

AXPM60631

200mA Dual DC-DC Converter for Powering AMOLED Display



Datasheet – Aug 2022

Description

The AXPM60631 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 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)
- 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

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	DFN12L 2.4 × 1.5 × 0.5mm	Reel



DFN12L 2.4 × 1.5 × 0.5mm

Contents

Description.....	1
Features.....	1
Applications	1
1 Block Diagram and Application Circuit.....	4
2 Pin Description	5
2.1 Pin Names.....	5
2.2 Pin Functions.....	5
3. Electrical Specifications.....	6
3.1 Absolute Maximum Ratings	6
3.2 Thermal Data.....	6
3.3 ESD and Latch Up.....	6
3.4 Electrical Characteristics	7
4 Functional Description.....	9
4.1 Overview	9
4.2 Step-up Converter (VPOS)	9
4.3 Inverting Converter (VNEG).....	9
4.4 Soft Start and Start-up Sequence	10
4.5 CTRL.....	10
4.6 Under-voltage Lockout.....	11
4.7 Short Circuit Protection.....	11
4.8 Output Discharge During Shut Down	11
4.9 Device Functional Modes	12
4.10 Typical Performances.....	12
5 Package Information	14
5.1 Package Outline dimensions	14
5.2 Package Marking Information	15
6 Packing Information.....	16
7 Revision History	17

List of Figures

Figure 1 Block Diagram	4
Figure 2 Application Circuit	4
Figure 3 Pin Connection	5
Figure 4 SWIRE Digital Interface Using CTRL	9
Figure 5 Start-up Sequence	10
Figure 6 Output During Start-up and Shutdown	11
Figure 7 Efficiency vs Output Current (VPOS & VNEG)	12
Figure 8 Efficiency, L=1239AS-H-100M=P2 (muRata) 10μH, 1A, 460mΩ, 2.5x2.0x1.2mm	13
Figure 9 Efficiency, L=MPL2520S100MWT (Sunlord) 10μH, 0.8A, 300mΩ, 2.5x2.0x1.0mm	13
Figure 10 Efficiency, L=VLS252010HBX-4R7M (TDK), 4.7μH, 1.4A, 240mΩ, 2.5x2.0x1.0mm ...	13
Figure 11 DFN12L 2.4 × 1.5 × 0.5mm Mechanical Data and Package Dimensions.....	14
Figure 12 DFN12L 2.4 x 1.5 x 0.5 mm Marking Information	15
Figure 13 Reel Packing Information	16

List of Tables

Table 1 Device Summary	1
Table 2 Pin Functions	5
Table 3 Absolute Maximum Ratings	6
Table 4 Thermal Data	6
Table 5 ESD and Latch Up	6
Table 6 Electrical Characteristics	7
Table 7 VNEG Programming by SWIRE	10
Table 8 Shutdown Output Programming by SWIRE	11
Table 9 Document Revision History	17

1 Block Diagram and Application Circuit

Figure 1 Block Diagram

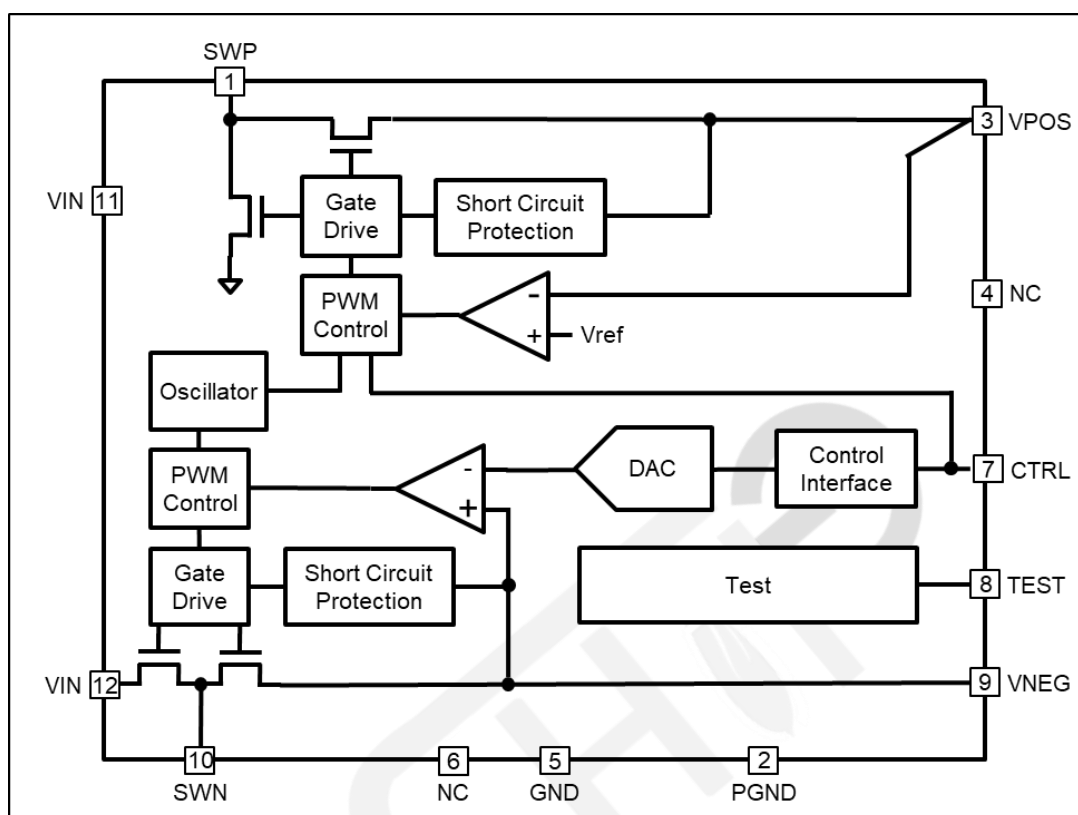
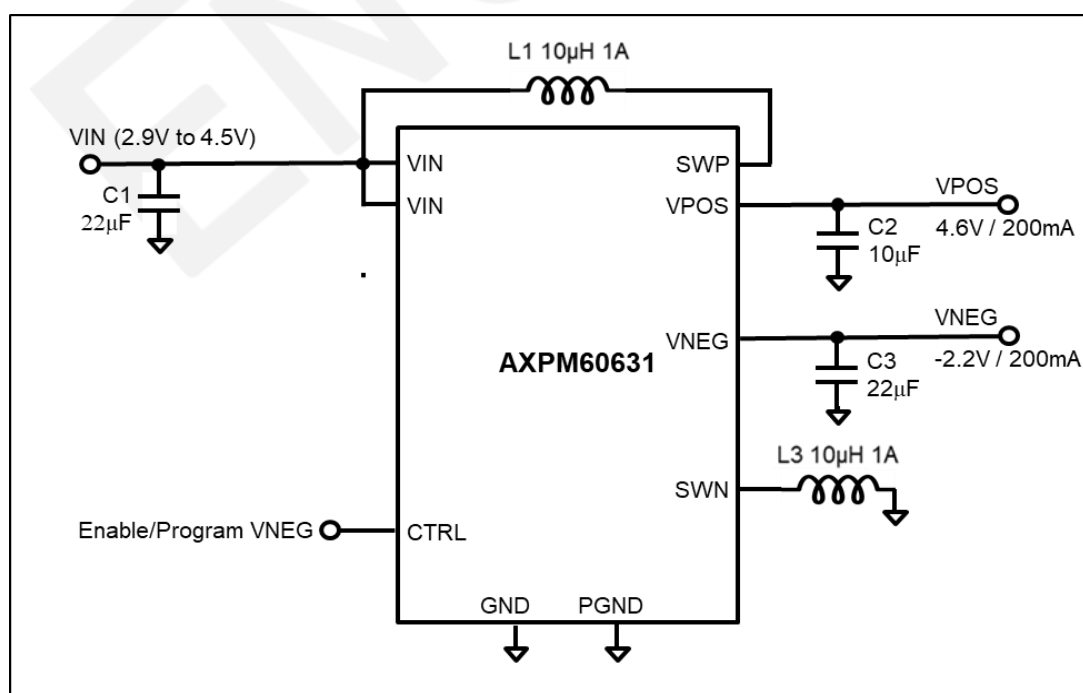


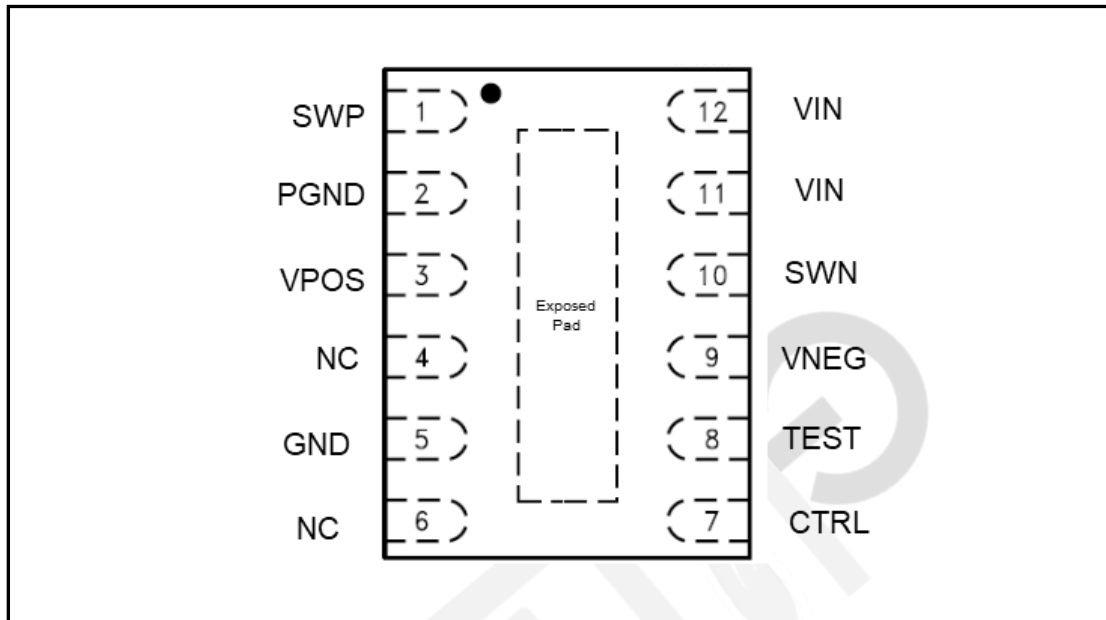
Figure 2 Application Circuit



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	VPOS	Step-up converter (VPOS) output
4	NC	Reserved Pin. Not to be connected
5	GND	Ground for the device
6	NC	Reserved Pin. Not to be connected
7	CTRL	Step-up converter (VPOS) and VNEG enable/program pin
8	TEST	Reserved for Device Testing. Not to be connected
9	VNEG	Inverting converter output (VNEG)
10	SWN	Inverting converter switch pin
11	VIN	Supply Voltage for the device
12	VIN	Supply voltage for the power stage
EPAD		Connect this pad to GND, PGND

3. Electrical Specifications

3.1 Absolute Maximum Ratings

Table 3 Absolute Maximum Ratings

Symbol	Parameter	Value	Unit
SWP, VPOS, VIN	DC supply voltage, output voltage.	-0.3 to +5.5	V
VNEG	Output voltage	-6.0 to +0.3	V
SWN	Switching node voltage	-6.5 to +4.8	V
TEST, CTRL,	Input logic voltage, analog input.	-0.3 to +5.5	V
Tj	Junction temperature	150	°C
Tstg	Storage temperature	-55 to +150	°C

3.2 Thermal Data

Table 4 Thermal Data

Symbol	Parameter	Value	Unit
Rth j-amb	Thermal resistance junction-ambient referred to the FR-4 PCB	48.8	°C/W
Rth 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 T_A = 25°C (unless otherwise noted).

Table 6 Electrical Characteristics

Symbol	Parameter	Test condition	Min	Typ	Max	Unit
General						
V _{IN}	Supply input voltage		2.9	3.7	4.5	V
Temp	Operating temperature		-40	25	85	°C
I _{SD}	Shutdown current	CTRL=GND			1	μA
V _{UVLO}	Under-voltage lockout threshold	V _{IN} Falling		2.1		V
		V _{IN} Rising		2.3		V
Logic Signals (CTRL)						
V _H	High Threshold	V _{IN} =2.9 to 4.5V	1.2			V
V _L	Low Threshold				0.4	V
R _{DOWN}	Pull-down resistance			300		kΩ
Step-up Converter (VPOS)						
VPOS	Positive output voltage			4.6		V
	Positive output voltage variation	25°C≤T _A ≤ 85°C No load	-0.5		+0.5	%
		-30°C≤T _A ≤ 85°C No load	-0.8		+0.8	%
	Line regulation	I _{VPOS} =200mA		0.01		%/V
	Load regulation	1 mA≤ I _{VPOS} ≤200 mA		0.1		%/A
R _{DS(on)1A}	Switch on-resistance	I _{SWP1} =200mA		200		mΩ
R _{DS(on)1B}	Rectifier on-resistance			350		mΩ
f _{SW1}	Switching frequency	I _{VPOS} =200mA		1.5		MHz
I _{SW1}	Switch current limit	Inductor peak current		0.6		A
I _{O1MAX}	Maximum output current	V _{IN} =2.9V to 4.5V	200			mA
V _{SCP1}	Short circuit threshold in operation	VPOS falling		85% of VPOS		
t _{SCP1}	Short circuit detection time in operation			3		ms
R _{DCHG1}	Discharge resistance	CTRL=GND I _{SWP1} =1mA		30		Ω
Inverting Converter (VNEG)						
VNEG	Output voltage default			-2.2		V
	Output voltage range		-1.4		-4.4	V
	Output voltage accuracy	25°C≤T _A ≤ 85°C No load	-50		+50	mV
		-30°C≤T _A ≤ 85°C No load	-60		+60	mV
	Line regulation	I _{VNEG} =200mA		0.01		%/V
	Load regulation			0.1		%/A
R _{DS(on)2A}	SWN mosfet on-resistance	I _{SWN} =200mA		200		mΩ
R _{DS(on)2B}	SWN mosfet rectifier on-resistance			300		mΩ
f _{SW2}	SWN Switching frequency	I _{VNEG} =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 VNEG		85% of VNEG		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 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. 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.

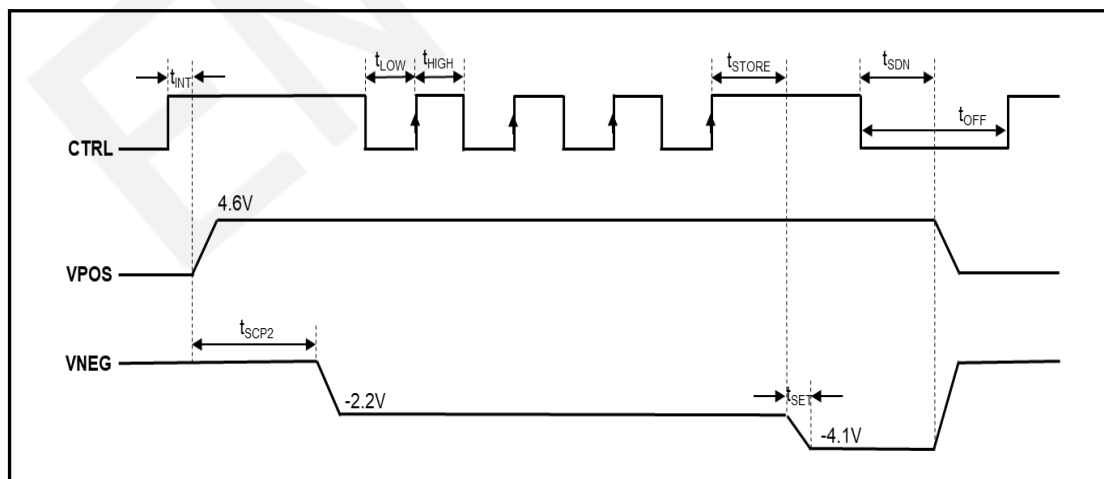
4.3 Inverting Converter (VNEG)

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.

Figure 4 SWIRE Digital Interface Using CTRL



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

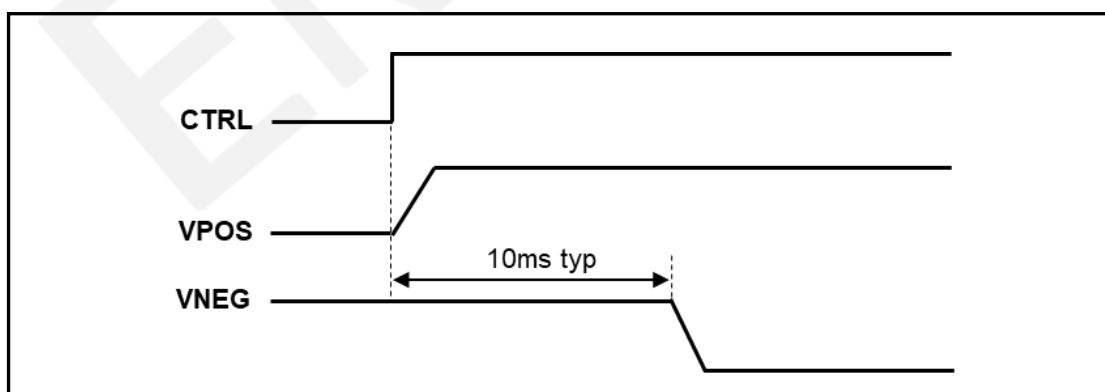
4.3.2 VNEG Transition Time

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, typical 300 μ s.

4.4 Soft Start and Start-up Sequence

AXPM60631 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 200µs 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.

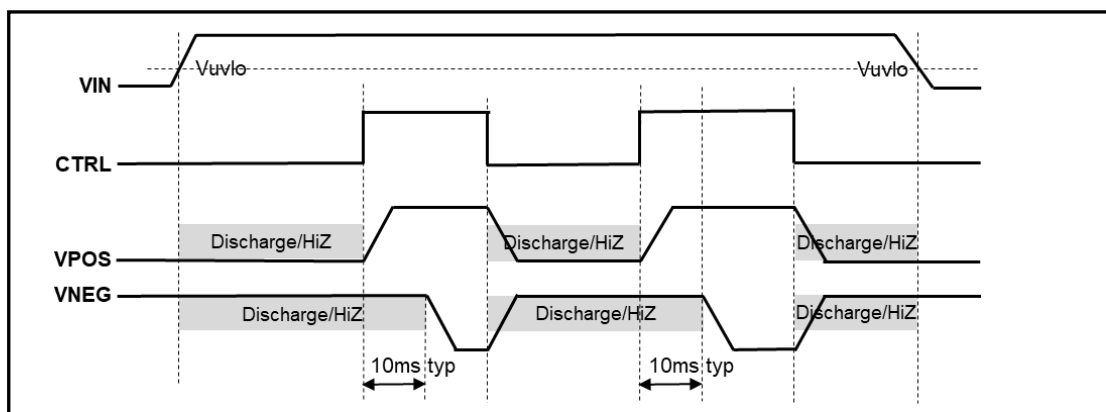
4.8 Output Discharge During Shut Down

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 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 have 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)

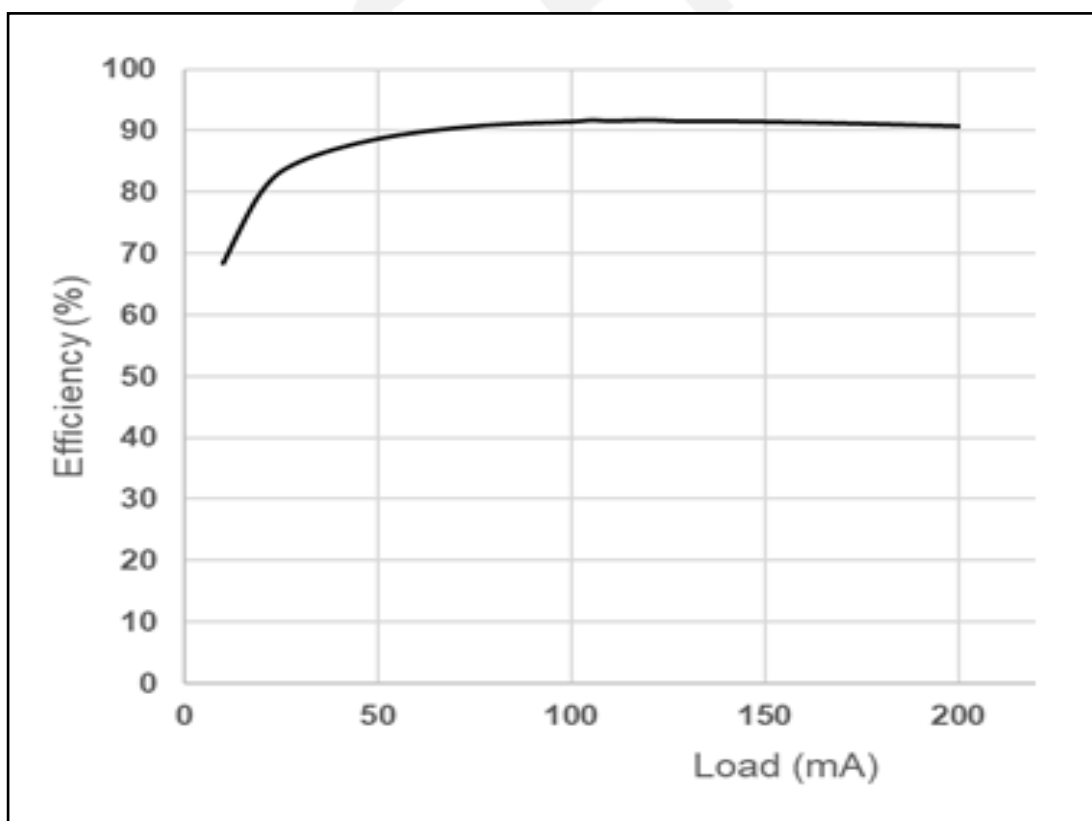


Figure 8 Efficiency, L=1239AS-H-100M=P2 (muRata) 10μH, 1A, 460mΩ, 2.5x2.0x1.2mm

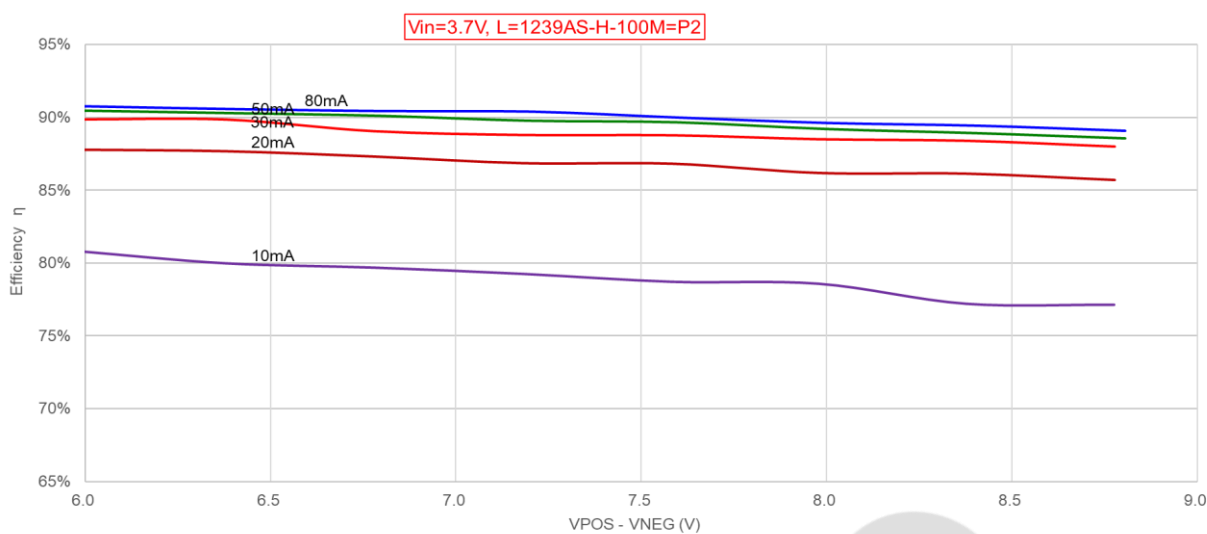


Figure 9 Efficiency, L=MPL2520S100MWT (Sunlord) 10μH, 0.8A, 300mΩ, 2.5x2.0x1.0mm

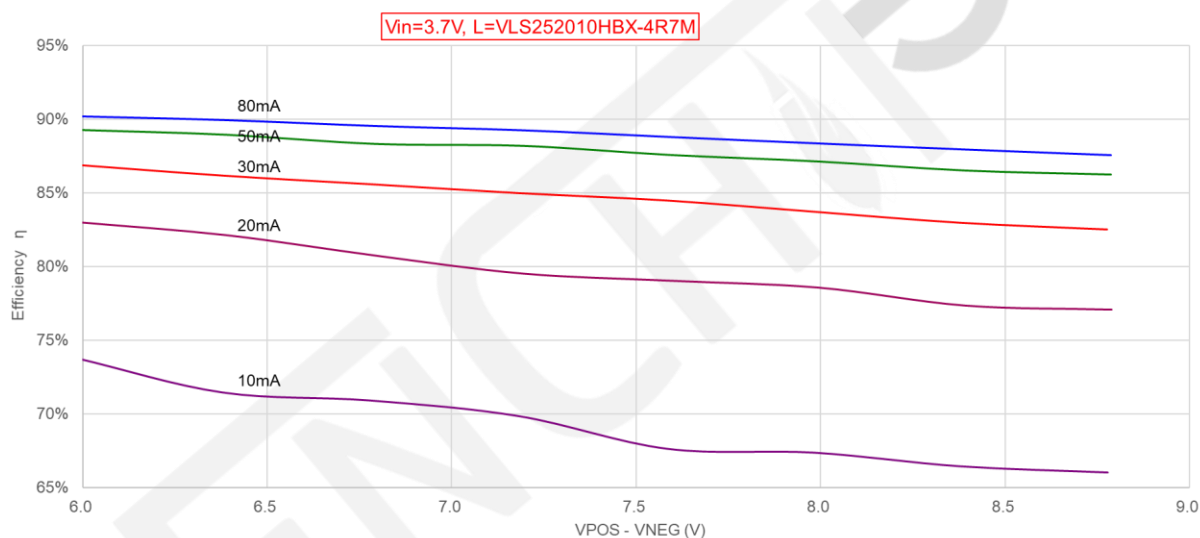
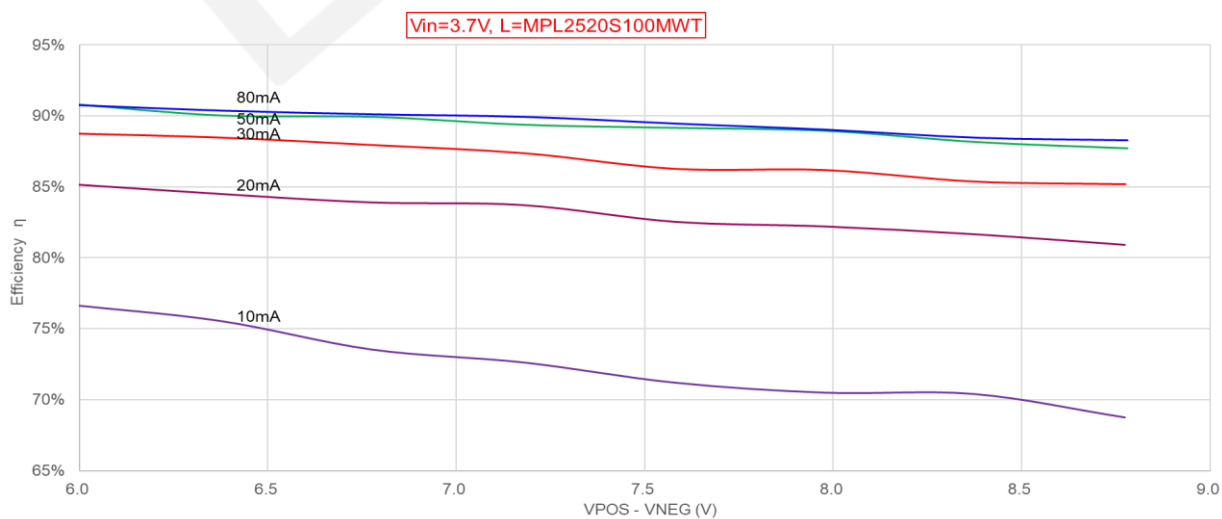


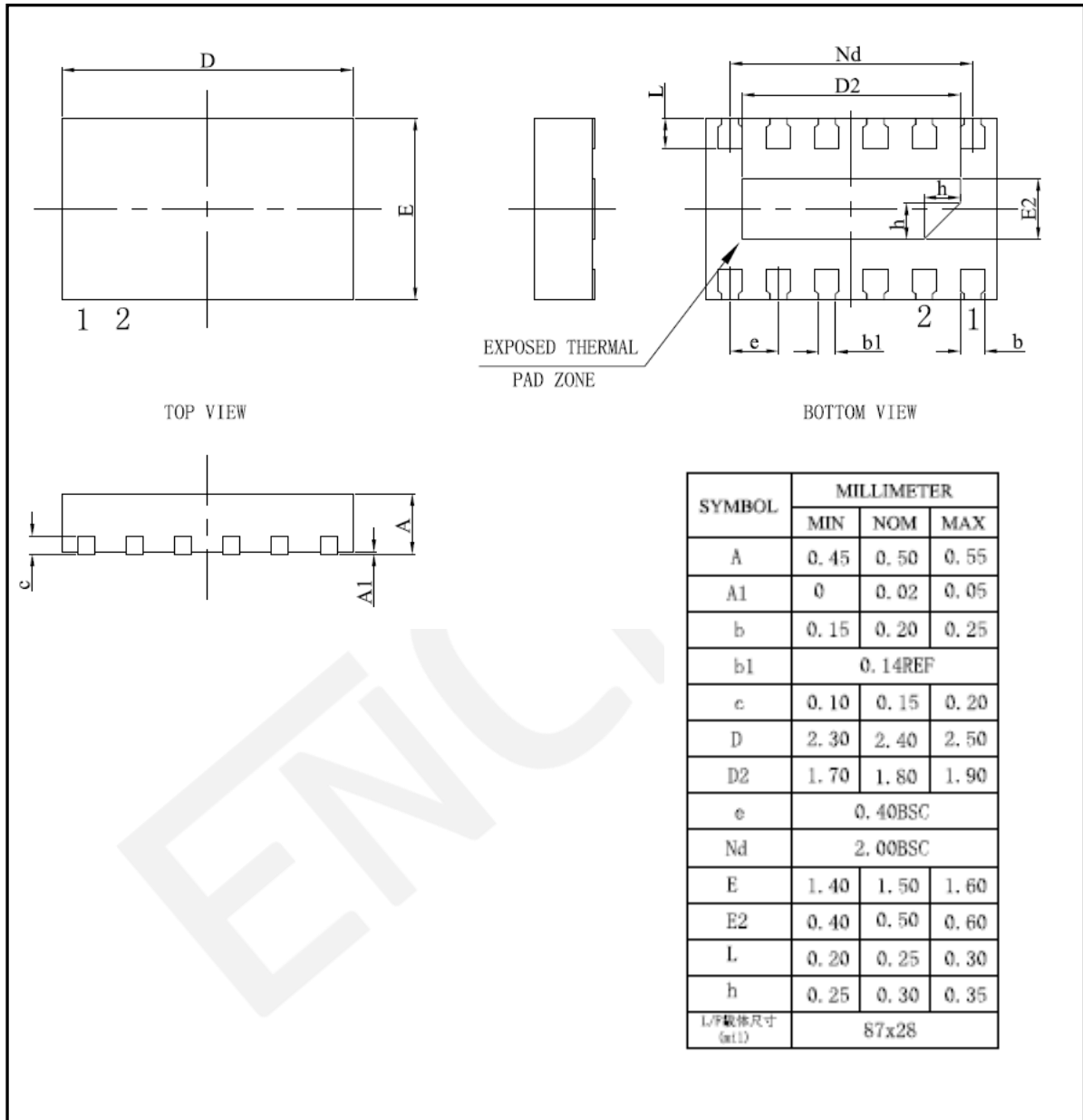
Figure 10 Efficiency, L=VLS252010HBX-4R7M (TDK), 4.7μH, 1.4A, 240mΩ, 2.5x2.0x1.0mm



5 Package Information

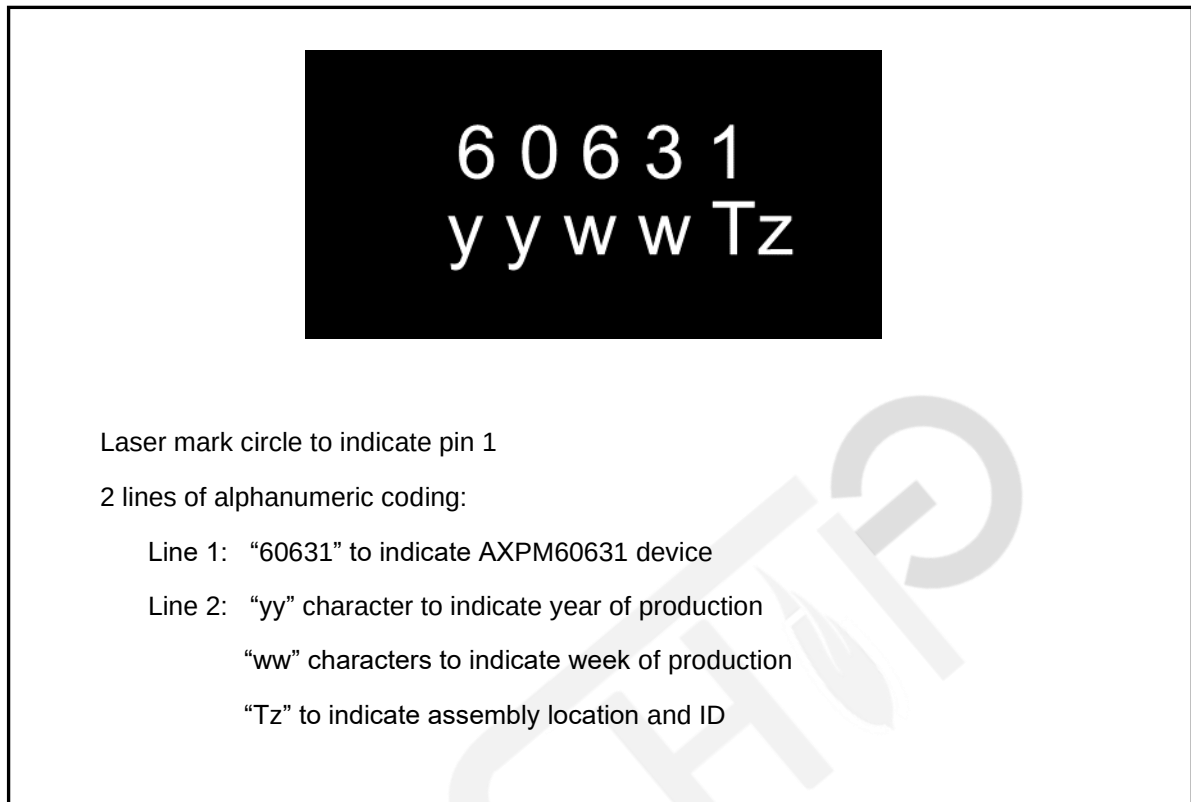
5.1 Package Outline dimensions

Figure 11 DFN12L 2.4 × 1.5 × 0.5mm Mechanical Data and Package Dimensions



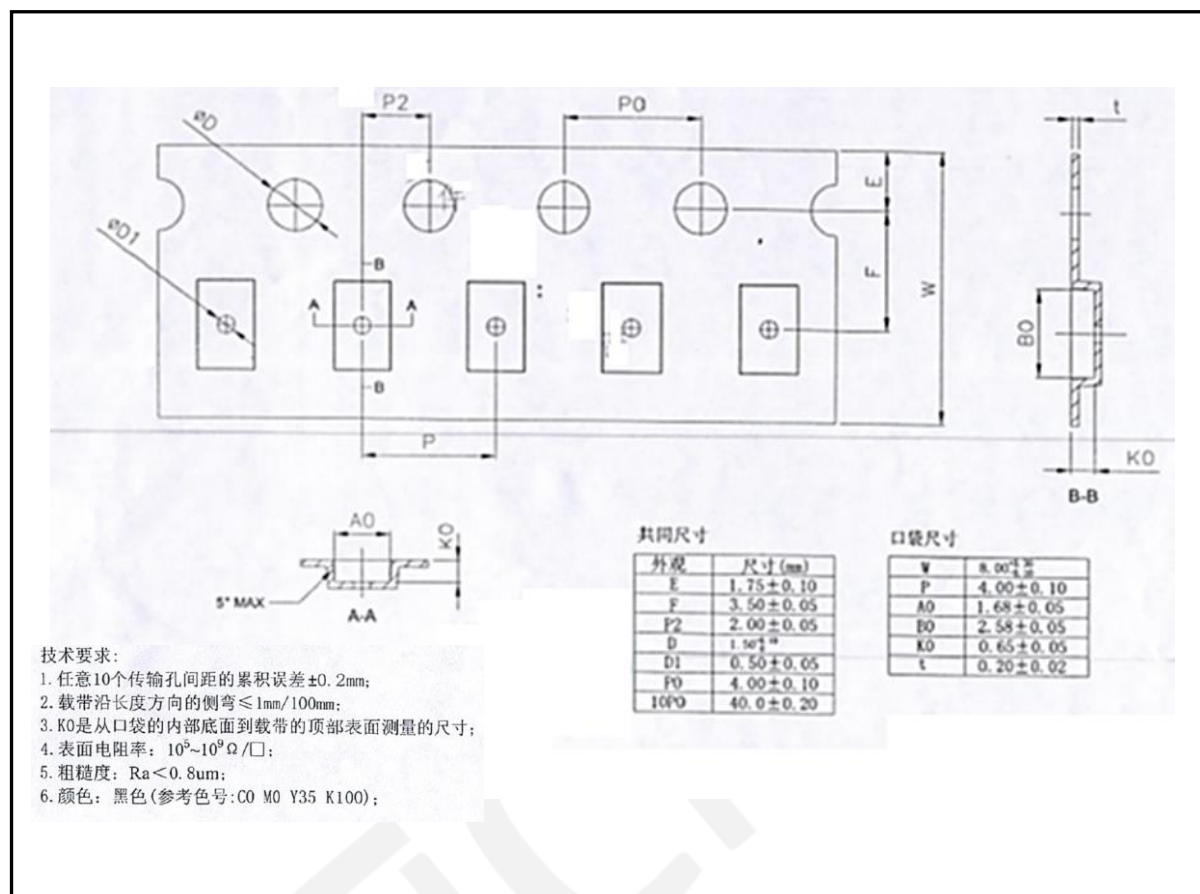
5.2 Package Marking Information

Figure 12 DFN12L 2.4 x 1.5 x 0.5 mm Marking Information



6 Packing Information

Figure 13 Reel Packing Information



7 Revision History

Table 9 Document Revision History

Date	Version	Description
Feb 2022	1.0	First Version
Jun 2022	1.01	Application Diagram showing inductor rating as 10μH 1A
Aug 2022	1.10	Added Efficiency diagrams vs Inductor types