

AXPM60631/3

200mA Dual DC-DC Converter for Powering AMOLED Display



Datasheet – Dec 2021

Description

The AXPM60631/3 is designed to drive AMOLED (Active Matrix Organic Light Emitting Diode) displays requiring positive and negative supply rails. The device integrates a boost converter for VPOS and an inverting buck boost converter for VNEG and is suitable for battery-operated products. The digital control pin (CTRL) allows programming the negative output voltage in digital steps. The AXPM60631/3 uses a novel technology enabling excellent line transient performance.

Features

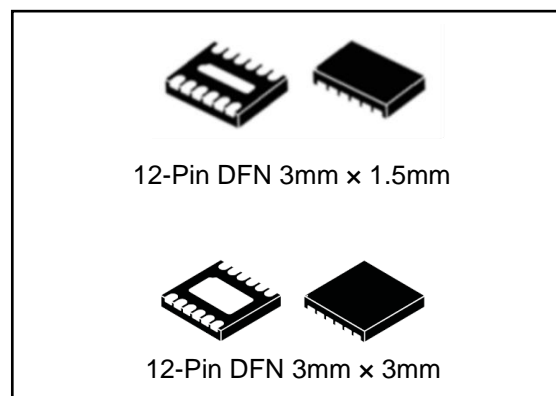
- Operating input voltage range from 2.9V to 4.5V
- Step-up converter (VPOS)
 - 4.6V output voltage
 - 200mA output current
 - 0.5% accuracy (25°C to 85°C)
 - Dedicated output sense pin
- Inverting converter (VNEG)
 - -1.4V to -4.4V programmable output voltage (-2.2V default)
 - 200mA output current
- Efficiency >90%
- Excellent line and load regulation
- Short circuit protection
- Thermal shutdown
- Available in
 - DFN12L 3mm x 1.5mm x 0.5mm: AXPM60631
 - DFN12L 3mm x 3mm x 0.75mm: AXPM60633

Applications

- AMOLED power supply in portable devices like mobile phones, multi-media players, camcorders, digital still cameras and wearables.

Table 1 Device Summary

Order code	Package	Packing
AXPM60631	DFN12 3mm x 1.5mm x 0.5mm	Reel
AXPM60633	DFN12 3mm x 3mm x 0.75mm	Reel



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1 Block Diagram and Application Circuit

Figure 1 Block Diagram

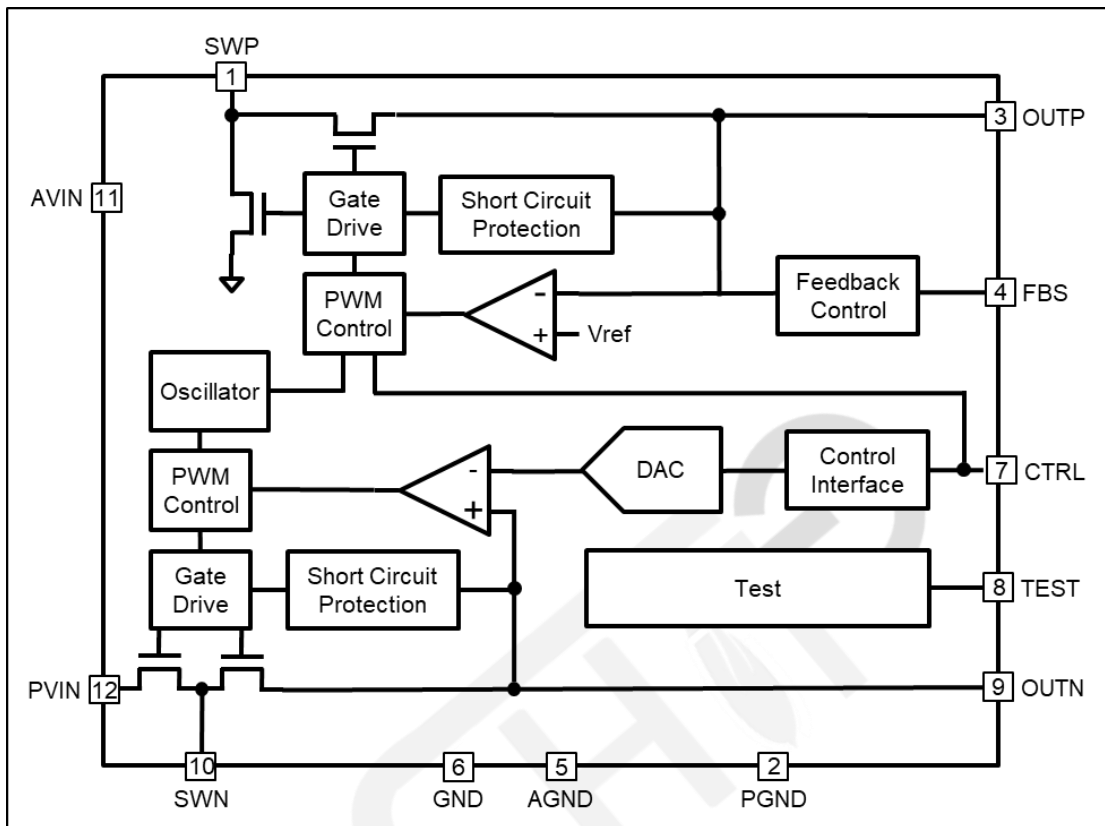
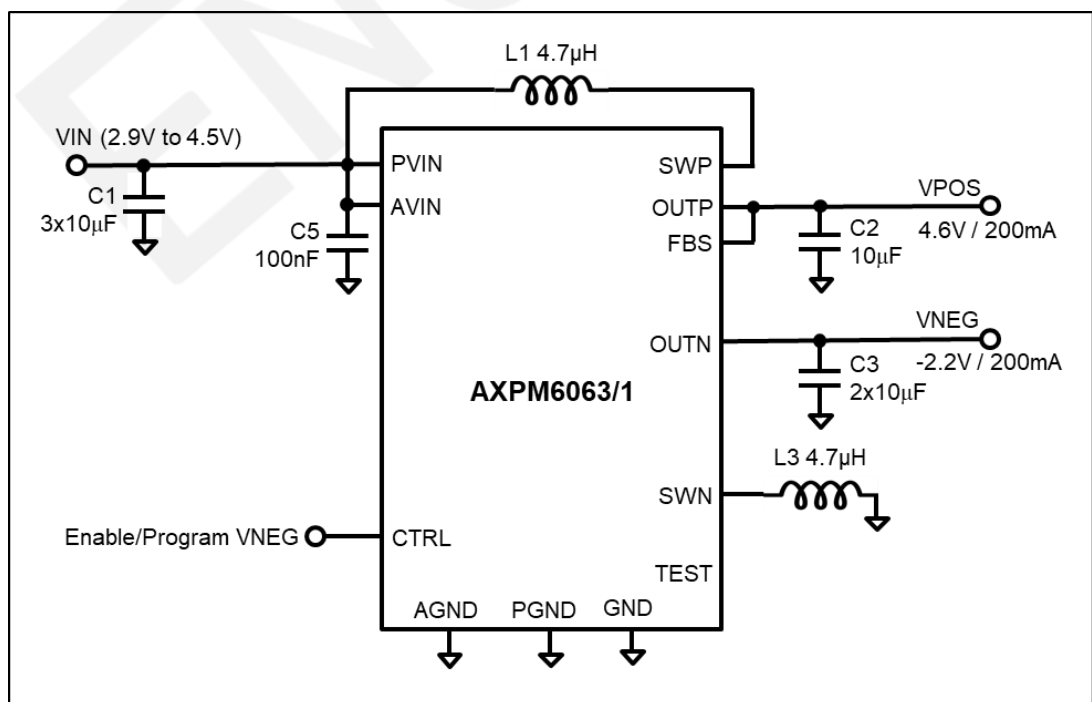


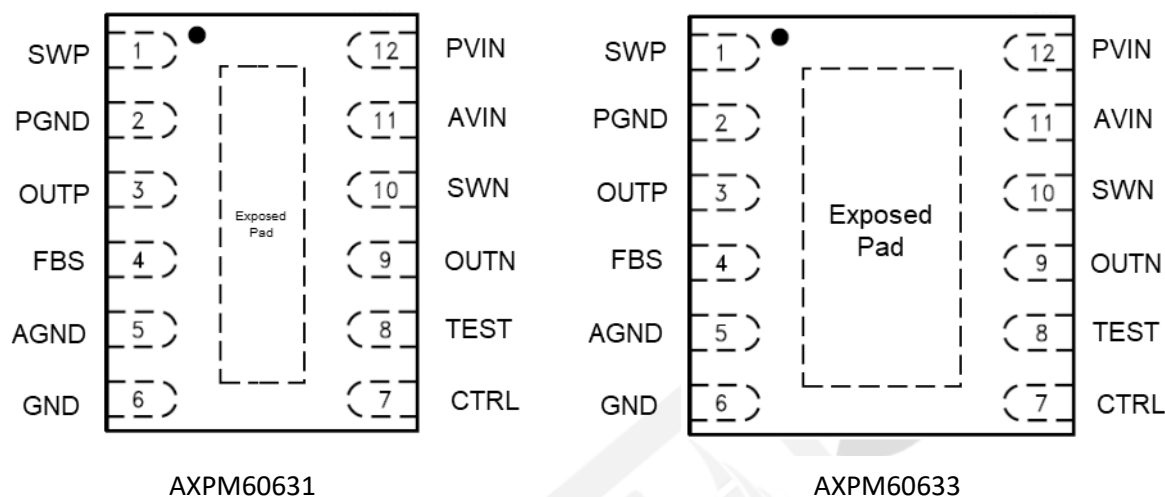
Figure 2 Application Circuit



2 Pin Description

2.1 Pin Names

Figure 3 Pin Connection



2.2 Pin Functions

Table 2 Pin Functions

Pin number	Pin name	Description
1	SWP	Step-up converter (VPOS) switch pin
2	PGND	Step-up converter (VPOS) power ground
3	OUTP	Step-up converter 1 (VPOS) output
4	FBS	Step-up converter 1 (VPOS) feedback sense pin
5	AGND	Analog ground
6	GND	Ground for the device
7	CTRL	Step-up converter (VPOS) and VNEG enable/program pin
8	TEST	Reserved for Device Testing. Not connected
9	OUTN	Inverting converter output (VNEG)
10	SWN	Inverting converter switch pin
11	AVIN	Supply Voltage for the device
12	PVIN	Supply voltage for the power stage
EPAD		Connect this pad to AGND, PGND1 and PGND2.

3. Electrical Specifications

3.1 Absolute Maximum Ratings

Table 3 Absolute Maximum Ratings

Symbol	Parameter	Value	Unit
SWP, OUTP, FBS, PVIN, AVIN	DC supply voltage, output voltage, output voltage sense input.	-0.3 to +5.5	V
OUTN	Output voltage	-6.0 to +0.3	V
SWN	Switching node voltage	-6.5 to +4.8	V
CT, CTRL,	Input logic voltage, analog input.	-0.3 to +5.5	V
T _j	Junction temperature	150	°C
T _{stg}	Storage temperature	-55 to +150	°C

3.2 Thermal Data

Table 4 Thermal Data

Symbol	Parameter	Value	Unit
R _{th j-amb}	Thermal resistance junction-ambient referred to the FR-4 PCB	48.8	°C/W
R _{th j-case}	Thermal resistance junction-to-case	2.6	°C/W

3.3 ESD and Latch Up

Table 5 ESD and Latch Up

Symbol	Parameter	Value	Unit
All pins	ESD HBM	±2,000	V
All pins	ESD CDM	±500	V
All pins	Latch Up JESD78, Class A	≥ 100	mA

3.4 Electrical Characteristics

VIN=3.7V, CTRL=3.7V, VPOS=+4.6V, VNEG=-2.2V, typical values are at TA = 25°C (unless otherwise noted).

Table 6 Electrical Characteristics

Symbol	Parameter	Test condition	Min	Typ	Max	Unit
General						
VIN	Supply input voltage	VIN=PVIN=AVIN	2.9	3.7	4.5	V
Temp	Operating temperature		-40	25	85	°C
ISD	Shutdown current	CTRL=GND			1	μA
VUVLO	Under-voltage lockout threshold	VIN Falling		2.1		V
		VIN Rising		2.3		V
Logic Signals (CTRL)						
VH	High Threshold	VIN=2.9 to 4.5V	1.2			V
VL	Low Threshold				0.4	V
RDOWN	Pull-down resistance			300		kΩ
Step-up Converter (OUTP = VPOS)						
VPOS	Positive output voltage			4.6		V
	Positive output voltage variation	25°C ≤ TA ≤ 85°C No load	-0.5		+0.5	%
		-30°C ≤ TA ≤ 85°C No load	-0.8		+0.8	%
	Line regulation	IPOS=200mA		0.01		%/V
Load regulation	1 mA ≤ IPOS ≤ 200 mA		0.1		%/A	
RDS(on)1A	Switch on-resistance	ISWP1=200mA		200		mΩ
RDS(on)1B	Rectifier on-resistance			350		mΩ
fSW1	Switching frequency	IPOS=200mA		1.5		MHz
ISW1	Switch current limit	Inductor peak current		0.6		A
IO1MAX	Maximum output current	VIN=2.9V to 4.5V	200			mA
VSCP1	Short circuit threshold in operation	VPOS falling		85% of VPOS		
tSCP1	Short circuit detection time in operation			3		ms
VT	Output voltage sense threshold	VOUTP1 – VFBS increasing	860	1,100	1,270	mV
		VOUTP1 – VFBS decreasing	630	740	830	mV
RFBS	FBS pin pull-down resistance			300		kΩ
RDCHG1	Discharge resistance	CTRL=GND ISWP1=1mA		30		Ω
Inverting Converter (OUTN = VNEG)						
VNEG	Output voltage default			-2.2		V
	Output voltage range		-1.4		-4.4	V
	Output voltage accuracy	25°C ≤ TA ≤ 85°C No load	-50		+50	mV
		-30°C ≤ TA ≤ 85°C No load	-60		+60	mV
	Line regulation	INEG=200mA		0.01		%/V
	Load regulation			0.1		%/A
RDS(on)2A	SWN mosfet on-resistance	ISWN=200mA		200		mΩ
RDS(on)2B	SWN mosfet rectifier on-resistance			300		mΩ

f _{SW2}	SWN Switching frequency	I _{NEG} =10mA		1.5		MHz
I _{SW2}	SWN switch current limit	V _{IN} =2.9V		0.6		A
I _{O2MAX}	Maximum output current	V _{IN} =2.9V	-200			mA
V _{SCP2}	Short circuit threshold in operation	Voltage increase from nominal V _{NEG}		85% of V _{NEG}		V
	Short circuit threshold in start up			250		mV
t _{SCP2}	Short circuit detection time in start up			10		ms
	Short circuit detection time in operation			3		ms
R _{DCHG2}	Discharge resistance	CTRL=GND I _{SWN} =1mA		150		Ω
Others						
t _{INIT}	Initialization time			300		μs
t _{STORE}	Data storage/accept time period		30	55	80	μs
T _{SDN}	Shutdown time period		30	55	80	μs
T _{SD}	Thermal shutdown temperature			145		°C
T _R	Thermal shutdown recovery temperature			130		°C
Timing Requirements CTRL Interface						
t _{LOW}	Low-level pulse duration		2	10	25	μs
t _{HIGH}	High-level pulse duration		2	10	25	μs

4 Functional Description

4.1 Overview

The AXPM60631/3 consists of a boost converter and an inverting buck boost converter. The VPOS output is fixed at 4.6V and VNEG output is programmable via a digital interface in the range of -1.4V ~ -4.4V, the default is -2.2V. With CT connected to GND, the transition time of VNEG output is set to a default fast timing internally. The device has internal over-temperature protection, under voltage lockout and soft start which guarantees proper operation during start-up.

4.2 Step-up Converter (VPOS)

Step-up converter uses a fixed-frequency current-mode topology. Its output voltage (VPOS) is programmed at the factory to 4.6V and cannot be changed by the user.

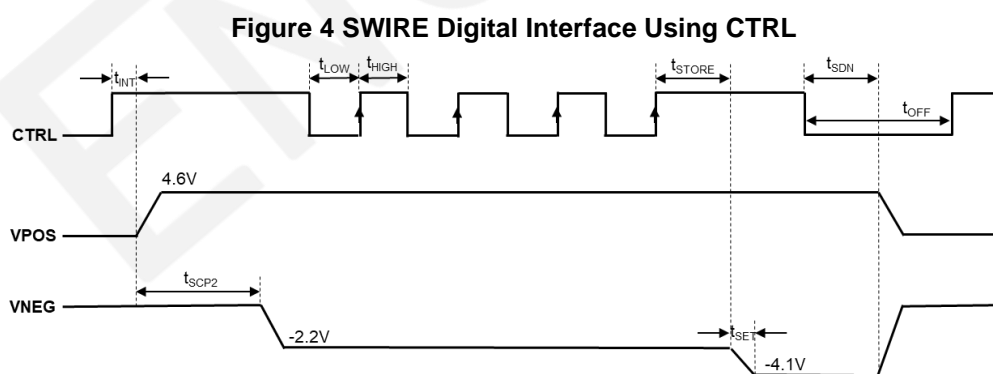
For highest output voltage accuracy, connect the output sense pin (FBS) directly to the positive terminal of the main output capacitor.

4.3 Inverting Converter (VNEG)

The inverting converter uses a constant-off-time current-mode topology. The converter's default output voltage (VNEG) is -2.2V. It can be programmed from -1.4V to -4.4V.

4.3.1 Programming VNEG

The digital interface allows programming of VNEG in discrete steps. If the output voltage setting function is not required, then the CTRL pin can also be used as a standard enable pin. The digital output voltage programming of VNEG is implemented using a simple digital interface (SWIRE) with the timing shown in figure 4.



When CTRL is pulled high, the device starts up with its default voltage of -2.2V. The device includes a DAC that generates the output voltages shown in table 7. The interface counts the rising edges applied to the CTRL pin once the device is enabled. According to table 7, VNEG is programmed to -4.1V since 4 rising edges are detected.

Table 7 VNEG Programming by SWIRE

Pulse	VNEG (V)	Pulse	VNEG (V)
0	-2.2	16	-2.9
1	-4.4	17	-2.8
2	-4.3	18	-2.7
3	-4.2	19	-2.6
4	-4.1	20	-2.5
5	-4.0	21	-2.4
6	-3.9	22	-2.3
7	-3.8	23	-2.2
8	-3.7	24	-2.1
9	-3.6	25	-2.0
10	-3.5	26	-1.9
11	-3.4	27	-1.8
12	-3.3	28	-1.7
13	-3.2	29	-1.6
14	-3.1	30	-1.5
15	-3.0	31	-1.4

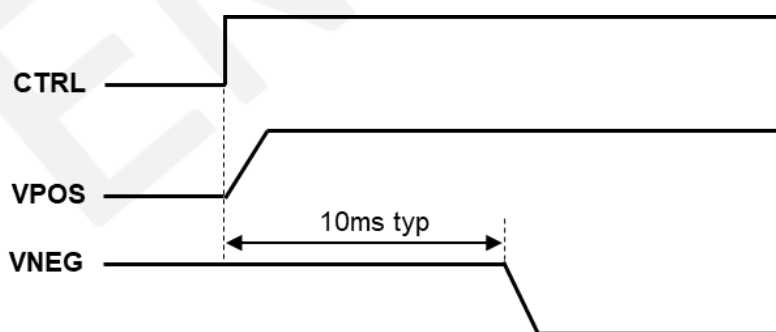
4.3.2 VNEG Transition Time

The transition time (t_{SET}) is the time required to move VNEG from one voltage level to the next. It has by default a fast transition time.

4.4 Soft Start and Start-up Sequence

AXPM60631/3 features a soft-start function to limit inrush current. When CTRL goes high, step-up converter starts with a reduced switch current limit and 10 ms later the inverting converter starts with its default value of -2.2V. The typical start-up sequence is shown in Figure 5. The 2 step-up converters operate independently.

Figure 5 Start-up Sequence



4.5 CTRL

The CTRL pin serves two functions: one is to enable and disable the device, and the other is to program the output voltage (VNEG) of the inverting buck-boost converter (see Programming VNEG). If the VNEG programming function is not required, the CTRL pin can be used as a standard enable pin for the device, which will start up with its default value of -2.2V on VNEG.

The device is enabled when CTRL is pulled high and disabled when CTRL is pulled low. Note that to ensure proper start up CTRL must be pulled low for a minimum of 100µs before being pulled high again.

4.6 Under-voltage Lockout

The device features an under-voltage lockout function that disables it when the input supply voltage is too low for proper operation.

4.7 Short Circuit Protection

4.7.1 Short Circuit During Operation

The device is protected against short circuit of VPOS and VNEG to ground and short circuit of these two outputs to each other. During normal operation, an error condition is detected if VPOS falls below 4.1V for longer than 3ms or VNEG is pulled above 85% of the programmed nominal output by 500mV for longer than 3ms. In either case the device goes into shutdown and the outputs are disconnected from the input. This state is latched, and to resume normal operation, VIN must cycle below the under-voltage lockout threshold, or CTRL must toggle LOW and then HIGH.

4.7.2 Short Circuit During Start-up

During start-up, an error condition is detected in the following cases:

- VPOS is not in regulation 10ms after CTRL goes HIGH.
- VNEG is higher than threshold level 10ms after CTRL goes HIGH.
- VNEG is not in regulation 20ms after CTRL goes HIGH.

If any of the above conditions is met the device goes into shutdown and the outputs are disconnected from the input. This state is latched, and to resume normal operation, VIN has to cycle below the undervoltage threshold, or CTRL has to toggle LOW and HIGH.

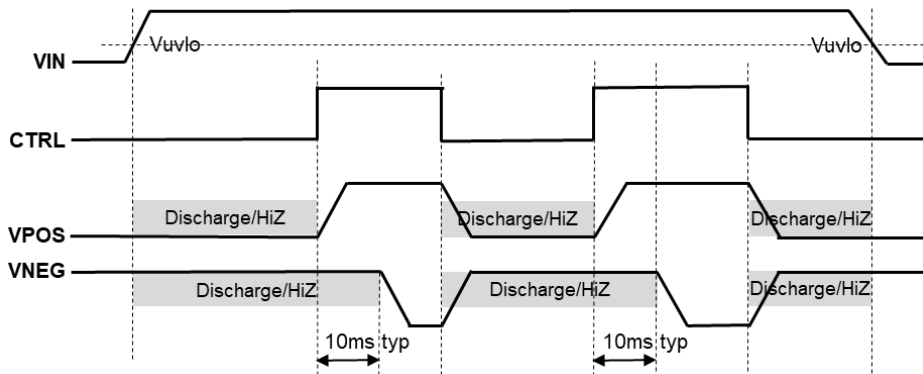
4.8 Output Discharge During Shut Down

The device outputs can be programmed for Discharge or HiZ during shutdown. Figure 6 shows the shutdown output control. Device is default programmed for Discharge during shutdown.

Table 8 Shutdown Output Programming by SWIRE

Pulse	Outputs
50	HiZ
51	Discharge

Figure 6 Output During Start-up and Shutdown



4.9 Device Functional Modes

4.9.1 Operation with $V_{IN} < 2.9V$

The recommended minimum input supply voltage for full performance is 2.9V. The device continues to operate with input supply voltages below 2.9V but full performance is not guaranteed. It does not operate with input supply voltages below the UVLO threshold.

4.9.2 Operation with $V_I \approx V_{POS}$ (Diode Mode)

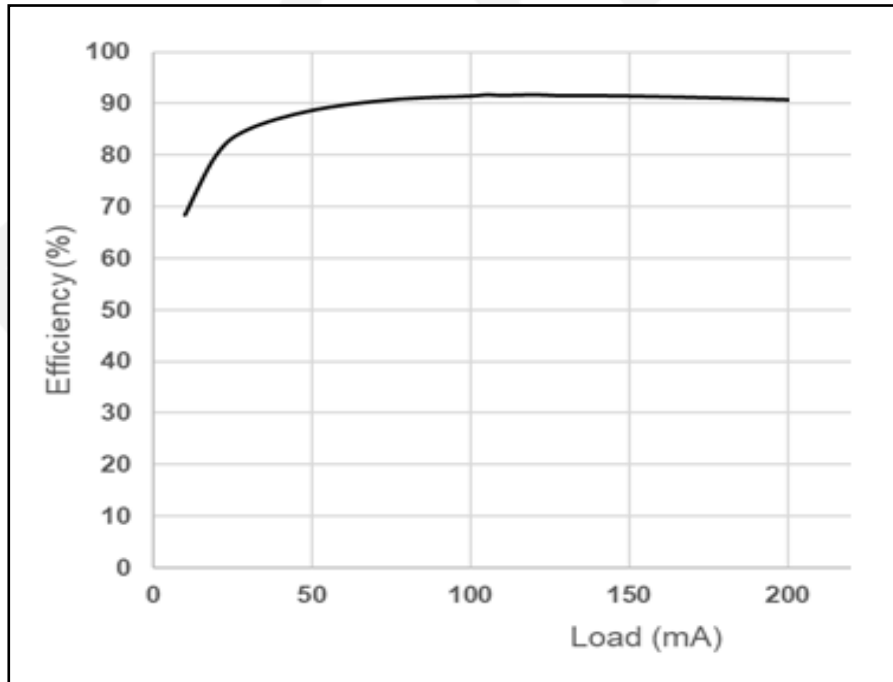
AXPM60631/3 features a "diode" mode that enables it to regulate its VPOS output even when the input supply voltage is close to VPOS (that is, too high for normal step-up operation). When operating in diode mode the VPOS boost converter's high-side switch is disabled and its body diode used as the rectifier. Note that a minimum load of $\approx 2mA$ is required to proper output regulation in diode mode.

4.9.3 Operation with CTRL

When a low-level signal is applied to the CTRL pin the device is disabled and switching is inhibited. When the input supply voltage is above the UVLO threshold and a high-level signal is applied to the CTRL pin the device is enabled and its start-up sequence begins.

4.10 Typical Performances

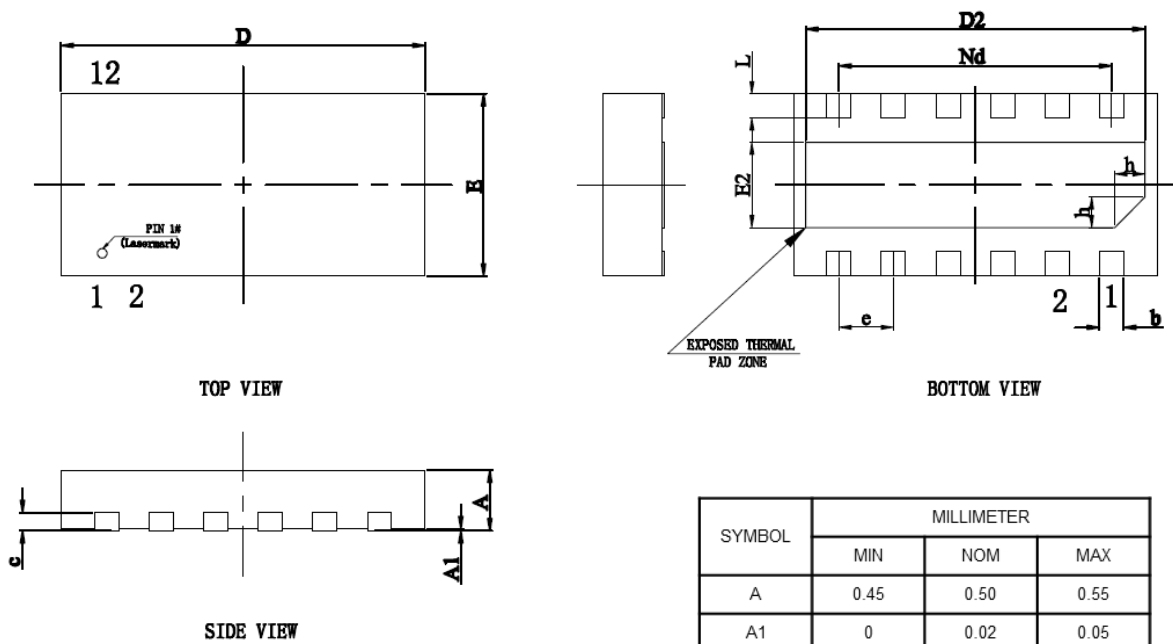
Figure 7 Efficiency vs Output Current (VPOS & VNEG)
($V_{IN} = 3.7V$, CTRL = 1, EN = 0)



5 Package Information

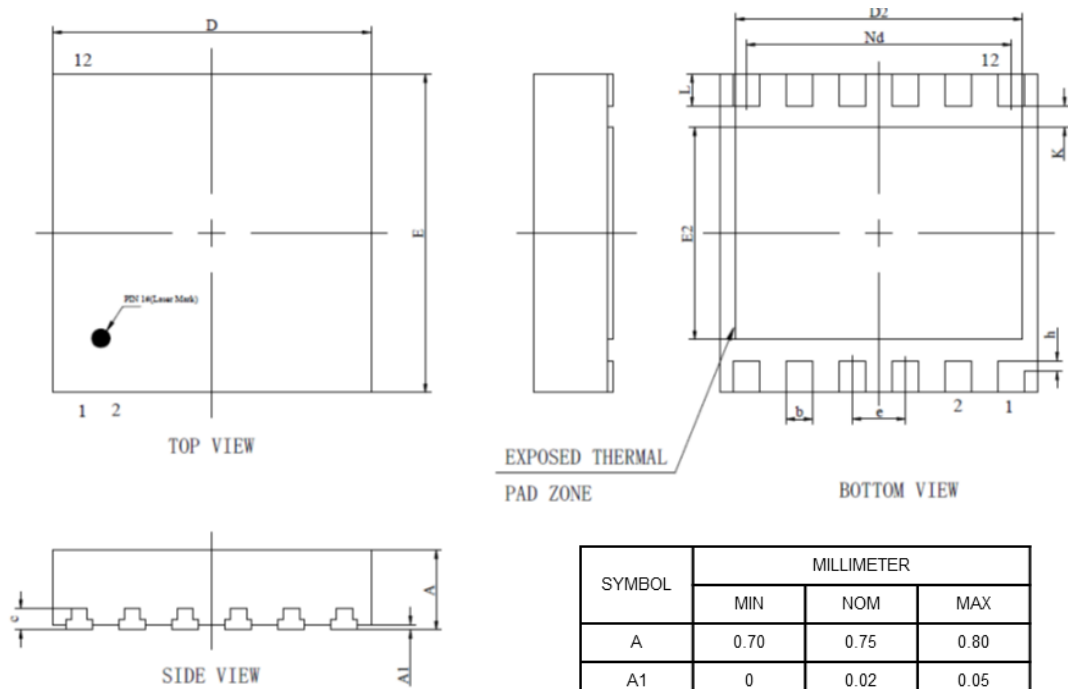
5.1 Package Outline dimensions

Figure 8 12-Pin DFN 3mm x 1.5mm x 0.5mm



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.45	0.50	0.55
A1	0	0.02	0.05
b	0.15	0.20	0.25
c	0.10	0.15	0.20
D	2.90	3.00	3.10
D2	2.75	2.80	2.85
e	0.45BSC		
Nd	2.25BSC		
E	1.40	1.50	1.60
E2	0.65	0.70	0.75
L	0.15	0.20	0.25
h	0.20	0.25	0.30

Figure 9 12-Pin DFN 3mm x 3mm x 0.75mm



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0	0.02	0.05
b	0.20	0.25	0.30
c	0.203REF		
D	2.90	3.00	3.10
D2	2.6	2.70	2.80
e	0.50BSC		
Nd	2.50BSC		
E	2.90	3.00	3.10
E2	1.90	2.00	2.10
L	0.224	0.30	0.376
h	0.10REF		
K	0.20REF		

5.2 Package Marking Information



6 Packing Information

7 Revision History

Table 9 Document Revision History

Date	Version	Description
Dec 2021	Draft	Preliminary version.