MAS6250

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**
- **External Drive and Self-Drive Audio Frequency Control for 2-Terminal Piezo**
- **LED Driver**
- **High Efficiency**
- **External Schottky Diode Not Needed**
- **Small 0806 Size 2.2µH Inductor**

DESCRIPTION

MAS6250 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.

MAS6250 uses synchronous type boost DC/DC converter which makes external Schottky diode unnecessary. Thus MAS6250 is a low part count and low-cost solution for a high sound pressure piezo driver.

Two piezo driver outputs (VOP, VON) allow driving piezo in both single-ended and differential bridge-tied load (BTL) configurations. MAS6250 supports external drive and self-drive modes for a 2-terminal piezo.

In external drive mode (ROSC=VIN) an external audio frequency is fed directly to digital audio input pin (DIN) allowing external system to drive desired frequency tones to the piezo. The first rising edge of DIN pin only turns on the DC/DC boost converter but the piezo outputs are still kept disabled. When disabled the piezo driver outputs (VOP, VON) are pulled actively to GND.

Continuous logic high level at DIN inputs keeps DC/DC converter on and allows using MAS6250 as DC/DC power supply which is controlled from DIN pin.

At the second rising edge of DIN pin the piezo driver outputs are activated and DIN signal is transferred to the piezo output VOP. The same signal is inverted into output VON for using differential output. 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.

In self-drive mode the audio frequency is produced from precise internal oscillator which is adjustable by just one external resistor. Self-drive mode is selected by connecting frequency adjustment resistor from ROSC pin to GND. In self-drive mode the DIN pin is used to control internal oscillator on (DIN=HIGH) and off (DIN=LOW) and the oscillator signal is transferred to the piezo outputs.

MAS6250 has ILED pin for sinking up to 15mA current from series connected LEDs. The current sink is enabled by CTRL pin 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 high.

MAS6250 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
- External Drive and Self-Drive Modes
- 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
- Sport Watches
- 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, VOP, VON, SW, ILED		-0.3	20	V
Voltage Range for Input Pins	DIN, CTRL		-0.3	6	V
	FB, RLED		-0.3	3	V
	ROSC		-0.3	VIN + 0.3	V
Piezo Buffer Output Short-Circuit Duration	t_{SC}	VOP=VON=GND **Note 1**		Continuous	
Storage Temperature		**Note 2**	-40	+125	ºC
Junction Temperature			-40	+150	ºC
ESD Rating	V_{HBM}	Human Body Model (HBM) **Note 3**	±1000		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
Thermal Shutdown Temperature	T_{TSD}	Rising temperature (device off) Falling temperature (device on)	+140 +125	+150 +135	+160 +145	°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 Input Signal Frequency	F_{DIN}		0.2		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, DIN = 3.4 kHz; unless otherwise specified

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
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	No feedback resistors R1, R2	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
Piezo Driver Output Voltage at Capacitive Load	VOP, VON	VIN=3V, VOUT=15V (R2/R1=36.5) VON: C_{LOAD}=15nF VOP-VON: C_{LOAD}=15nF VON: C_{LOAD}=75nF, C_{OUT}=470nF VOP-VON: C_{LOAD}=75nF, C_{OUT}=470nF		 15 29.8 14.9 29		 Vpp
		VIN=1.2V, VOUT=15V (R2/R1=36.5) VON: C_{LOAD}=15nF VOP-VON: C_{LOAD}=15nF VON: C_{LOAD}=75nF, C_{OUT}=470nF VOP-VON: C_{LOAD}=75nF, C_{OUT}=470nF		 14.7 29.2 13.6 23.6		 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 1**		0.11	2	µA
Quiescent Current	I_Q	CTRL=LOW, DIN=HIGH, no load VOUT=15V (R2/R1=36.5) VIN=3.0V, VIN=4.2V, **Note 2**		 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=15V (R2/R1=36.5) VON: C_{LOAD}=15nF VOP-VON: C_{LOAD}=15nF VON: C_{LOAD}=75nF, C_{OUT}=470nF VOP-VON: C_{LOAD}=75nF, C_{OUT}=470nF		 6.5 14 28 62		 mA
		VIN=1.2V, VOUT=15V (R2/R1=36.5) VON: C_{LOAD}=15nF VOP-VON: C_{LOAD}=15nF VON: C_{LOAD}=75nF, C_{OUT}=470nF VOP-VON: C_{LOAD}=75nF, C_{OUT}=470nF		 25 52 89 160		 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 3**		 71		 %
Boost DC/DC Converter Switch ON-Resistance	$R_{DS(ON)\_LS}$	Low side switch VIN=3V, VOUT=15V, T_A = 27°C		0.55	1.0	Ω
	$R_{DS(ON)\_HS}$	High side switch VIN=3V, VOUT=15V, T_A = 27°C		1.1	2.5	

Note 1: 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 close to 10MΩ level.
Note 2: Current consumption when boost converter is active but outputs are not loaded
Note 3: 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, DIN = 3.4 kHz; unless otherwise specified

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Audio Signal Frequency from Internal Oscillator	FAUDIO	Oscillator frequency adjustment resistor; V_{IN}=3V, T_A = 27°C FAUDIO=415.6kHz*kΩ/ROSC, ROSC=412kΩ ROSC=280kΩ ROSC=210kΩ ROSC=165kΩ ROSC=140kΩ ROSC=133kΩ ROSC=127kΩ ROSC=121kΩ ROSC=118kΩ ROSC=105kΩ, **Note 1**	3.33	1.0 1.5 2.0 2.5 3.0 3.1 3.3 3.43 3.5 4.0	3.5	kHz
DC/DC Converter Startup-Up Time	$t_{START-UP}$	VOUT=15V (R2/R1=36.5) VIN=3.0V VIN=1.2V		250 650		µs
Output Rise/Fall Time	t_{SLEW}	VIN=3V, VOUT=15V (R2/R1=36.5) VON: C_{LOAD}=15nF VOP-VON: C_{LOAD}=15nF VON: C_{LOAD}=75nF, C_{OUT}=470nF VOP-VON: 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 2**	0.9			V
	VIL	DIN and CTRL pins			0.4	V
Control Input Current	IIH	DIN, CTRL = 3V DIN, CTRL = 0.4V, **Note 3**		0.01 1	1	µA
	IIL	DIN, CTRL = 0V		0.01	1	µA

Note 1: The external ROSC resistor adjusts oscillator bias current which sets the oscillator frequency. The oscillator frequency is not available from the OSC pin.
Note 2: Control inputs can be driven even from low supply voltage controller due to low 0.9V VIH min threshold.
Note 3: DIN and CTRL pins have active pull-down by 400kΩ which disabled to save current when inputs are pulled high.

BLOCK AND APPLICATION DIAGRAMS

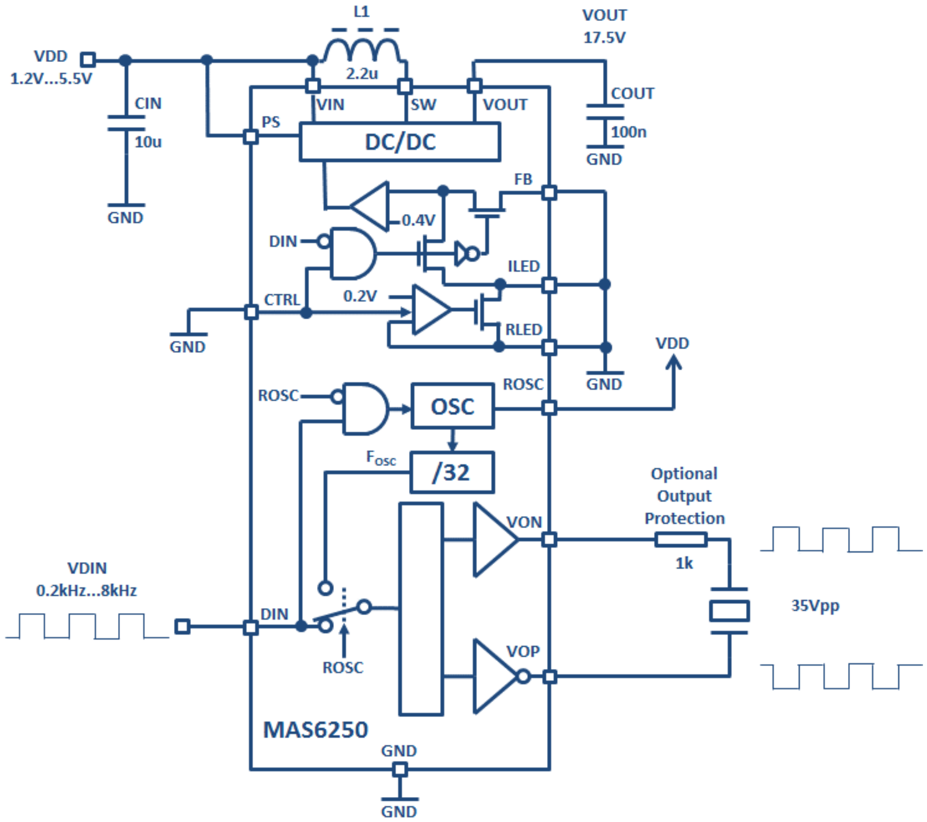


Figure 1. External drive mode driving piezo in differential configuration by DIN control

In figure 1 there is utilized output over voltage protection (OVP) feature of MAS6250 which limits the output voltage to 17.5V when the feedback resistors are left out which also reduces external part count.

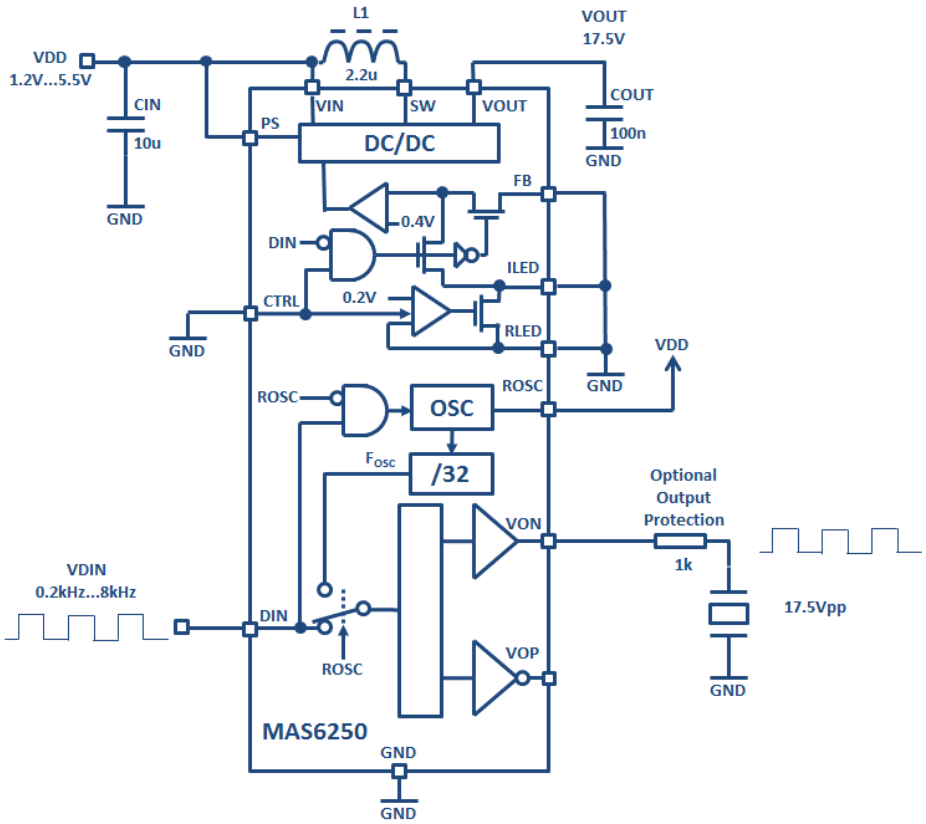


Figure 2. External drive mode driving piezo in single-ended configuration by DIN control

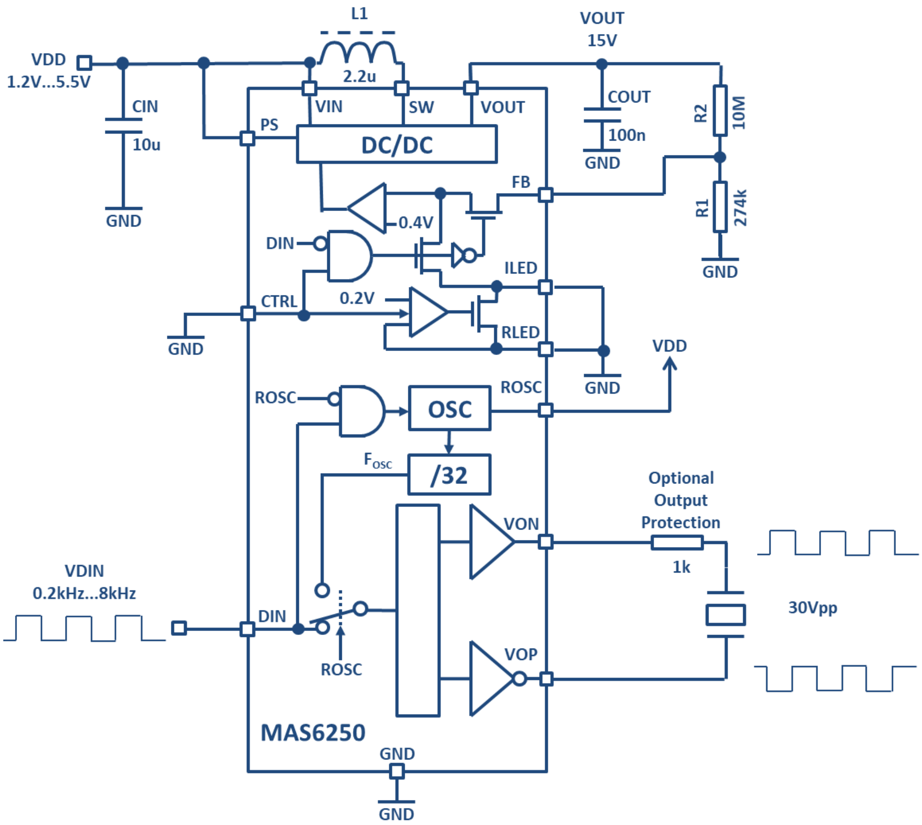


Figure 3. External drive mode with 15V DC/DC output driving piezo in differential configuration by DIN control

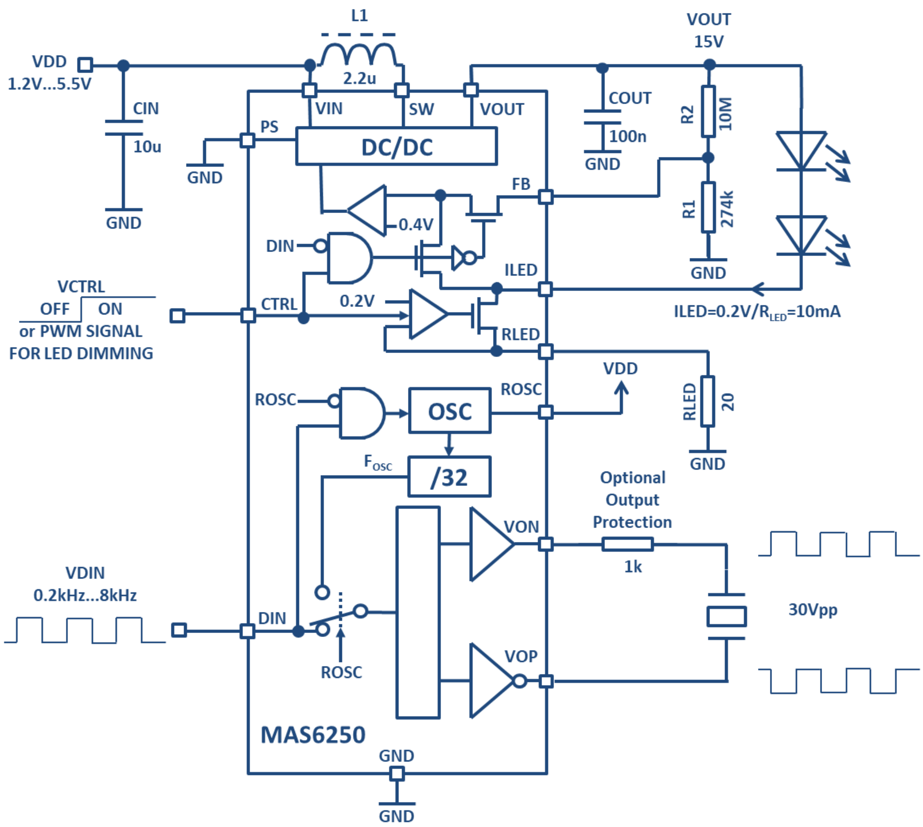


Figure 4. External drive mode driving piezo and two series 10mA LEDs by DIN and CTRL controls

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.

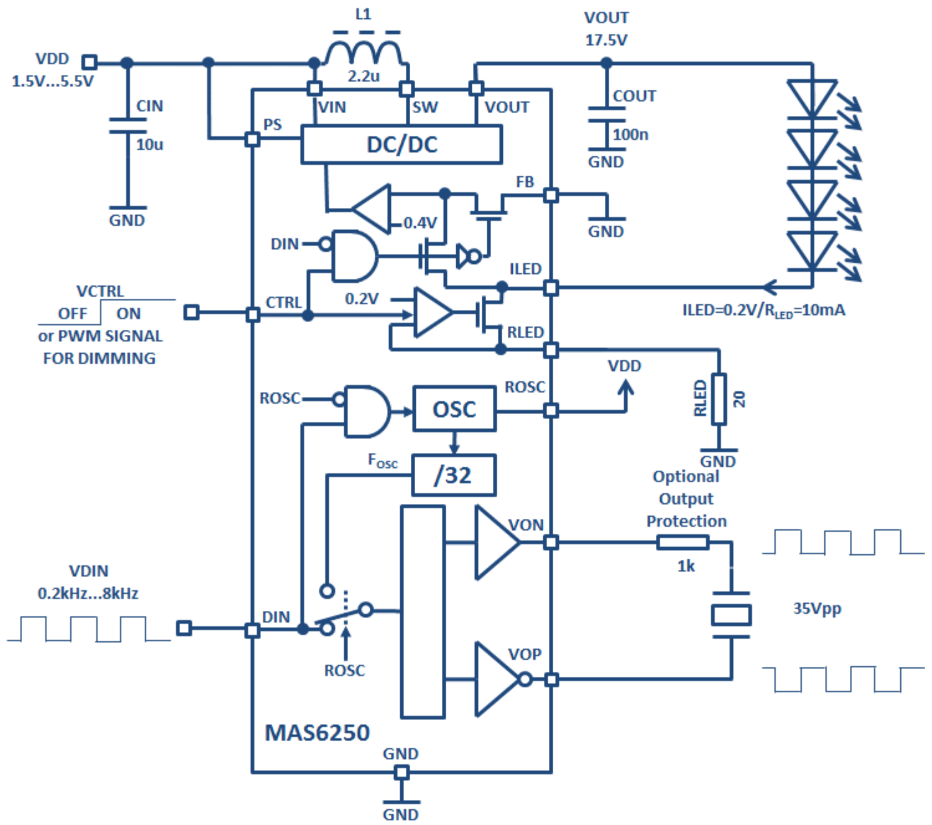


Figure 5. External drive mode driving piezo and four series 10mA LEDs by DIN and CTRL controls

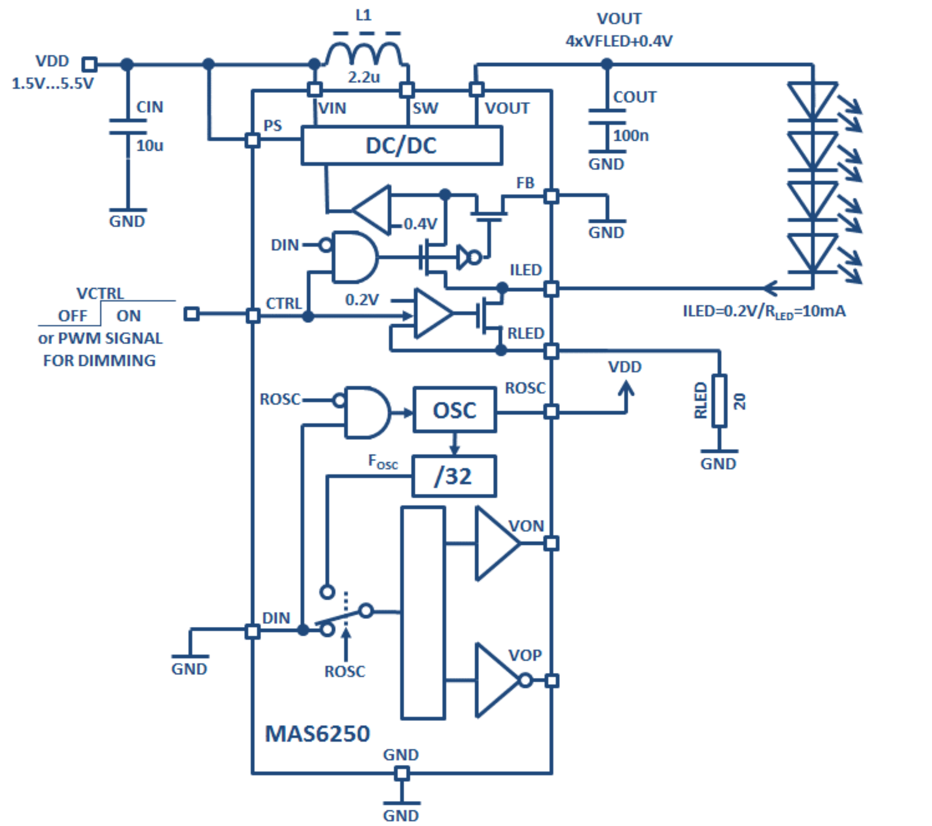


Figure 6. MAS6250 circuit for driving only series connected LEDs by CTRL control

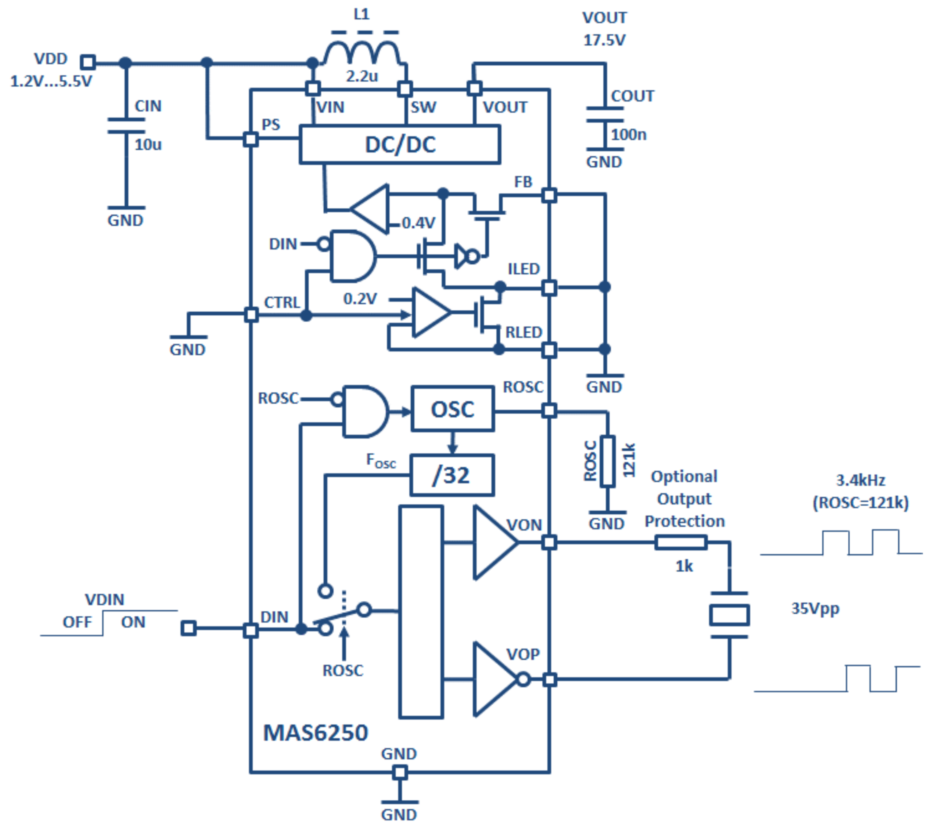


Figure 7. Self-drive mode driving piezo in differential configuration by DIN on/off control

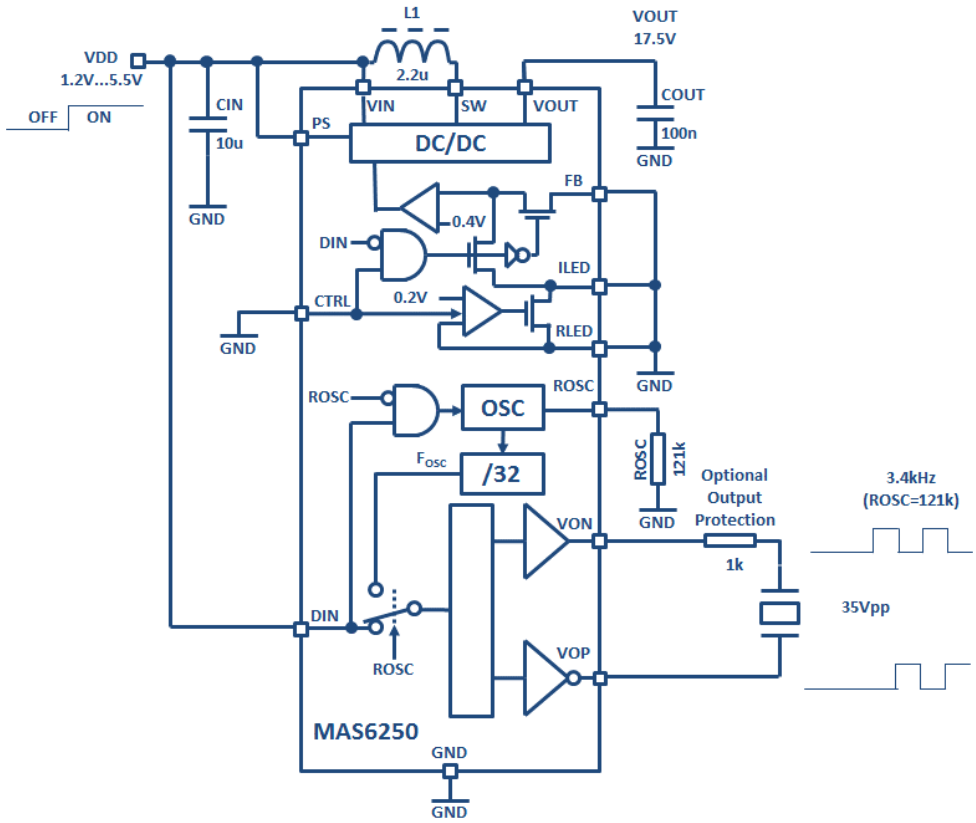


Figure 8. Self-drive mode driving piezo in differential configuration by VDD on/off control

The application figures above include optional 1kΩ output protection resistor which offers an extra protection for the over voltage that the piezo element could generate in a mechanical shock.

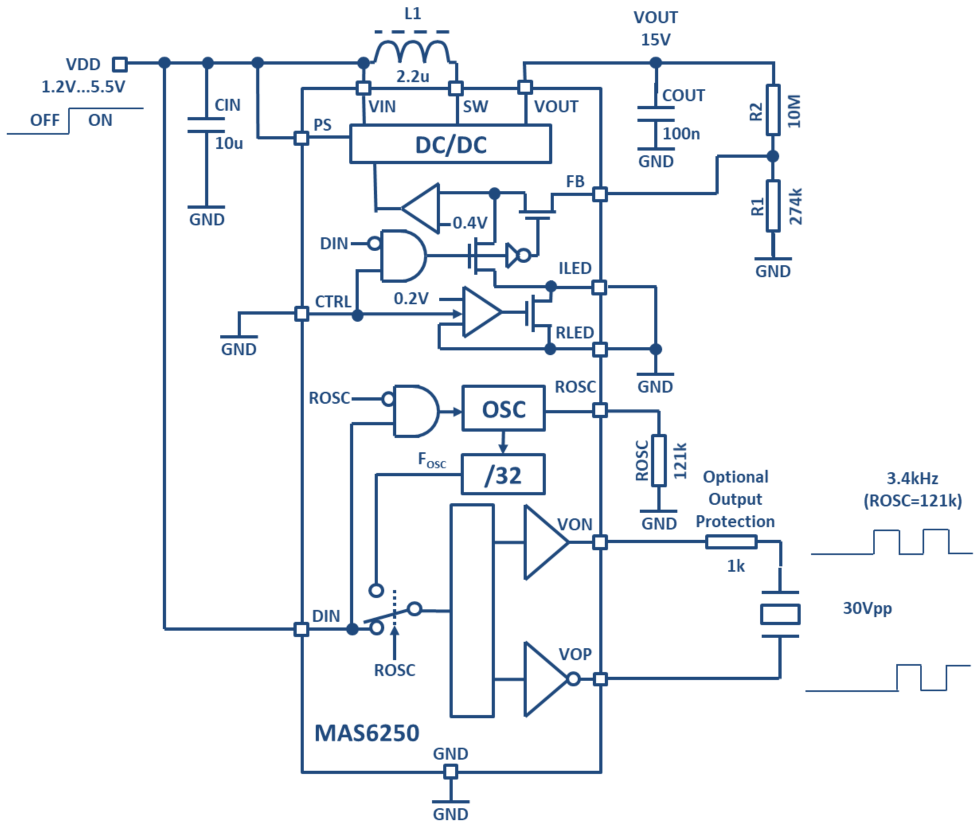


Figure 9. Self-drive mode with 15V DC/DC output driving piezo in differential configuration by VDD on/off control

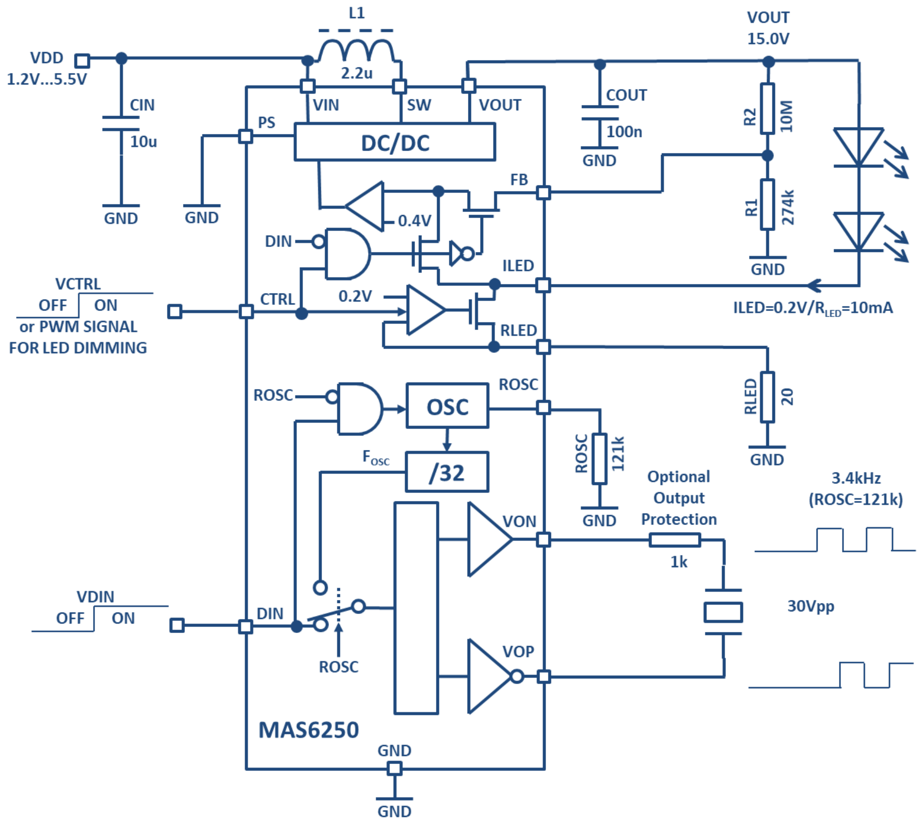


Figure 10. Self-drive mode driving piezo and two series 10mA LEDs by DIN and CTRL controls

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 10.

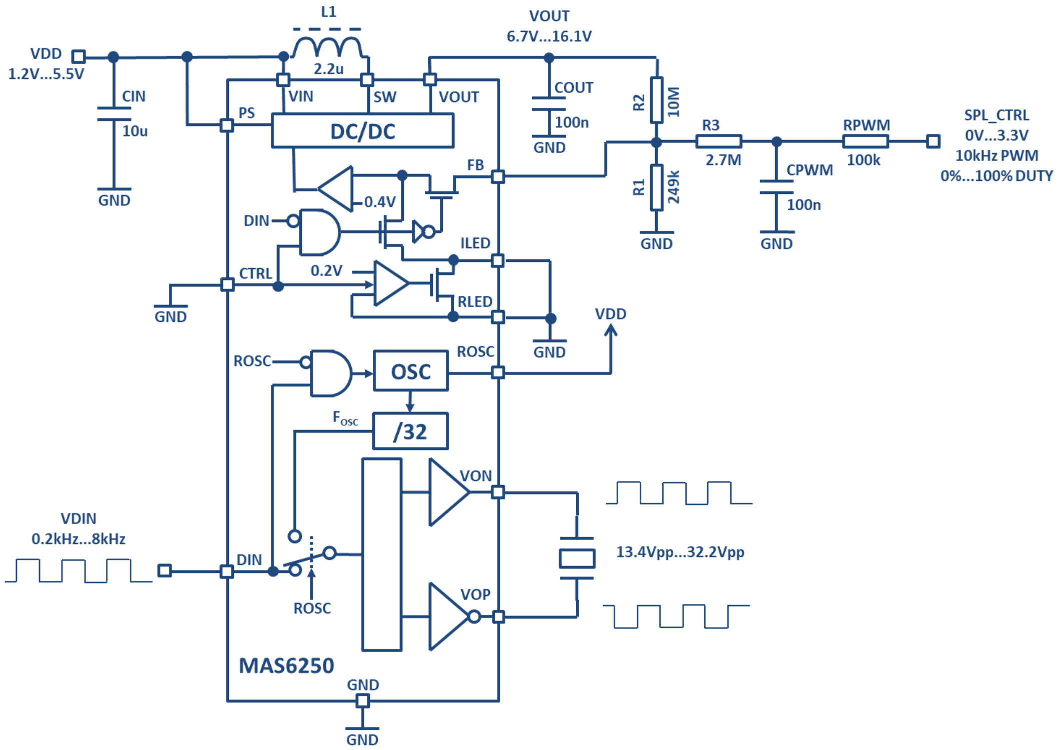


Figure 11. External drive mode with PWM volume control (VOUT=6.7V…16.1V i.e. 7.6dB control range)

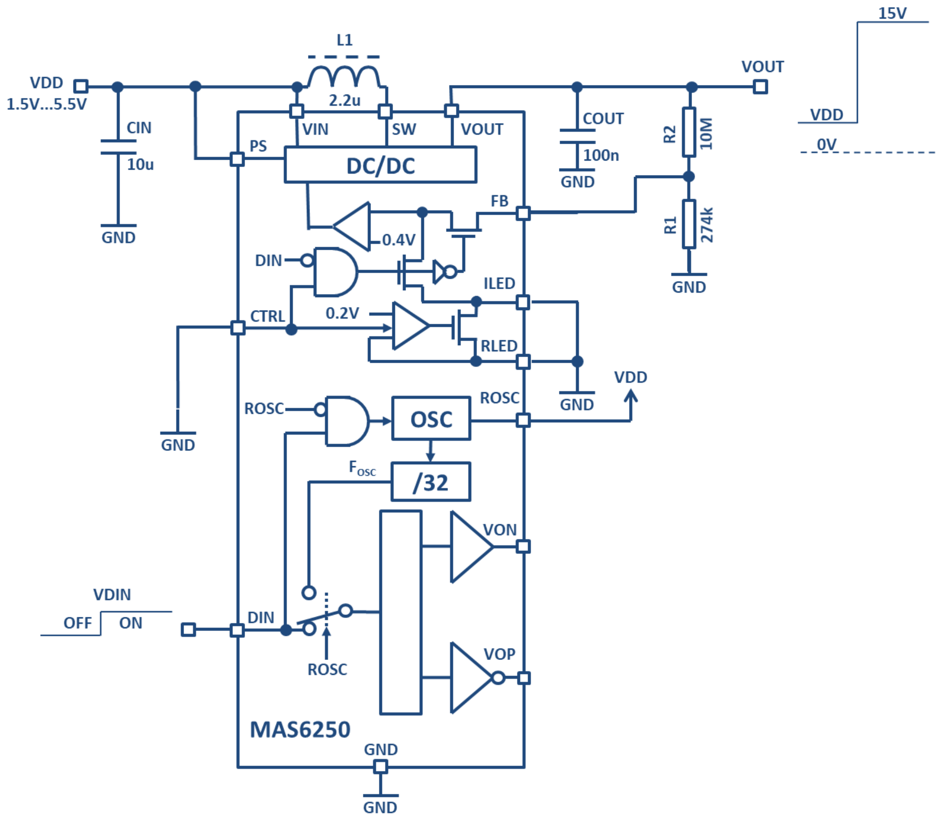


Figure 12. MAS6250 as +15V DC/DC power supply with DIN pin enable/disable control

MAS6250 can be also used just as DC/DC power supply with DIN enable/disable control. See figure 12. Note that in shutdown (DIN=low) the VOUT follows VIN (VDD) since there is internal diode connection from VIN to VOUT. When driving LEDs or resistive load the minimum supply voltage can be higher than 1.2V. See figures 21-23 for output current drive capability at LED and resistive loading.

DETAILED DESCRIPTION

MAS6250 operating modes are controlled by ROSC, DIN and CTRL pins as follows.

Table 1. Operating modes

CONTROL INPUTS			OPERATING MODES						
ROSC	**DIN**	**CTRL**	**DC/DC**	**OSC**	**PIEZO**	**LED**	**FB FET**	**PIEZO DRIVE**	**MODE**
VIN	LOW 2)	LOW 2)	OFF	OFF	OFF 4)	OFF	OFF	EXTERNAL	SHUTDOWN
VIN	LOW 2)	HIGH	ON	OFF	OFF 4)	ON	ON 5)	EXTERNAL	LED
VIN	HIGH 3)	LOW 2)	ON	OFF	ON 1)	OFF	OFF	EXTERNAL	PIEZO
VIN	HIGH 3)	HIGH	ON	OFF	ON 1)	ON	OFF	EXTERNAL	PIEZO+LED
ROSC 6)	LOW 2)	LOW 2)	OFF	OFF	OFF 4)	OFF	OFF	SELF	SHUTDOWN
ROSC 6)	LOW 2)	HIGH	ON	OFF	OFF 4)	ON	ON 5)	SELF	LED
ROSC 6)	HIGH	LOW 2)	ON	ON	ON	OFF	OFF	SELF	PIEZO
ROSC 6)	HIGH	HIGH	ON	ON	ON	ON	OFF	SELF	PIEZO+LED

Note 1: In external drive mode the piezo outputs are enabled after two rising edges appeared at DIN
Note 2: For DIN and CTRL "LOW" means being low at least max 15ms
Note 3: For DIN the "HIGH" corresponds to logic high level or pulsed signal at minimum 200Hz frequency
Note 4: Piezo "OFF" is disable mode in which both piezo outputs are pulled to ground (VOP=VON=GND)
Note 5: Feedback switch between FB and ILED is activated when only LED is driven
Note 6: SELF drive mode selected by connecting frequency adjustment resistor from ROSC pin to GND.

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.

The ROSC pin state selects between external drive and self-drive modes. In external drive mode (ROSC=VIN) the internal oscillator is always disabled (off). In self-drive mode (frequency adjustment resistor connected from ROSC pin to GND) the oscillator is enabled (on) when the DIN is set high.

In external drive mode (ROSC=VIN) the DIN pin can be used to control boost DC/DC converter on (DIN=HIGH) and off (DIN=GND) while keeping driver outputs (VOP, VON) disabled. When disabled the driver outputs are at GND state. The DC/DC converter is turned on by setting DIN=HIGH. By setting DIN=LOW turns off the DC/DC converter after max 15 ms shutdown delay. This is useful operating mode when using MAS6250 just as DC/DC power supply (see figure 12).

To drive piezo in external drive mode (ROSC=VIN) pulses need to be applied to the DIN pin at the desired signal frequency. The rising edge of the first DIN pulse turns on the DC/DC converter but the piezo driver outputs (VOP, VON) are enabled only at rising edge of the second DIN pulse as illustrated in figure 13. The piezo driver outputs are disabled and DC/DC converter is turned off after keeping DIN=LOW for typ 10ms as illustrated in figure 14. Again when new pulses are fed into DIN the charge pump and piezo driver will be enabled. In self-drive mode (ROSC=VIN) the internal oscillator will provide the necessary pulses to enable piezo driver outputs and drive audio frequency signal to the piezo.

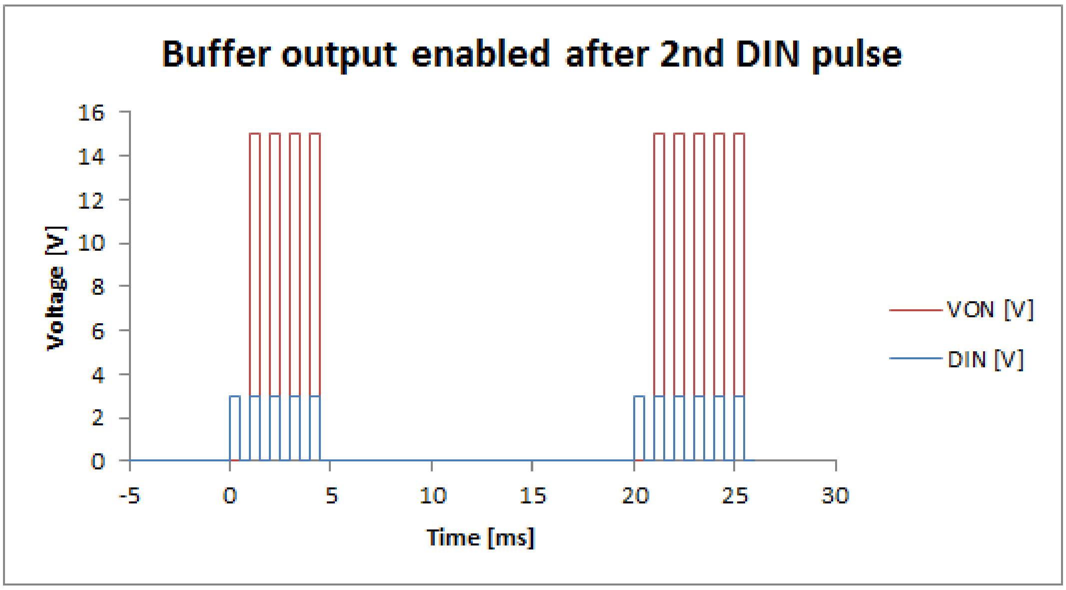


Figure 13. Enabling buffer outputs at rising edge of the 2nd DIN pulse

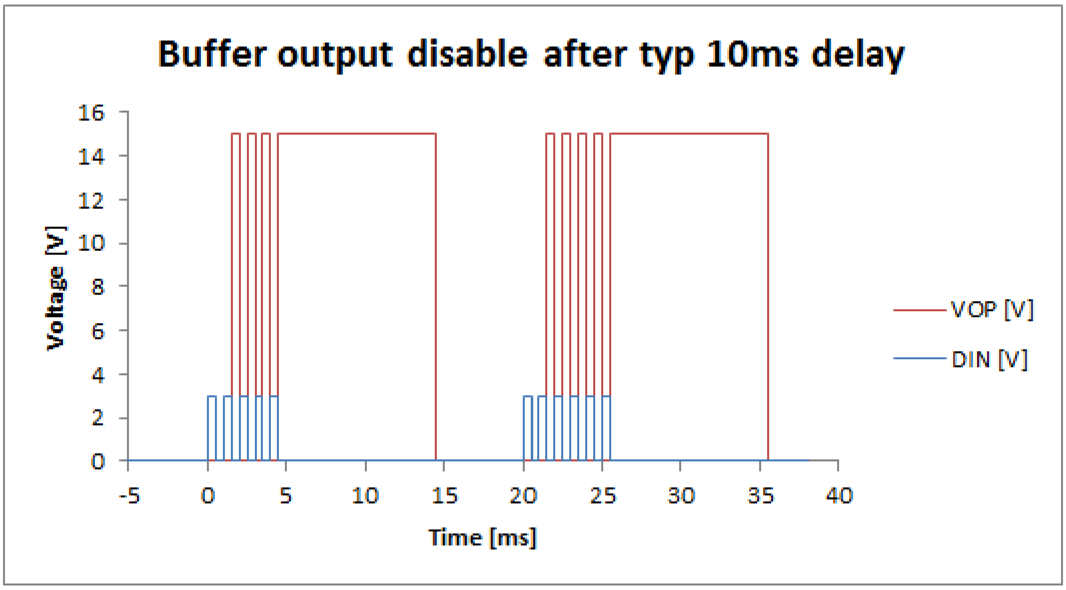


Figure 14. Disabling buffer outputs after power down delay

CIN and COUT capacitor values

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

Table 2. Recommended capacitor values

Capacitor	Nominal value
CIN	10µF
COUT	100nF

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 9-12. 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 5-8. 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) should be close to 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 and 10. 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

In self-drive mode (frequency adjustment resistor connected from ROSC pin to GND) the piezo audio signal frequency is generated from an internal oscillator. The oscillator frequency is controlled by external oscillator resistor ROSC. Table 5 shows examples of piezo audio signal frequencies achieved at different ROSC resistor values. Internal oscillator is factory trimmed to produce 3.435kHz frequency when using 121kΩ ROSC resistor. See note below the table 5.

Table 5. Self-drive mode oscillator resistor and output frequency examples

ROSC [kΩ] (E96 1%)	FAUDIO [kHz]
412	1.0
280	1.5
210	2.0
165	2.5
140	3.0
133	3.1
127	3.3
121	3.4
118	3.5
105	4.0

Note: FAUDIO [kHz] = 415.6 / ROSC [kΩ]

TYPICAL CHARACTERISTICS

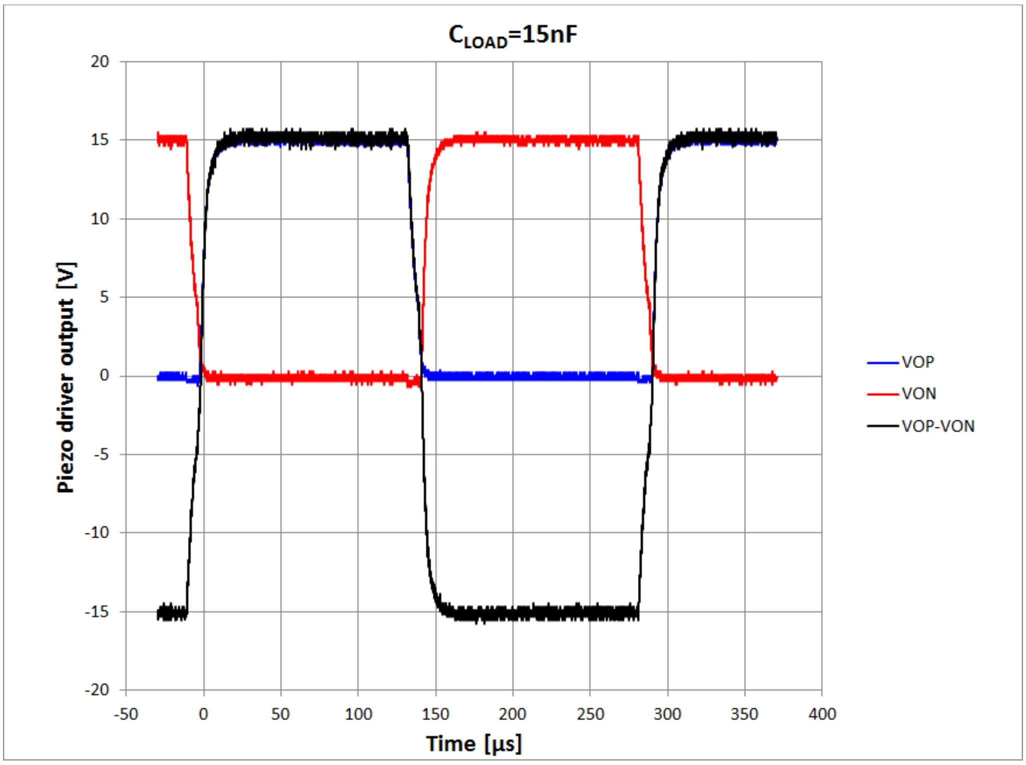


Figure 15. Piezo driver outputs at VIN=3V, VOUT=15V, DIN=3.4kHz, C_{LOAD}=15nF, C_{OUT}=100nF

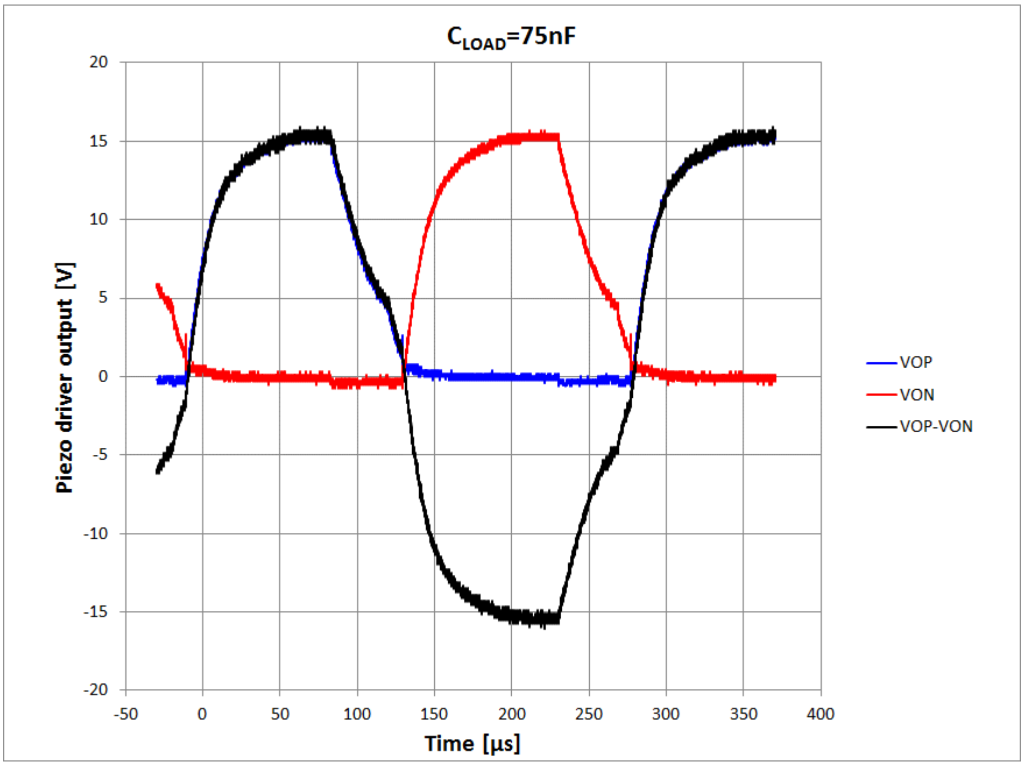


Figure 16. Piezo driver outputs at VIN=3V, VOUT=15V, DIN=3.4kHz, C_{LOAD}=75nF, C_{OUT}=470nF

TYPICAL CHARACTERISTICS (continued)

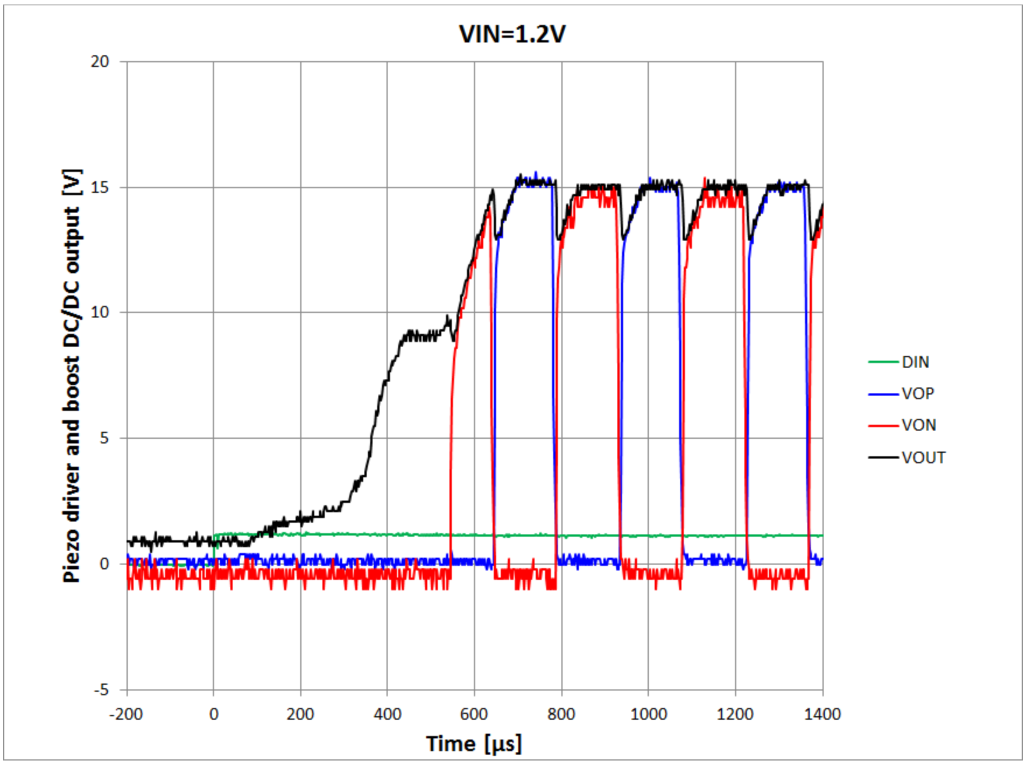


Figure 17. Piezo driver and boost DC/DC output start-up in self-drive mode at VIN=1.2V, VOUT=15V, FAUDIO=3.4kHz (ROSC=121kΩ), C_{LOAD}=15nF

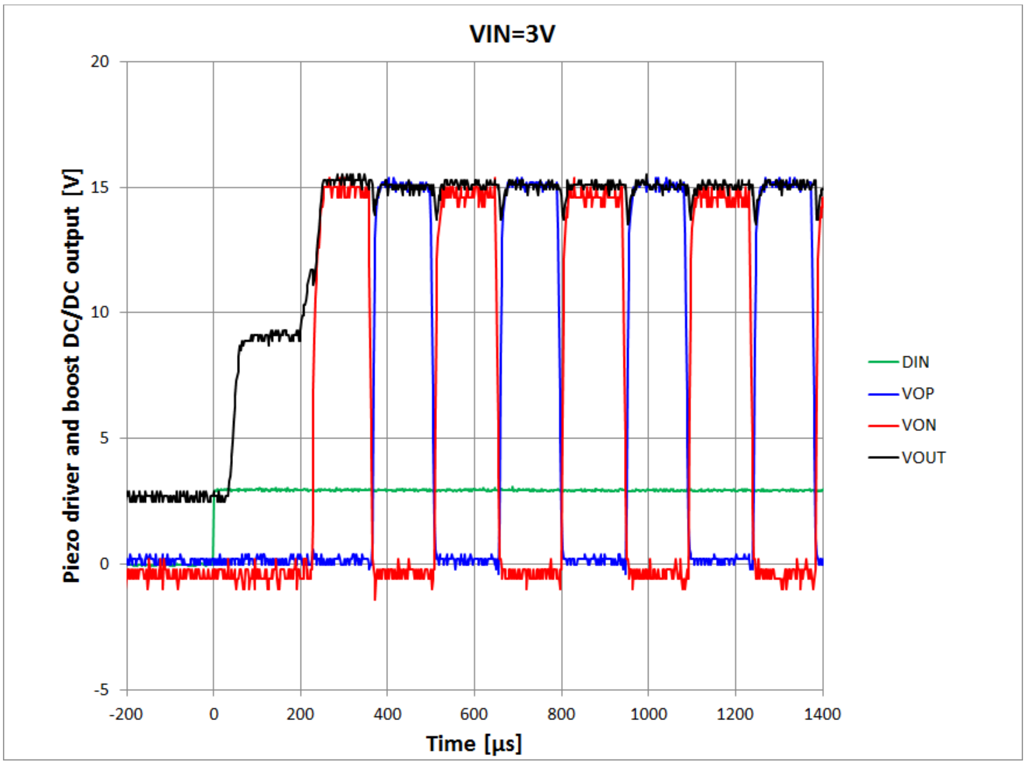


Figure 18. Piezo driver and boost DC/DC output start-up in self-drive mode at VIN=3V, VOUT=15V, FAUDIO=3.4kHz (ROSC=121kΩ), C_{LOAD}=15nF

TYPICAL CHARACTERISTICS (continued)

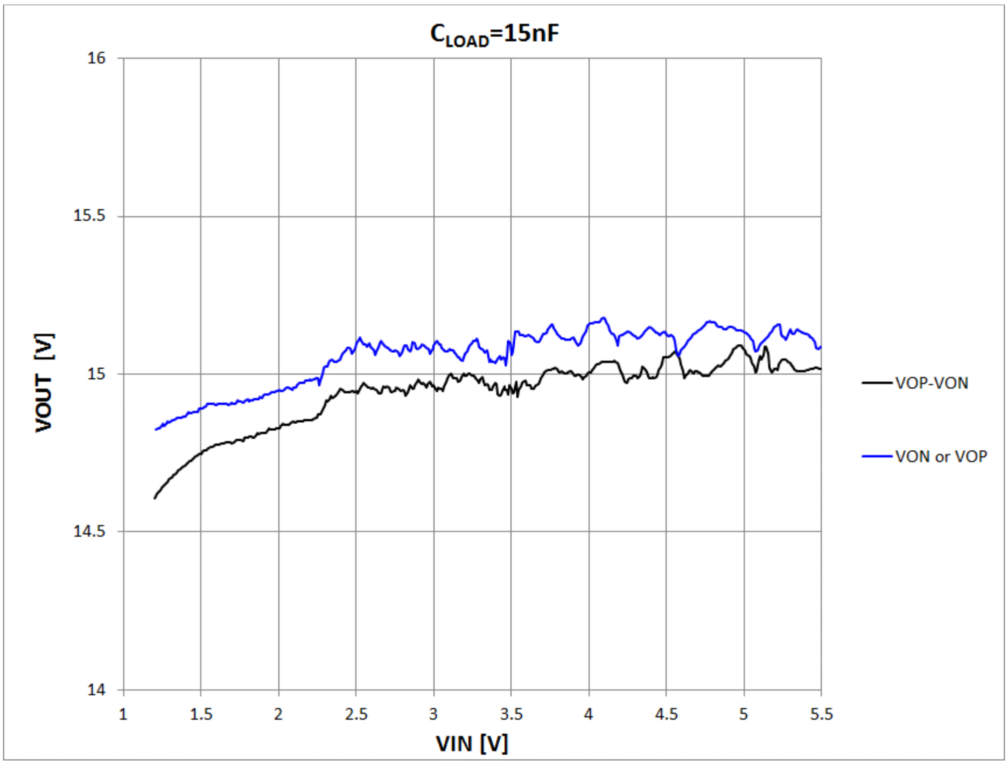


Figure 19. Output voltage at differential and single-ended piezo loading; VOUT=15V, DIN=3.4kHz, C_{LOAD}=15nF

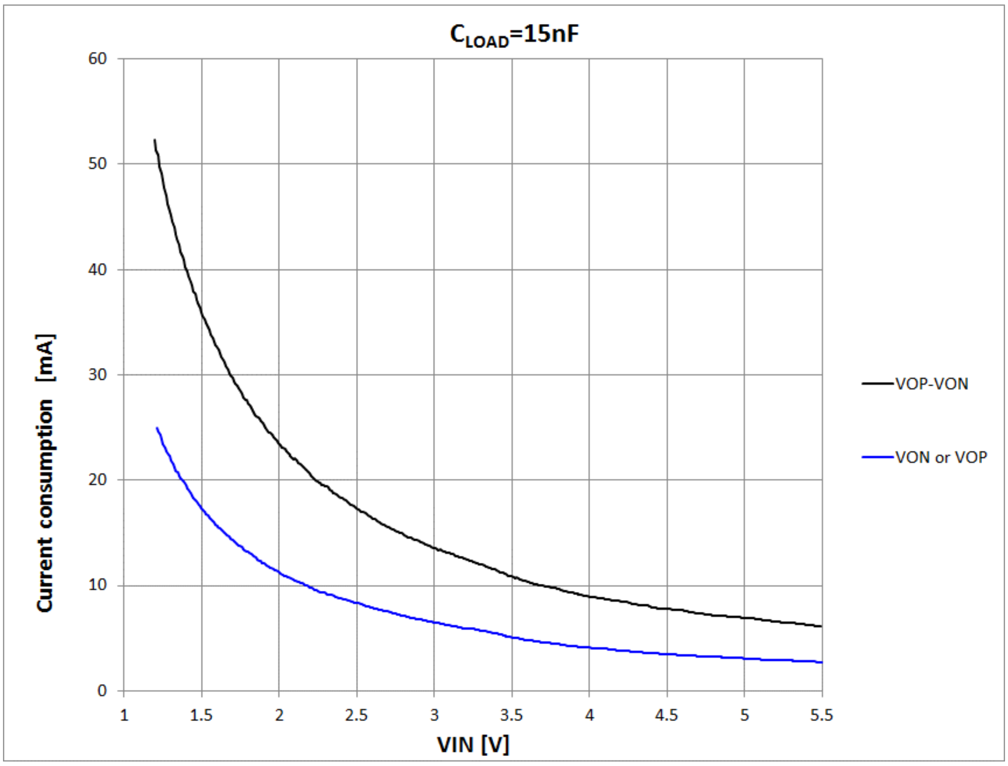


Figure 20. Current consumption at differential and single-ended piezo loading; VOUT=15V, DIN=3.4kHz, C_{LOAD}=15nF

TYPICAL CHARACTERISTICS (continued)

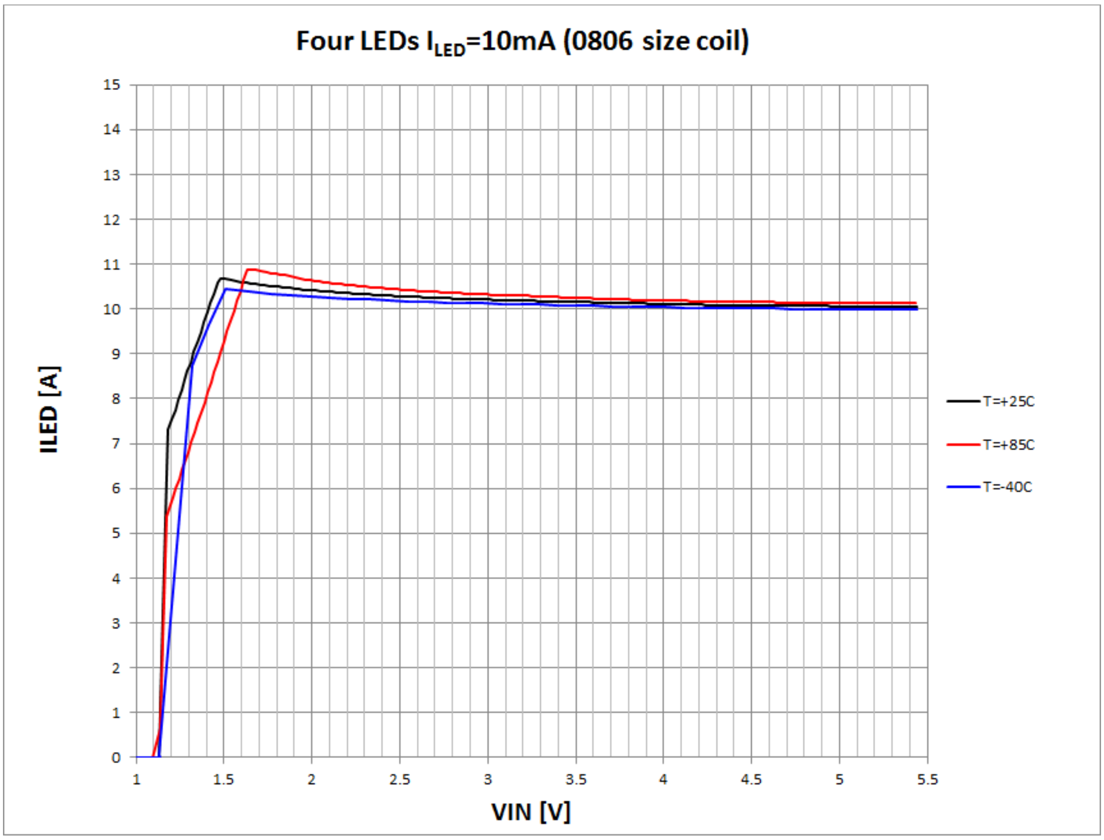


Figure 21. LED current drive capability over VIN; four LEDs (VOUT=11.7V), I_{LED}=10mA

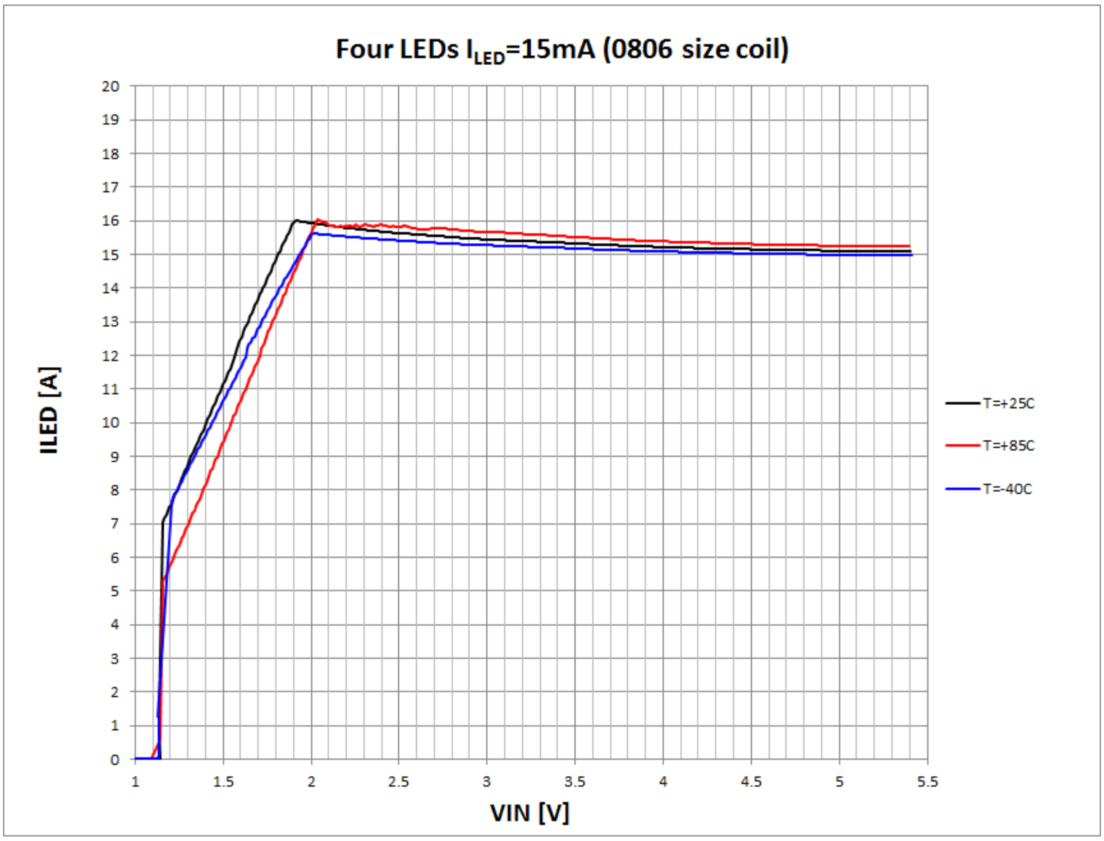


Figure 22. LED current drive capability over VIN; four LEDs (VOUT=12.4V), I_{LED}=15mA

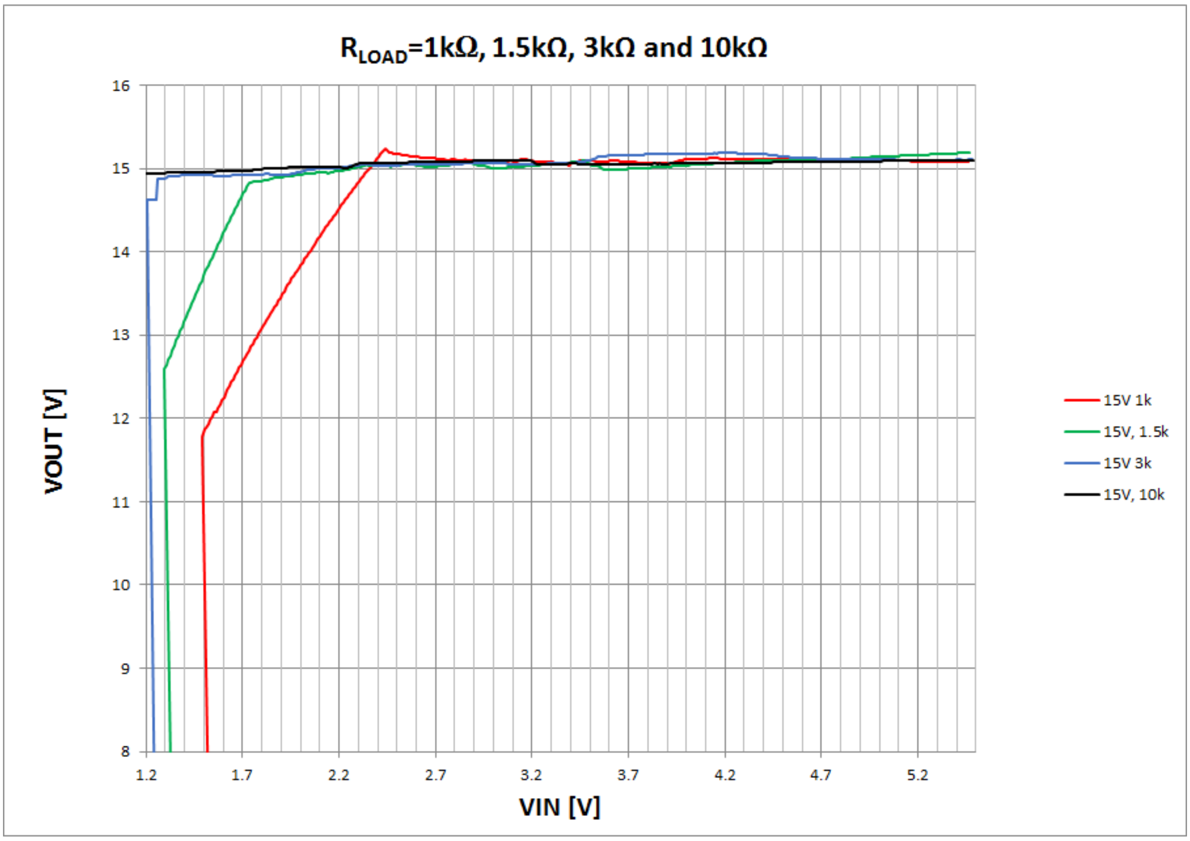


Figure 23. DC/DC converter output drive capability for a resistive loading at VOUT=15V (R2/R1=36.5) regulation

The figure 23 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 MAS6250 (U1) as possible and routed with low inductance connection to ground plane. See figure 24 below for a PCB layout example of figure 3 application circuit which includes output voltage adjustment resistors R1 and R2.

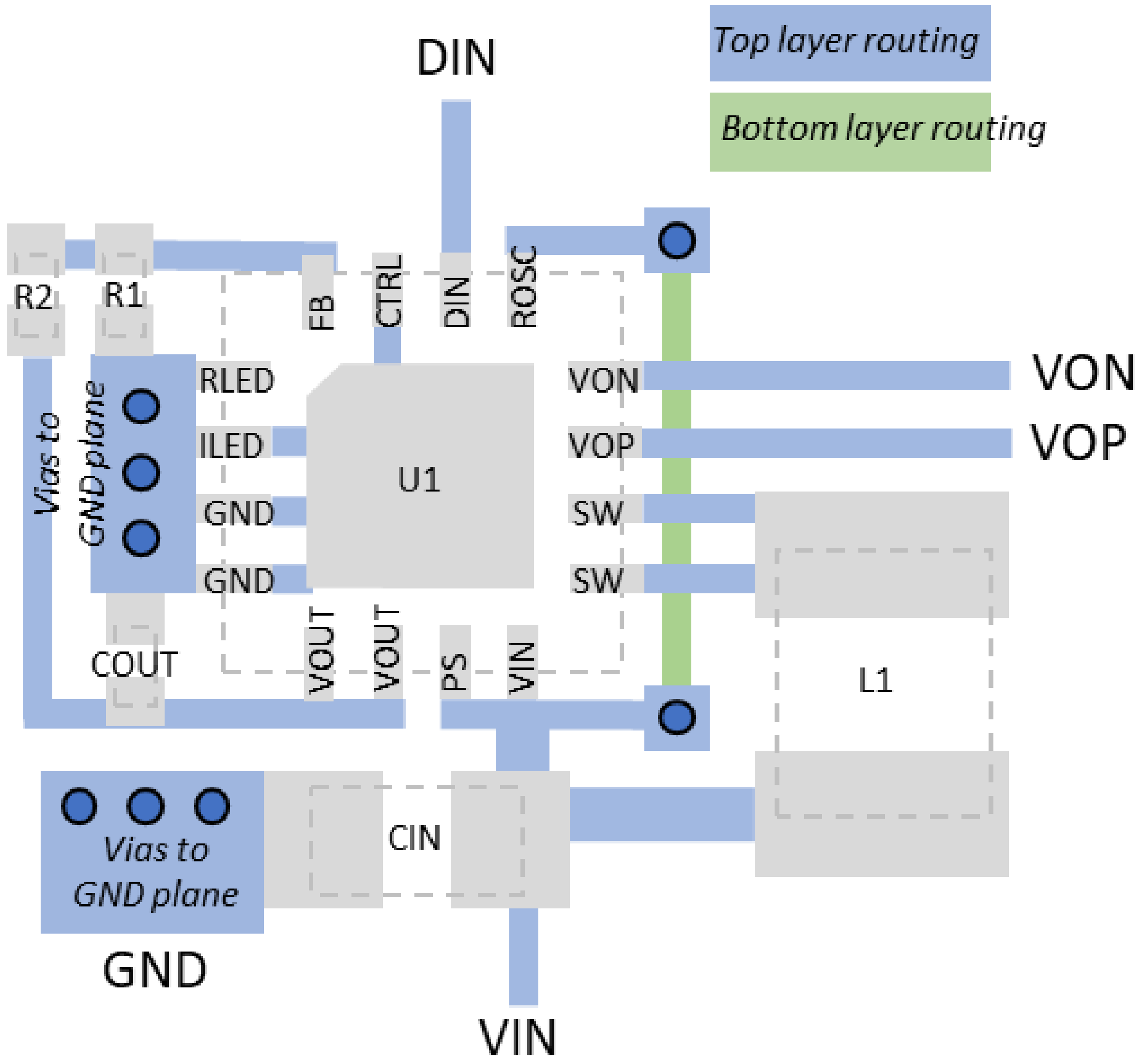
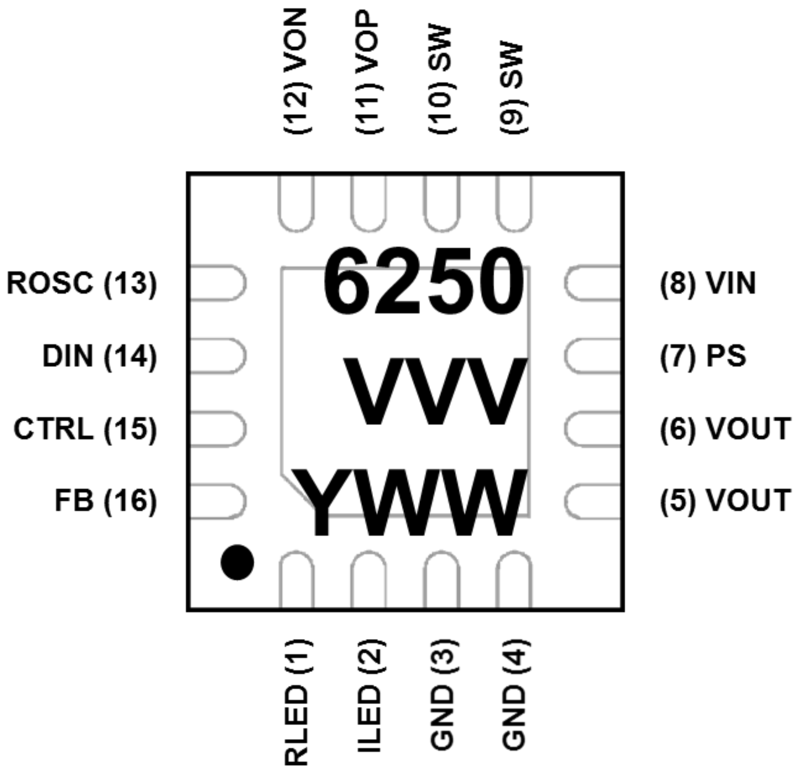


Figure 24. PCB layout example

Table 6. PCB layout example component details

Ref	Manuf. part	Value	Rating	Case inch (metric)	Dimensions (LxWxT)
U1	MAS6250BA2Q13	MAS6250		QFN-16 3x3	3.0x3.0x0.75 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
L1	LQM2MPN2R2MEH	2.2µH	0.7A (Isat)	0806 (2016)	2.0x1.6x0.7 mm
R1		274kΩ		0201 (0603)	0.6x0.3 mm
R2		10MΩ		0201 (0603)	0.6x0.3 mm

DEVICE OUTLINE CONFIGURATION



Top Marking Information:
6250 = 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 pin	
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	
VOP	11	AO	Inverted piezo driver output	
VON	12	AO	Non-inverted piezo driver output	
ROSC	13	AIO	Self-drive oscillator frequency adjustment resistor	2
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	3

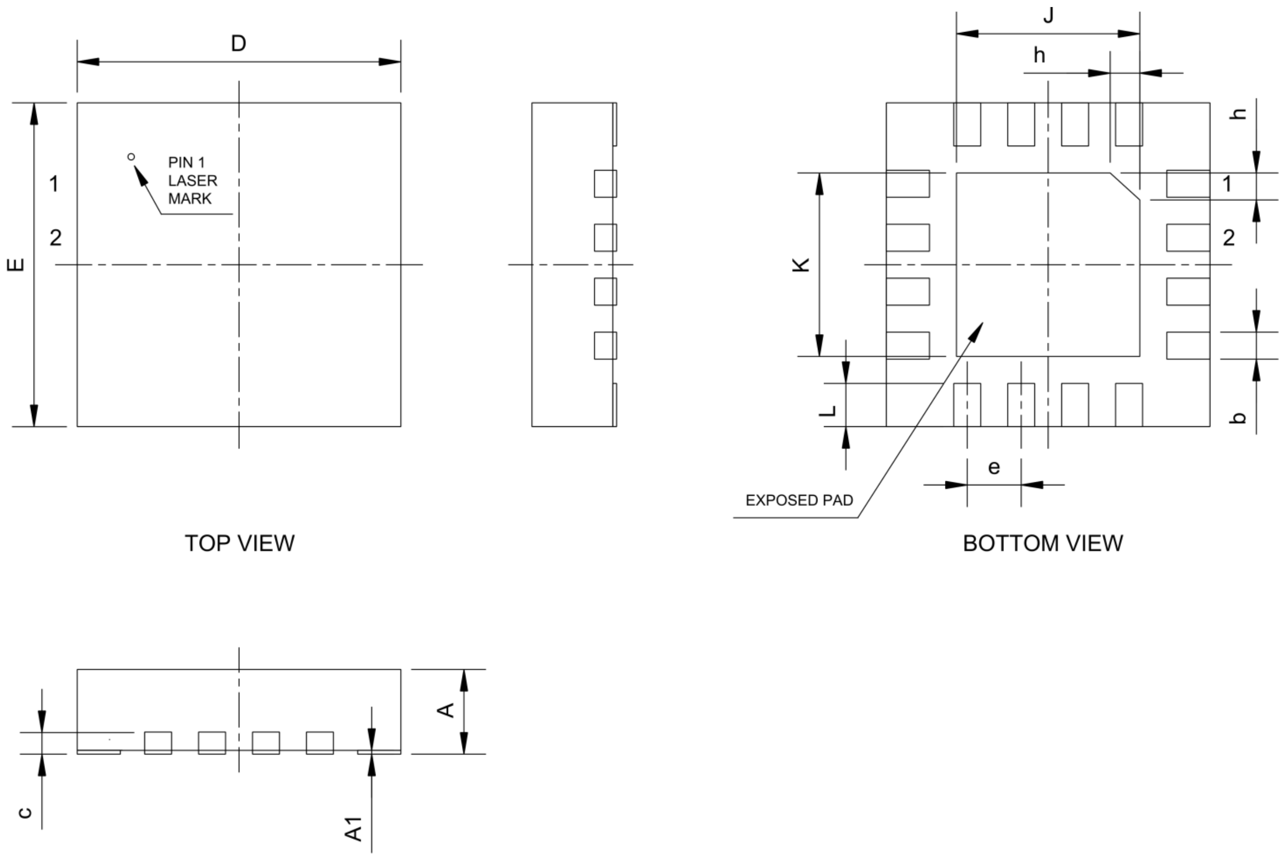
G = Ground, P = Power, D = Digital, A = Analog, I = Input, O = Output

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 figures 4 and 10.

Note 2: For external drive mode connect ROSC to VIN. For self-drive mode connect frequency adjustment resistor from ROSC pin to GND.

Note 3: On PCB the exposed thermal pad must be connected to GND plane using thermal vias functioning as thermal heat sink.

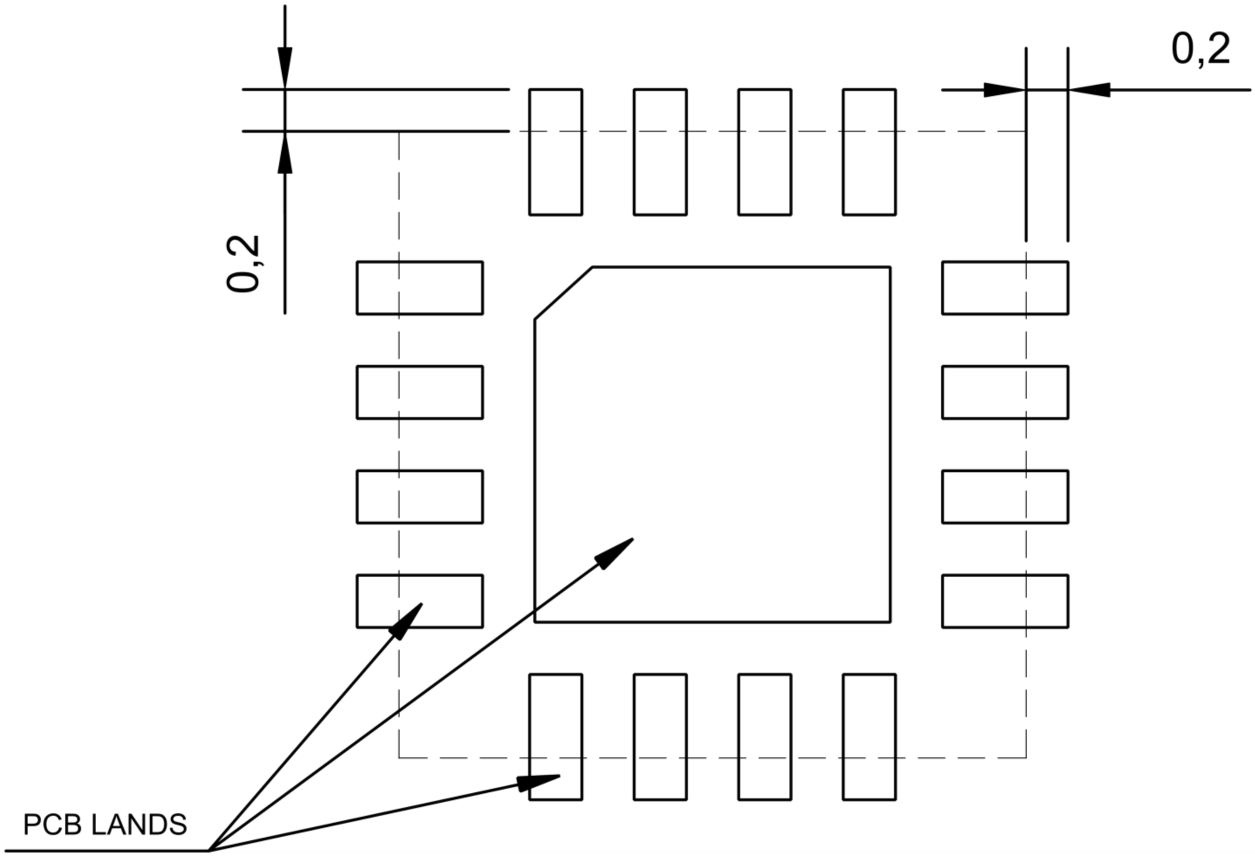
PACKAGE (QFN-16 3X3x0.75) OUTLINE



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
MAS6250BA2Q1306	Piezo and LED Driver with Synchronous Boost DC/DC Converter	QFN-16 3.0x3.0x0.75, Pb Free, RoHS Compliant	Tape and Reel 3000 pcs / r

Contact Micro Analog Systems Oy for bare die delivery options.

LOCAL DISTRIBUTOR

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