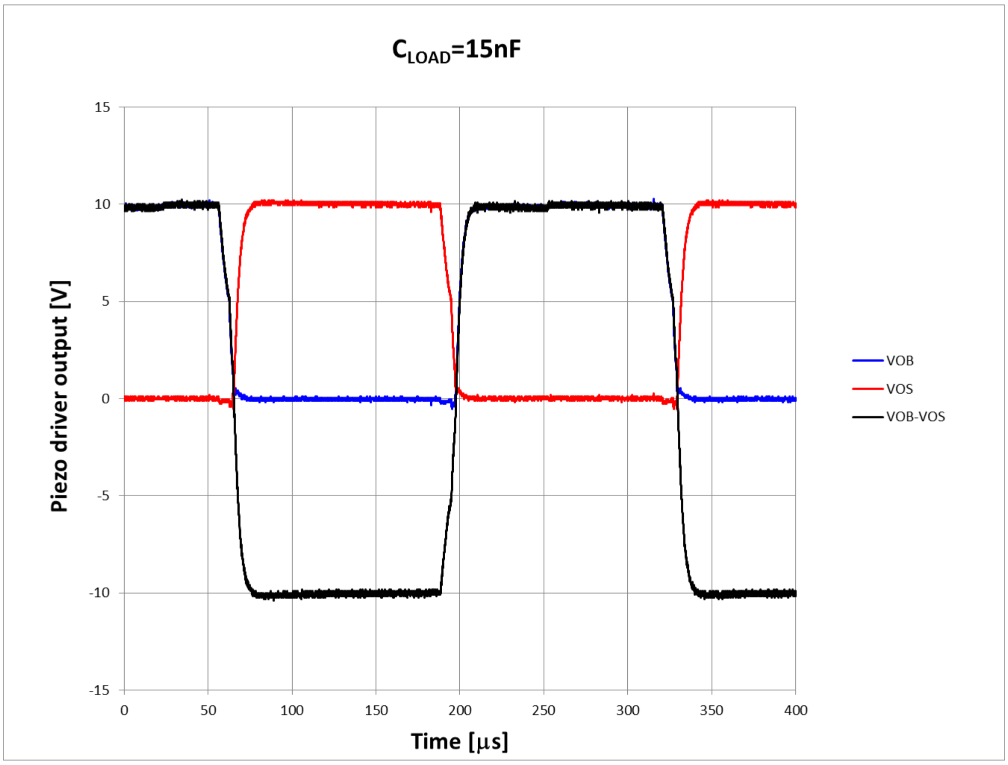


Figure 9. Piezo driver outputs at VIN=3V, VOUT=10V, F_{PIEZO}=3.8kHz, C_{LOAD}=15nF, C_{OUT}=100nF

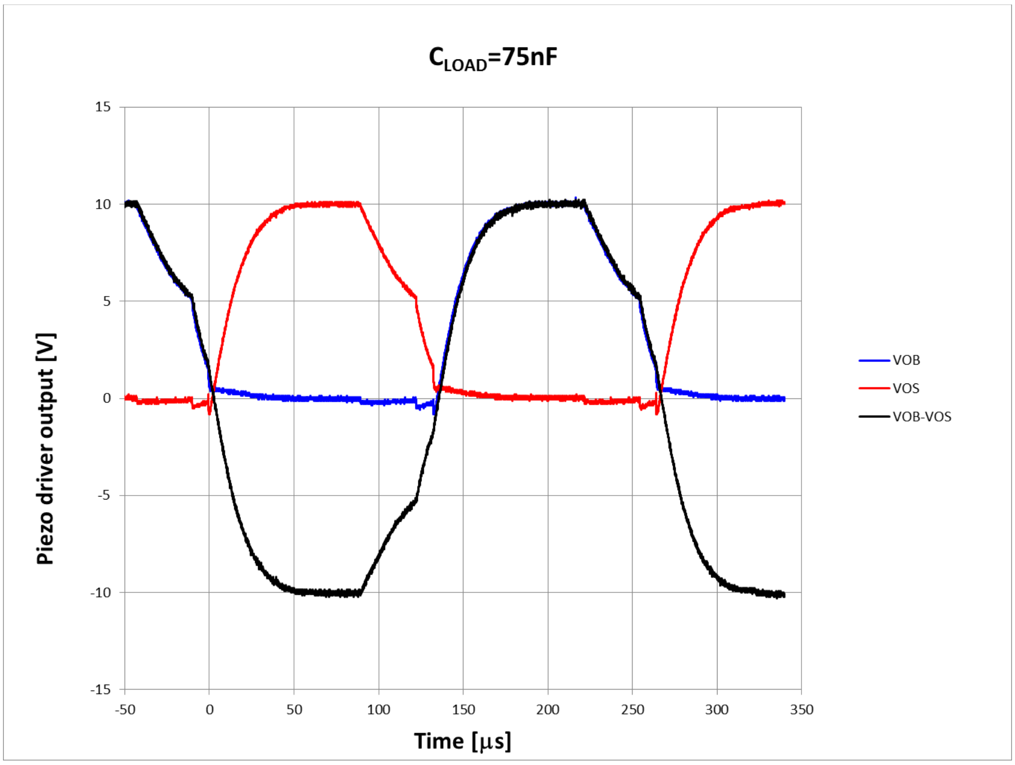


Figure 10. Piezo driver outputs at VIN=3V, VOUT=10V, F_{PIEZO}=3.8kHz, C_{LOAD}=75nF, C_{OUT}=470nF

TYPICAL CHARACTERISTICS (continued)

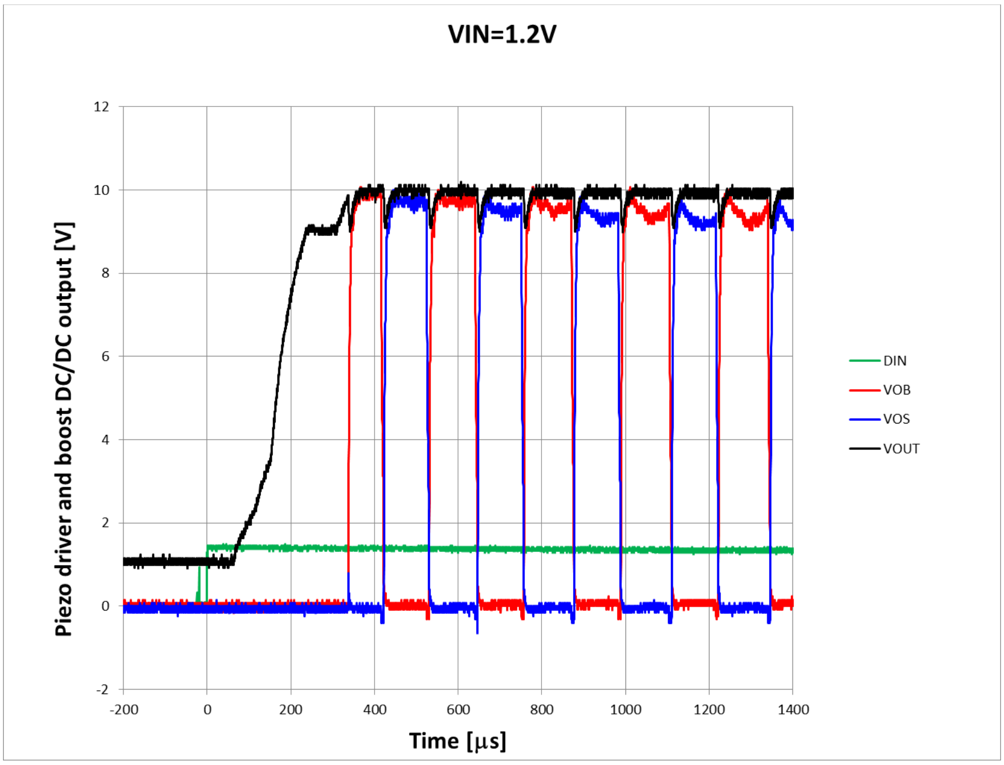


Figure 11. Piezo driver and boost DC/DC output start-up VIN=1.2V, VOUT=10V, F_{PIEZO}=3.8kHz

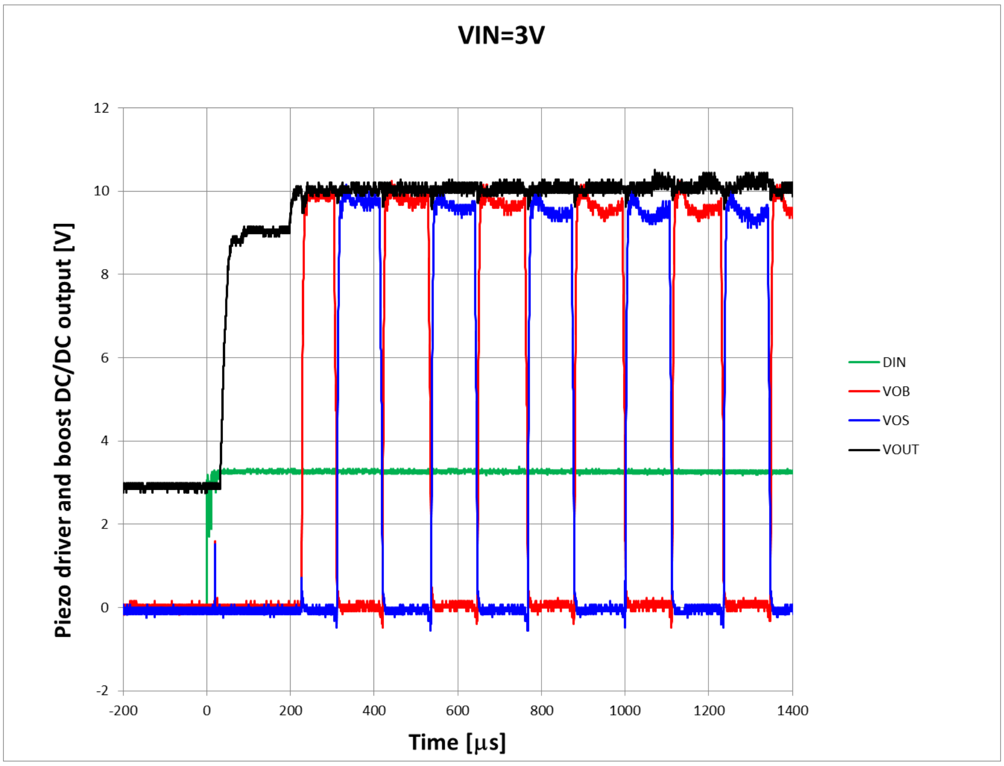


Figure 12. Piezo driver and boost DC/DC output start-up VIN=3V, VOUT=10V, F_{PIEZO}=3.8kHz

TYPICAL CHARACTERISTICS (continued)

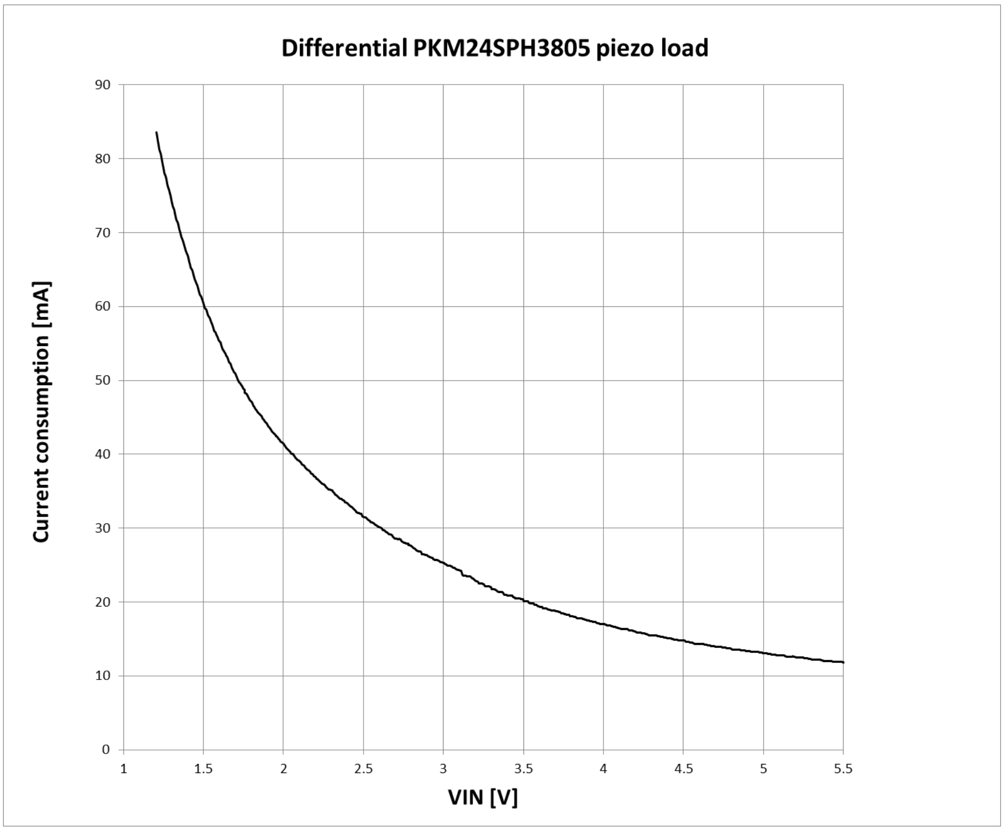


Figure 13. Current consumption at differential PKM24SPH3805 (Murata) piezo loading; VOUT=10V, F_{PIEZO}=3.8kHz

TYPICAL CHARACTERISTICS (continued)

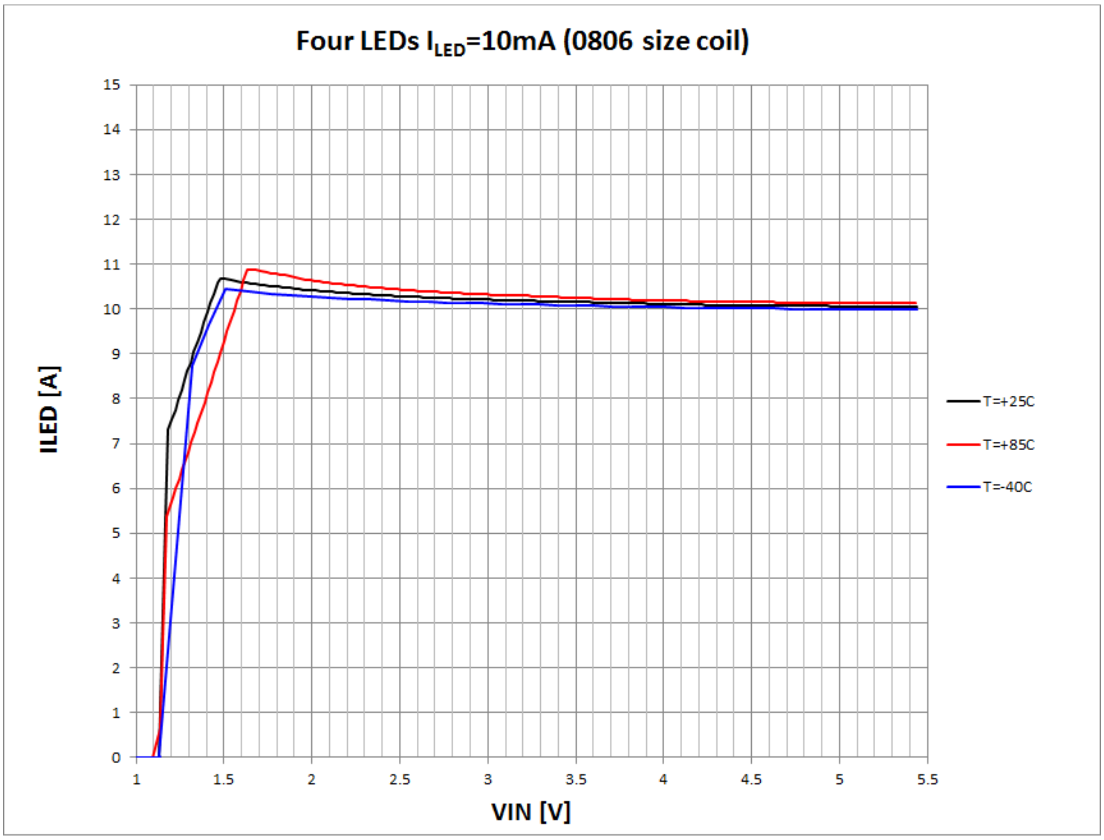


Figure 14. LED current drive capability over VIN; four LEDs (VOUT=11.7V), I_{LED}=10mA

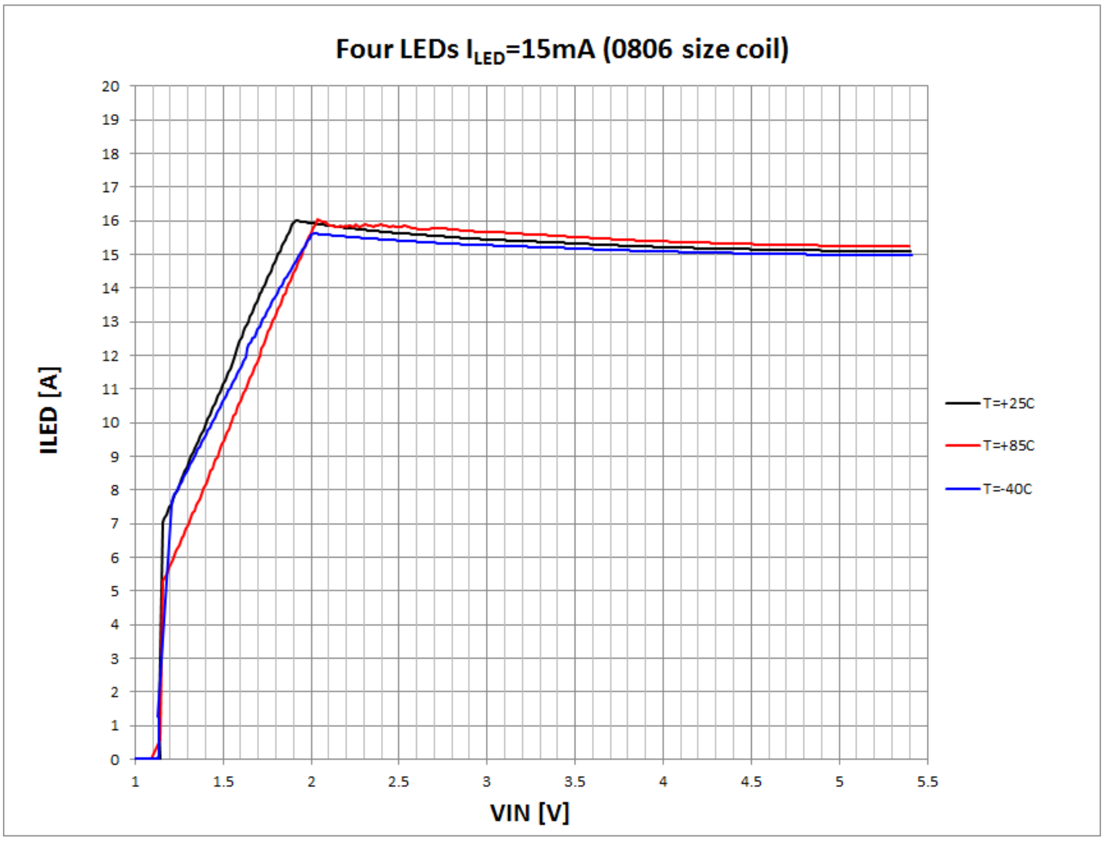


Figure 15. LED current drive capability over VIN; four LEDs (VOUT=12.4V), I_{LED}=15mA

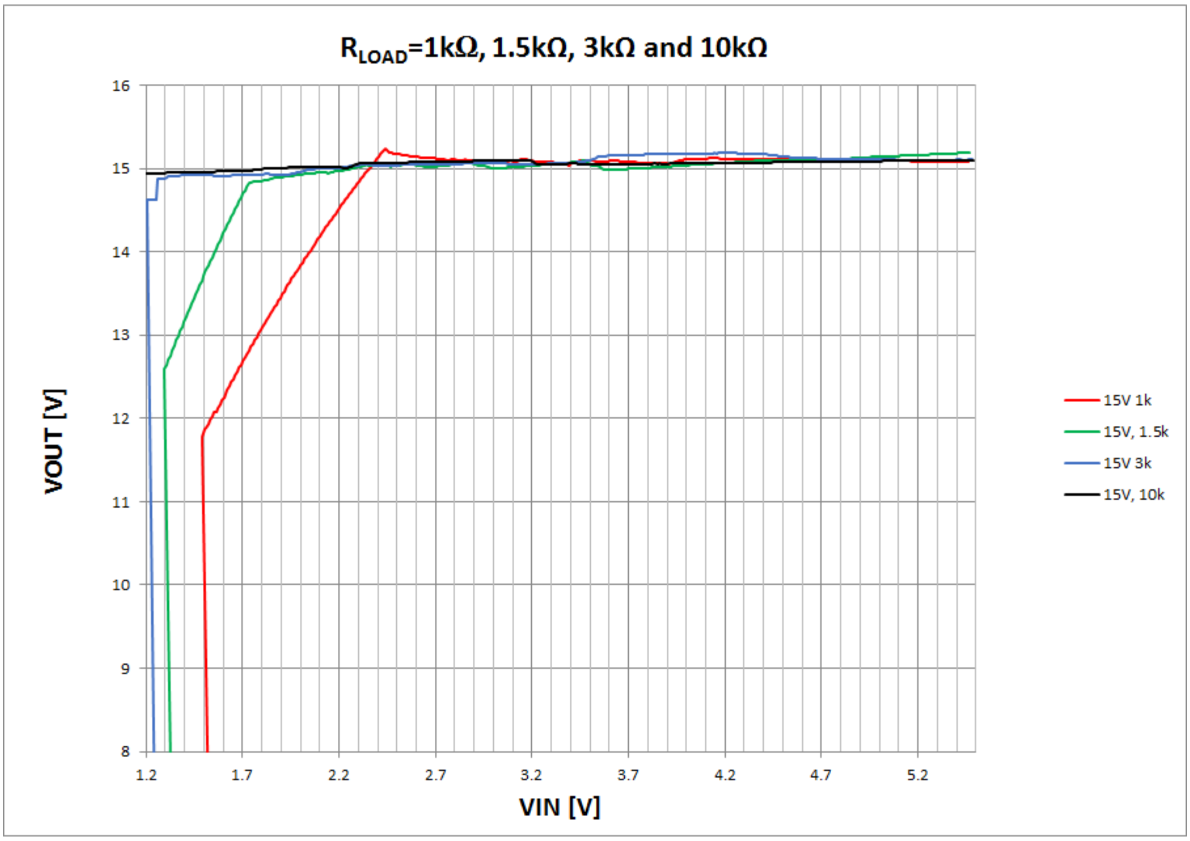


Figure 16. DC/DC converter output drive capability for a resistive loading at VOUT=15V (R2/R1=36.5) regulation

The figure 22 shows minimum supply (VIN) and maximum output (VOUT) voltage operating ranges at different resistive loading as follows.

R_{LOAD}=1kΩ: VIN_{MIN}=2.4V @ VOUT=15V and VIN_{MIN}=1.5V @ VOUT=12V
R_{LOAD}=1.5kΩ: VIN_{MIN}=1.8V @ VOUT=15V and VIN_{MIN}=1.3V @ VOUT=12.5V
R_{LOAD}=3kΩ: VIN_{MIN}=1.3V @ VOUT=15V and VIN_{MIN}=1.2V @ VOUT=14.5V
R_{LOAD}=10kΩ: VIN_{MIN}=1.2V @ VOUT=15V

PRINTED CIRCUIT BOARD (PCB) LAYOUT CONSIDERATIONS

In PCB layout design the input (CIN) and output (COUT) capacitors should be placed as close to the MAS6251 (U1) as possible and routed with low inductance connection to ground plane. See figure 17 below for a PCB layout example of figure 3 application circuit which includes output voltage adjustment resistors R1 and R2.

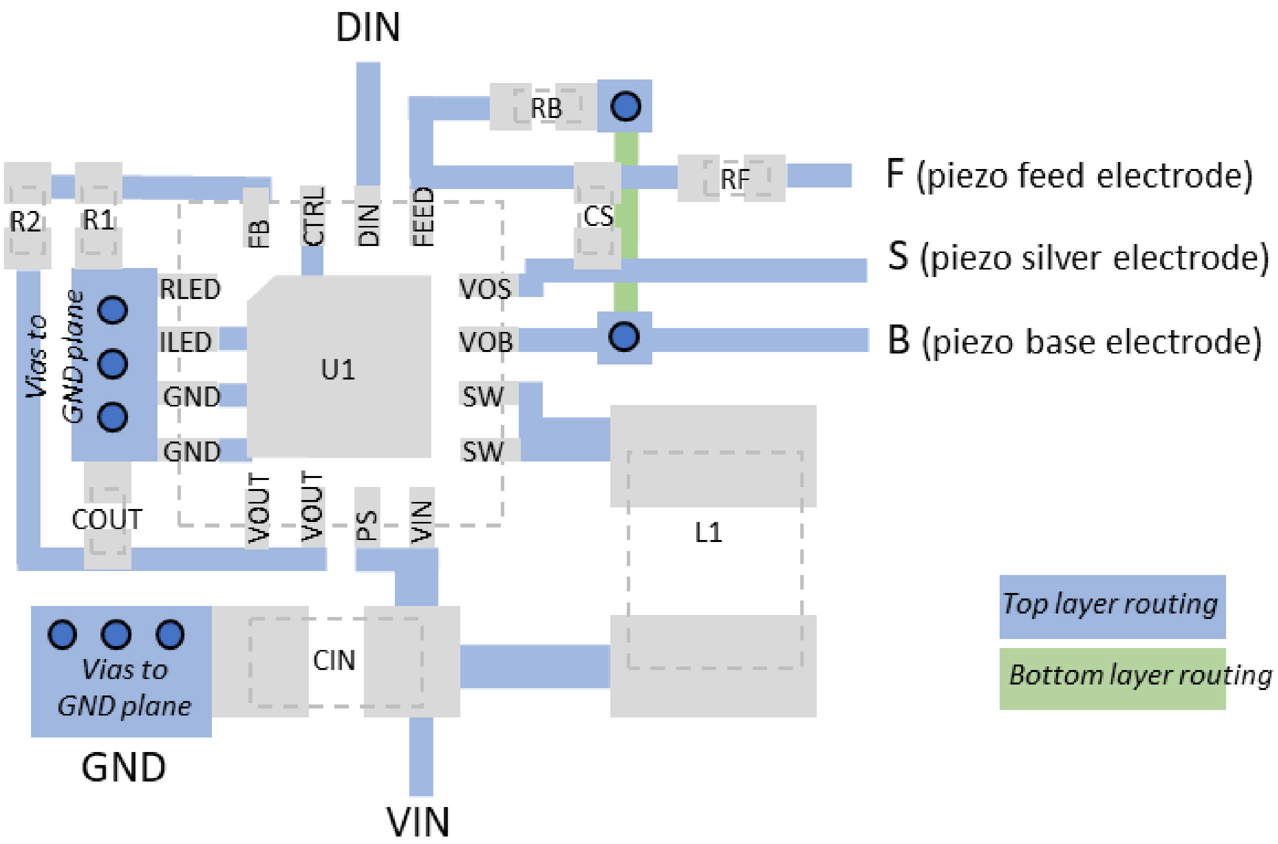
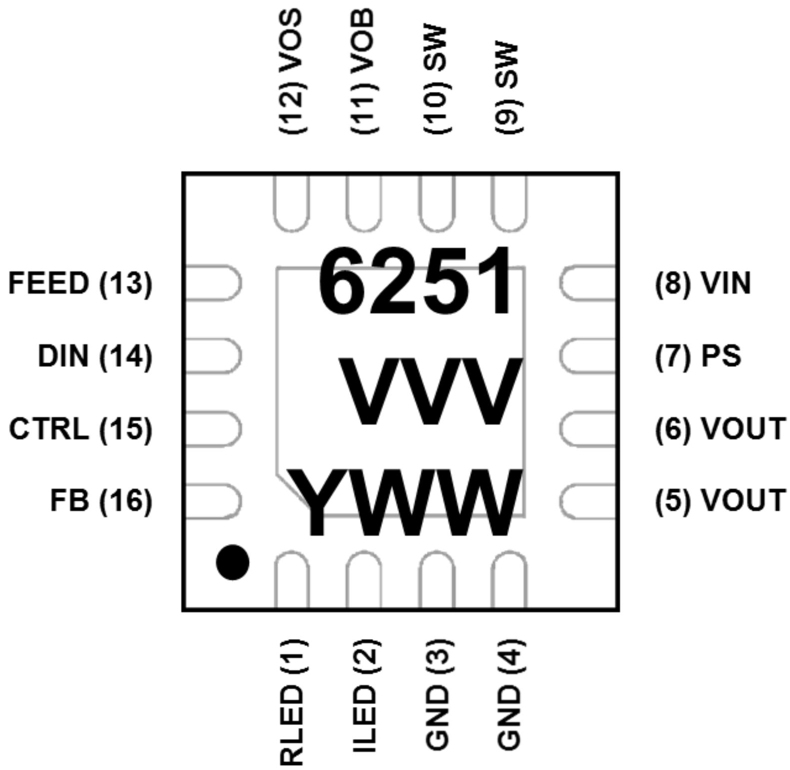


Figure 17. PCB layout example

Table 6. PCB layout example component details

Ref	Manuf. part	Value	Rating	Case inch (metric)	Dimensions (LxWxT)
U1	MAS6251AA1Q13	MAS6251		QFN-16 3x3	3.0x3.0x0.75 mm
L1	LQM2MPN2R2MEH	2.2μH	0.7A (Isat)	0806 (2016)	2.0x1.6x0.7 mm
CIN	GRM188R60J106KE47D	10μF	6.3V (X5R)	0603 (1608)	1.6x0.8x0.9 mm
COUT	C0603X5R1E104K030BB	100nF	25V (X5R)	0201 (0603)	0.6x0.3x0.3 mm
CS		470pF	25V (X5R)	0201 (0603)	0.6x0.3 mm
RB		33kΩ		0201 (0603)	0.6x0.3 mm
RF		1.5MΩ		0201 (0603)	0.6x0.3 mm
R1		274kΩ		0201 (0603)	0.6x0.3 mm
R2		10MΩ		0201 (0603)	0.6x0.3 mm

DEVICE OUTLINE CONFIGURATION



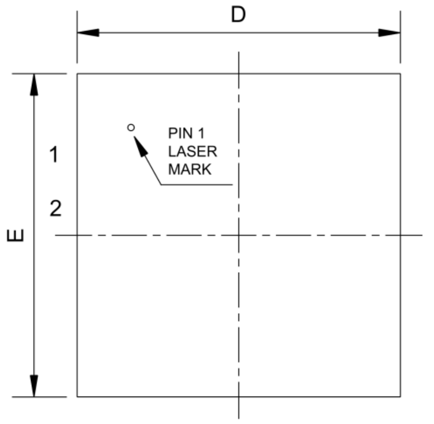
Top Marking Information:
6251 = Product Number
VVV = Version Number
YWW = Year Week

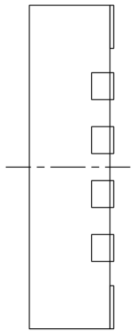
QFN-16 3.0x3.0x0.75 PIN DESCRIPTION

Pin Name	Pin	Type	Function	Note
RLED	1	AIO	LED current adjustment resistor	
ILED	2	AO	LED current sink	
GND	3-4	G	Supply ground	
VOUT	5-6	AO	Boost DC/DC converter voltage output	
PS	7	P	Power save pin	1
VIN	8	P	Positive supply voltage input	
SW	9-10	AO	Boost DC/DC converter switch	
VOB	11	AO	Piezo driver brass terminal output	
VOS	12	AO	Piezo driver silver terminal output	
FEED	13	AI	Piezo driver feedback terminal input	
DIN	14	DI	DC/DC and Piezo Drive ON (HIGH) / OFF (LOW) control	
CTRL	15	DI	LED current sink ON (HIGH) / OFF (LOW) control	
FB	16	AI	Boost DC/DC converter output voltage feedback input	
EXP_PAD	-	G	Exposed thermal pad connected to GND	2

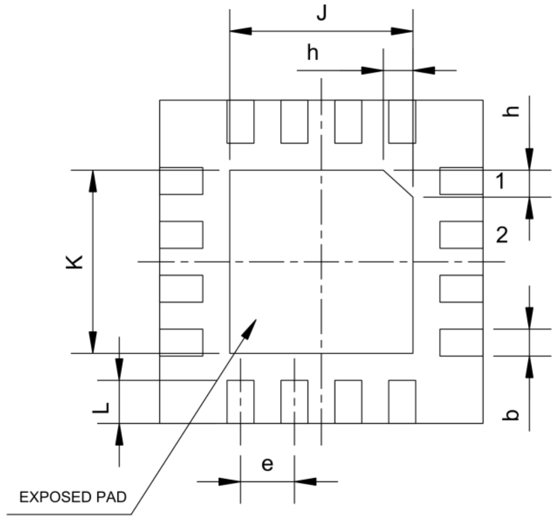
G = Ground, P = Power, D = Digital, A = Analog, I = Input, O = Output
Note 1: Normally the PS pin is connected to VIN. This offers reduced power consumption as part of electrical charge from piezo load is transferred back to input. In case the VOUT voltage is below 7V the PS pin should be connected GND for best efficiency. For example when driving only one or two 3V LEDs the PS pin should be connected to GND. See figure 4.
Note 2: On PCB the exposed thermal pad must be connected to GND plane using thermal vias functioning as thermal heat sink.

PACKAGE (QFN-16 3X3x0.75) OUTLINE

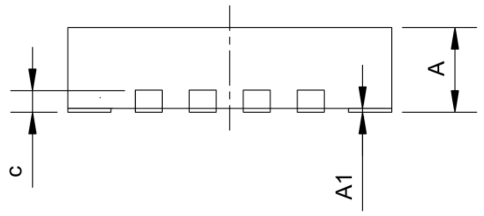




TOP VIEW



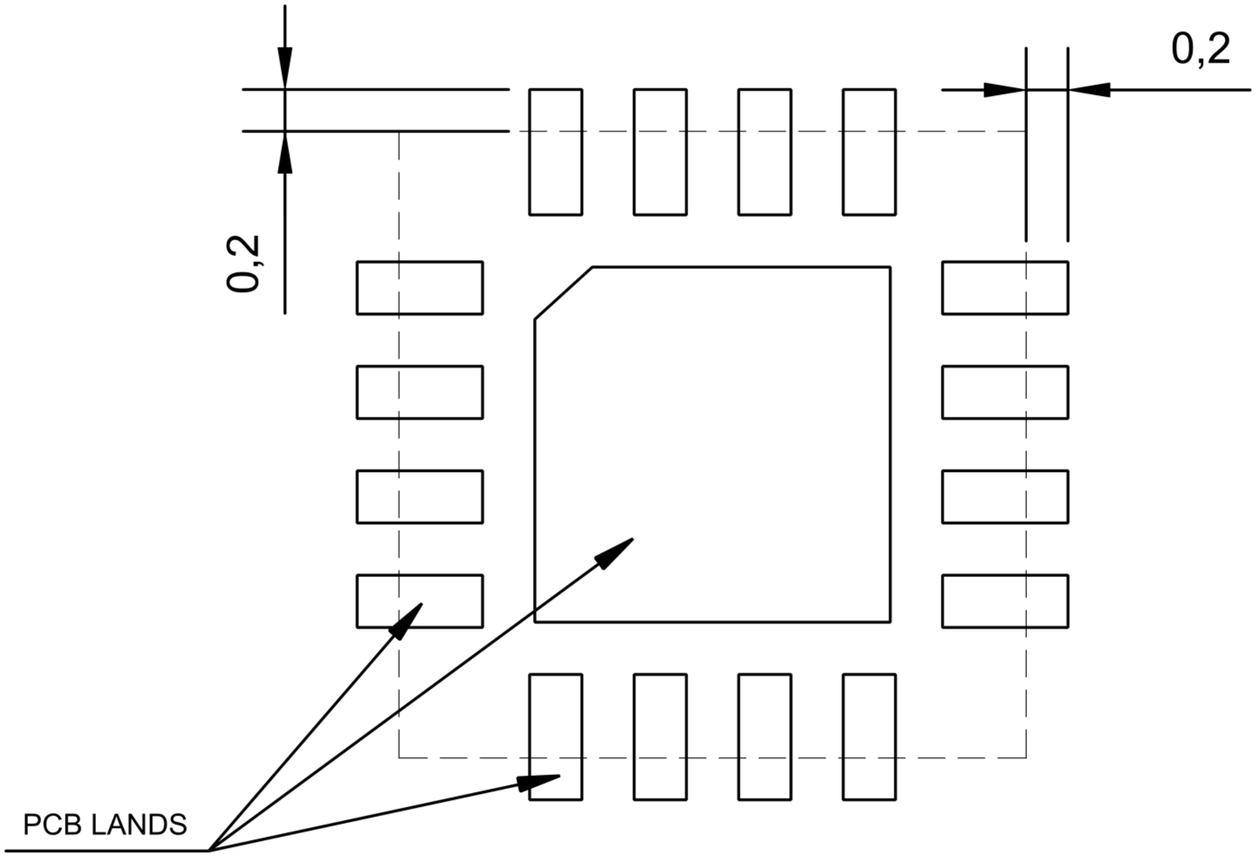
BOTTOM VIEW



Symbol	Min	Nom	Max	Unit
PACKAGE DIMENSIONS				
A	0.7	0.75	0.8	mm
A1	---	0.035	0.05	mm
b	0.2	0.25	0.3	mm
c	0.203 REF			mm
D	3 BSC			mm
E	3 BSC			mm
e	0.5 BSC			mm
J (Exposed.pad)	1.6	1.7	1.8	mm
K (Exposed.pad)	1.6	1.7	1.8	mm
L	0.35	0.4	0.45	mm
h	0.2	0.25	0.3	mm

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

QFN-16 3X3x0.75 PCB LAND PATTERN



Notes

- I/O lands should be 0.2mm longer than QFN pads and extend the same 0.2mm outside package outline
- exposed pad land size should be the same as QFN exposed pad size
- solder resist opening should be 120µm…150µm larger than the land size resulting in 60µm…75µm clearance between copper land and solder resist

ORDERING INFORMATION

Product Code	Product	Package	Comments
MAS6251AA1Q1306	Piezo and LED Driver with Synchronous Boost DC/DC Converter	QFN-16 3.0x3.0x0.75, Pb Free, RoHS Compliant	Tape and Reel 5000 pcs / r

Contact Micro Analog Systems Oy for bare die delivery options.

LOCAL DISTRIBUTOR

MICRO ANALOG SYSTEMS OY CONTACTS

Micro Analog Systems Oy
Kutomotie 16
FI-00380 Helsinki, FINLAND

Tel. +358 10 835 1100

http://www.mas-oy.com

NOTICE
Micro Analog Systems Oy (MAS) reserves the right to make changes to the products contained in this data sheet in order to improve the design or performance and to supply the best possible products. MAS assumes no responsibility for the use of any circuits shown in this data sheet, conveys no license under any patent or other rights unless otherwise specified in this data sheet, and makes no claim that the circuits are free from patent infringement. Applications for any devices shown in this data sheet are for illustration only and MAS makes no claim or warranty that such applications will be suitable for the use specified without further testing or modification.
MAS products are not authorized for use in safety-critical applications (such as life support) where a failure of the MAS product would reasonably be expected to cause severe personal injury or death. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of MAS products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by MAS. Further, Buyers must fully indemnify MAS and its representatives against any damages arising out of the use of MAS products in such safety-critical applications.
MAS products are neither designed nor intended for use in military/aerospace applications or environments. Buyers acknowledge and agree that any such use of MAS products which MAS has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.
MAS products are neither designed nor intended for use in automotive applications or environments. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, MAS will not be responsible for any failure to meet such requirements.