5.5 V, 2 A, 1 MHz High-Efficiency, 15 μA I_Q Constant On-Time Synchronous, Step-Down Converter

Features

- Low $R_{DS(ON)}$ for internal switches (top / bottom) 100 mΩ / 80 mΩ, 2.0 A
- 2.5 V ~ 5.5 V input voltage range
- 15 μA typical quiescent current
- High switching frequency 1 MHz minimizes the external components
- 100% dropout operation
- Output discharge function
- Power-good output
- Fixed frequency COT architecture achieve ultra fast transient response
- Internal soft start limits the inrush current
- Operating temperature range: -40°C to 85°C

Applications

- Portable navigation devices
- Set top boxes
- USB dongle
- Media players
- Smart phones

Package Information

Part Number	Package	Body Size
DIO60120	SOT23-5	1.6 mm × 2.9 mm
	SOT23-6	1.6 mm × 2.9 mm
	DFN2*2-8	2 mm × 2 mm
	DFN3*3-10	3 mm × 3 mm
	SOIC-8	3.9 mm × 4.9 mm

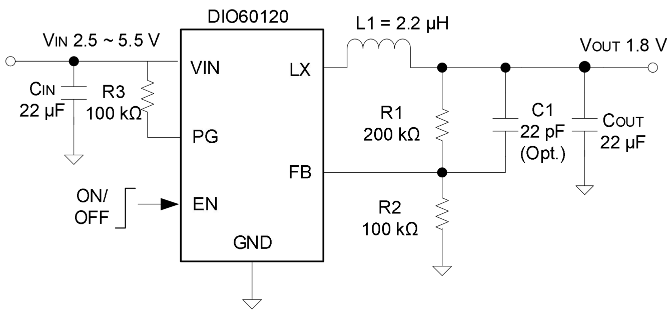
Description

The DIO60120 is high-efficiency synchronous step-down DC-DC regulator. The DIO60120 can achieve up to 2 A continuous output current from a 2.5 V to 5.5 V input voltage with excellent load and line regulation. The output voltage can be regulated to as low as 0.6 V.

Constant-on-time control provides a fast transient response and eases loop stabilization. The DIO60120 includes an automatically entered power save mode to maintain high efficiency down to very light loads for extending the system battery run-time.

The DIO60120 is ideal for a wide range of applications, including portable navigation devices, set top boxes and media players.

Simplified Schematic



Ordering Information

Ordering Part No.	Top Marking	MSL	RoHS	T_A	Package	
DIO60120ST5	F1VYW	3	Green	-40 to 85°C	SOT23-5	Tape & Reel, 3000
DIO60120ST6	WF1V	3	Green	-40 to 85°C	SOT23-6	Tape & Reel, 3000
DIO60120CN8	FA2V	3	Green	-40 to 85°C	DFN2*2-8	Tape & Reel, 3000
DIO60120CD10	FVA2V	3	Green	-40 to 85°C	DFN3*3-10	Tape & Reel, 5000
DIO60120CS8	DIOFA2V	3	Green	-40 to 85°C	SOIC-8	Tape & Reel, 2500

If you encounter any issue in the process of using the device, please contact our customer service at marketing@dioo.com or phone us at (+86)-21-62116882. If you have any improvement suggestions regarding the datasheet, we encourage you to contact our technical writing team at docs@dioo.com. Your feedback is invaluable for us to provide a better user experience.

Table of Contents

List of Figures

1. Pin Assignment and Functions

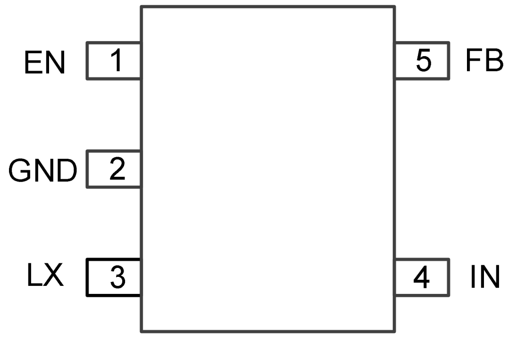


Figure 1. SOT23-5 (Top view)

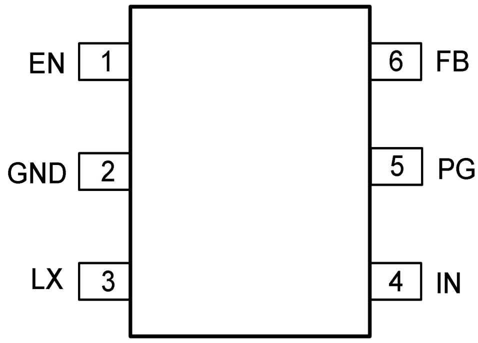


Figure 2. SOT23-6 (Top view)

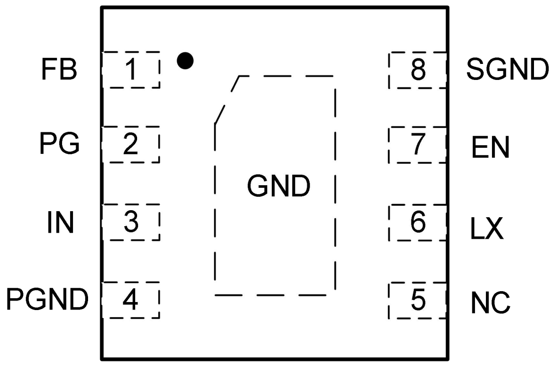


*Figure 3. DFN2*2-8 (Top view)*

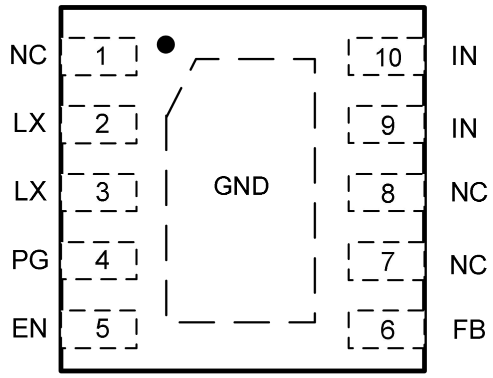


*Figure 4. DFN3*3-10 (Top view)*

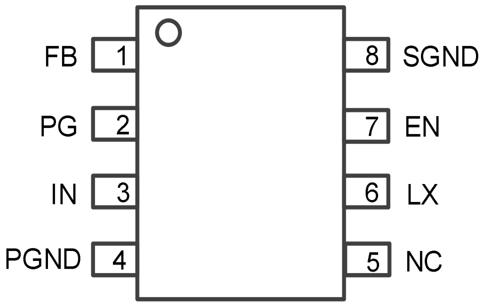


Figure 5. SOIC-8 (Top view)

Pin Name	I/O	Description
EN	I	Enable control. Pull high to turn on. Do not float.
Thermal pad (GND)	G	Internally connect to GND. Recommend to connect to a large ground plane for the improved thermal performance.
LX	I/O	Inductor pin. Connect this pin to the switching node of inductor.
VIN	I	Power input.
FB	O	Output feedback pin. Connect this pin to the center point of the output resistor divider to program the output voltage: $V_{OUT} = 0.6 \times (1 + R1/R2)$. Add optional C1 (22 pF ~ 47 pF) to speed up the transient response.
PG	O	Power good indicator. When the output voltage exceeds 95% of regulation point, it becomes open drain; low otherwise.
PGND	G	Power ground. Must connect this pin to the system ground on the board.
SGND	G	Signal ground. Must connect this pin to the system ground on the board.

2. Absolute Maximum Ratings

Exceeding the maximum ratings listed under Absolute Maximum Ratings when designing is likely to damage the device permanently. Do not design to the maximum limits because long-time exposure to them might impact the device's reliability. The ratings are obtained over an operating free-air temperature range unless otherwise specified.

Symbol	Parameter	Rating	Unit
V_{CC}	Supply voltage (V+ ~ V-)	-0.3 ~ 6.5	V
	Enable / FB voltage	-0.3 to V_{IN} + 0.2	V
P_D	Power dissipation at T_A = 25°C, SOT23-5	0.6	W
T_{STG}	Storage temperature range	-65 ~ 150	°C
T_J	Maximum junction temperature	150	°C
T_L	Maximum lead temperature r	260	°C
	Dynamic LX voltage in 50 ns duration	GND - 4 to V_{IN} + 3	V

3. Recommended Operating Conditions

Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. The ratings are obtained over an operating free-air temperature range unless otherwise specified.

Symbol	Parameter	Rating	Unit
V_{CC}	Supply voltage (V+ ~ V-)	2.5 ~ 5.5	V
T_J	Junction temperature range	-40 ~ 125	°C
T_A	Ambient temperature range	-40 ~ 85	°C

4. ESD Ratings

When a statically-charged person or object touches an electrostatic discharge sensitive device, the electrostatic charge might be drained through sensitive circuitry in the device. If the electrostatic discharge possesses sufficient energy, damage might occur to the device due to localized overheating.

Model	Condition	Value	Unit
HBM	JEDEC:JS-001	±4000	V
CDM	JEDEC:JS-002	±2000	V

5. Electrical Characteristics

The values are obtained under these conditions unless otherwise specified: V_{IN} = 5 V, V_{OUT} = 1.8 V, L1 = 2.2 μH, C_{OUT} = 22 μF, T_A = 25°C.

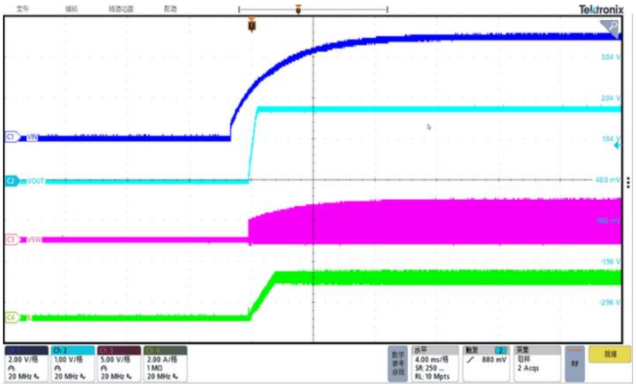
Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{IN}	Input voltage range		2.5		5.5	V
I_Q	Quiescent current	I_{OUT} = 0, FB = 0.65 V		15		μA
I_{SHDN}	Shutdown current	EN = 0		0.1	1	μA
V_{REF}	Feedback reference voltage		0.588	0.6	0.612	V
$R_{DS(ON)}$,P	PFET R_{ON}	I_{OUT} = 100 mA		100		mΩ
$R_{DS(ON)}$,N	NFET R_{ON}	I_{OUT} = 100 mA		80		mΩ
I_{LIM}	PFET current limit		2.7			A
V_{ENH}	EN rising threshold		1			V
V_{ENL}	EN falling threshold				0.4	V
V_{UVLO}	Input undervoltage lockout threshold			2.15	2.3	V
V_{HYS}	undervoltage lockout hysteresis			0.15		V
f_{OSC}	Oscillator frequency	I_{OUT} = 500 mA		1		MHz
V_{PG,UV_R}	Undervoltage PG rising threshold	Referenced to V_{FB} nominal		95		%
V_{PG,UV_F}	Undervoltage PG falling threshold			90		%
V_{PG,OV_R}	Overvoltage PG rising threshold			105		%
V_{PG,OV_F}	Overvoltage PG falling threshold			110		%
	Min ON time			80		ns
	Max duty cycle		100			%
t_{SS}	Soft-start time	V_{OUT} rise from 10% to 90%		0.55		ms
EN_{R-}	Pull-down resistor			1		MΩ
R_{dis}	Output discharge resistor	V_{EN} = 0 V, V_{OUT} = 1.2 V		1		kΩ
T_{SD}	Thermal shutdown temperature			150		°C
T_{HYS}	Thermal shutdown hysteresis			20		°C

Note:

(1) Specifications subject to change without notice.

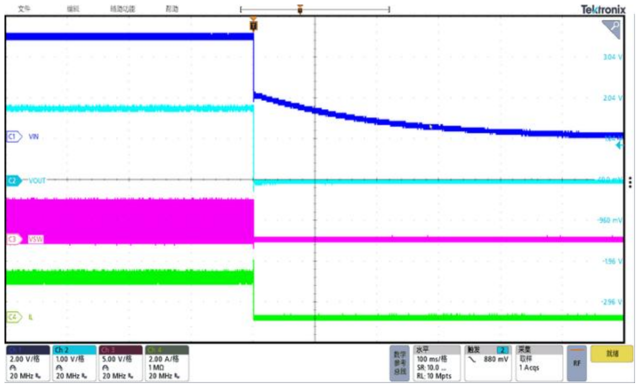
6. Typical Performance Characteristics

V_{IN} = 5 V, V_{OUT} = 1.8 V, L1 = 2.2 μH, C_{OUT} = 22 μF, T_A = 25°C, unless otherwise specified.



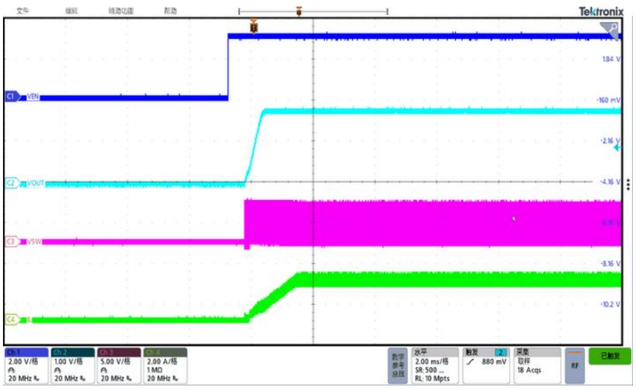
V_{IN} = 5 V, V_{OUT} = 1.8 V with 2 A load

Figure 6. V_{IN} start



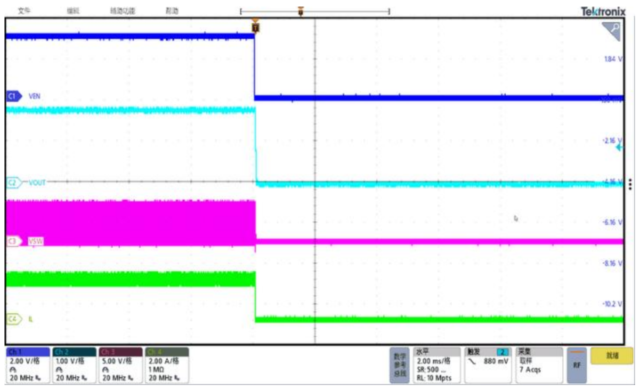
V_{IN} = 5 V, V_{OUT} = 1.8 V with 2 A load

Figure 7. V_{IN} drop



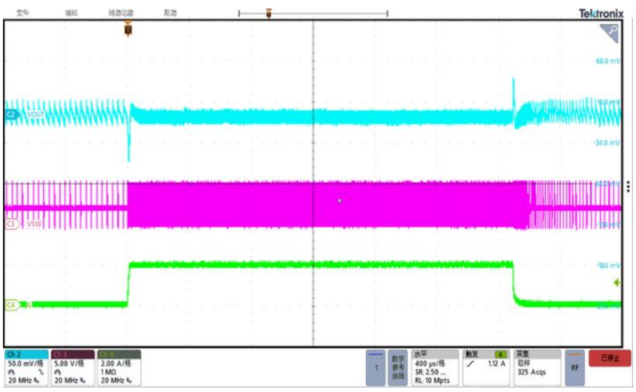
V_{IN} = 5 V, V_{OUT} = 1.8 V with 2 A load

Figure 8. V_{EN} start



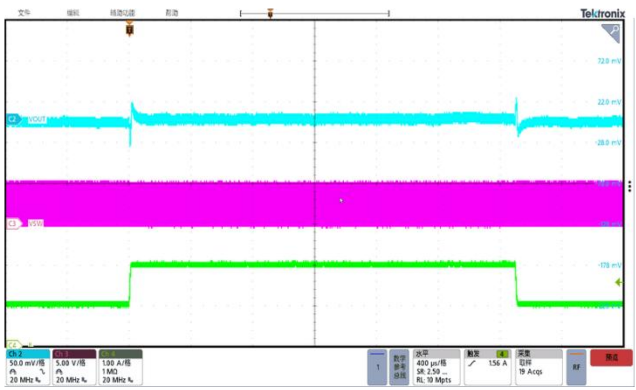
V_{IN} = 5 V, V_{OUT} = 1.8 V with 2 A load

Figure 9. V_{EN} drop



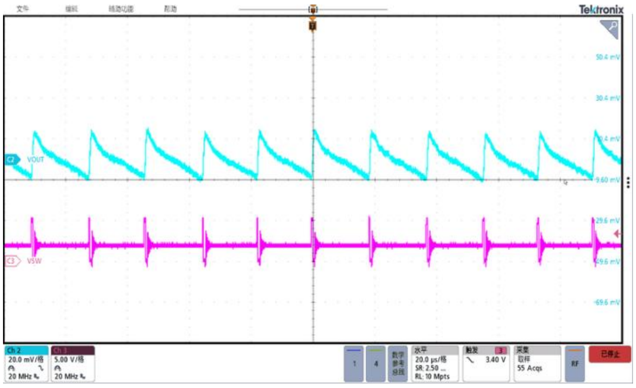
V_{IN} = 5 V, V_{OUT} = 1.8 V, 0.001A ~ 2 A

Figure 10. Load transient



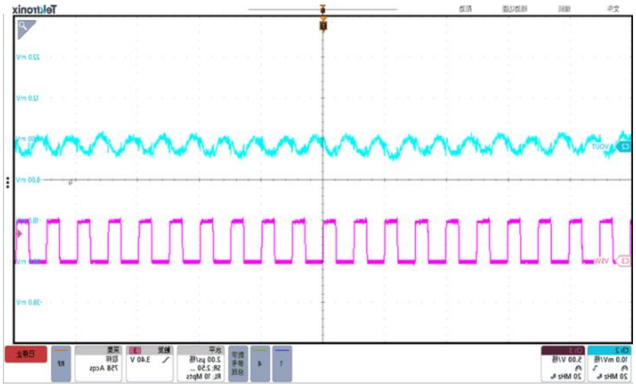
V_{IN} = 5 V, V_{OUT} = 1.8 V, 1 A ~ 2 A

Figure 11. Load transient



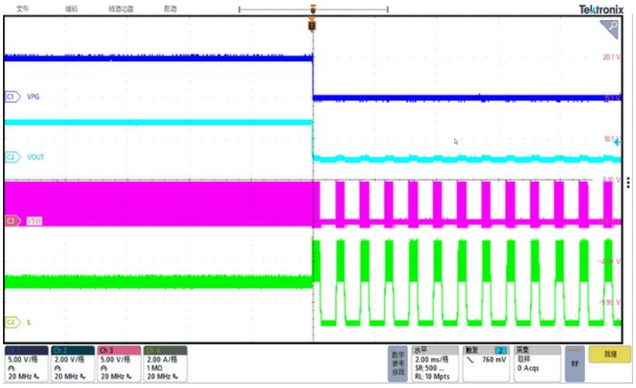
V_{IN} = 5 V, V_{OUT} = 1.8 V with 20 mA load

Figure 12. Ripple



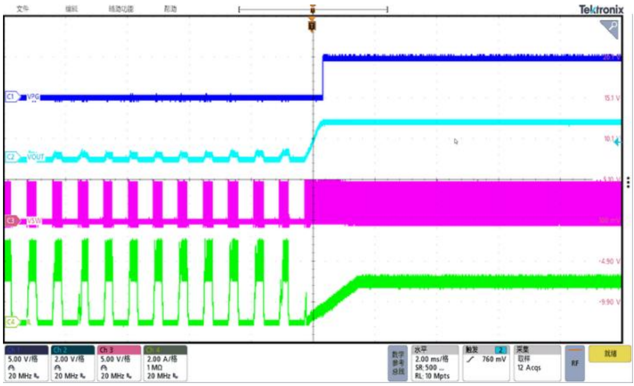
V_{IN} = 5 V, V_{OUT} = 1.8 V with 2 A load

Figure 13. Ripple



V_{IN} = 5 V, V_{OUT} = 1.8 V, 2 A load --> short

Figure 14. Short circuit protection



V_{IN} = 5 V, V_{OUT} = 1.8 V, short --> 2 A load

Figure 15. Short circuit recovery

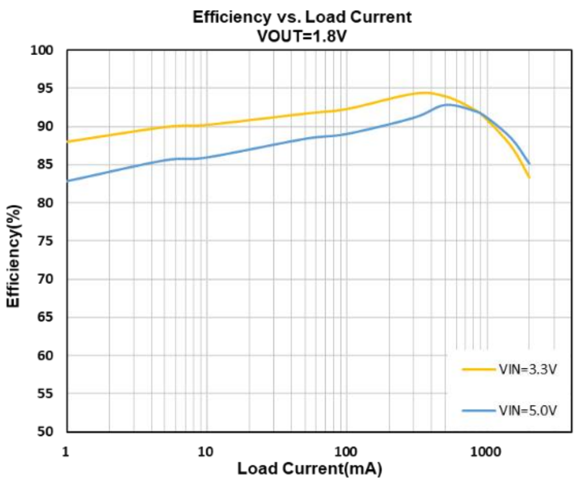
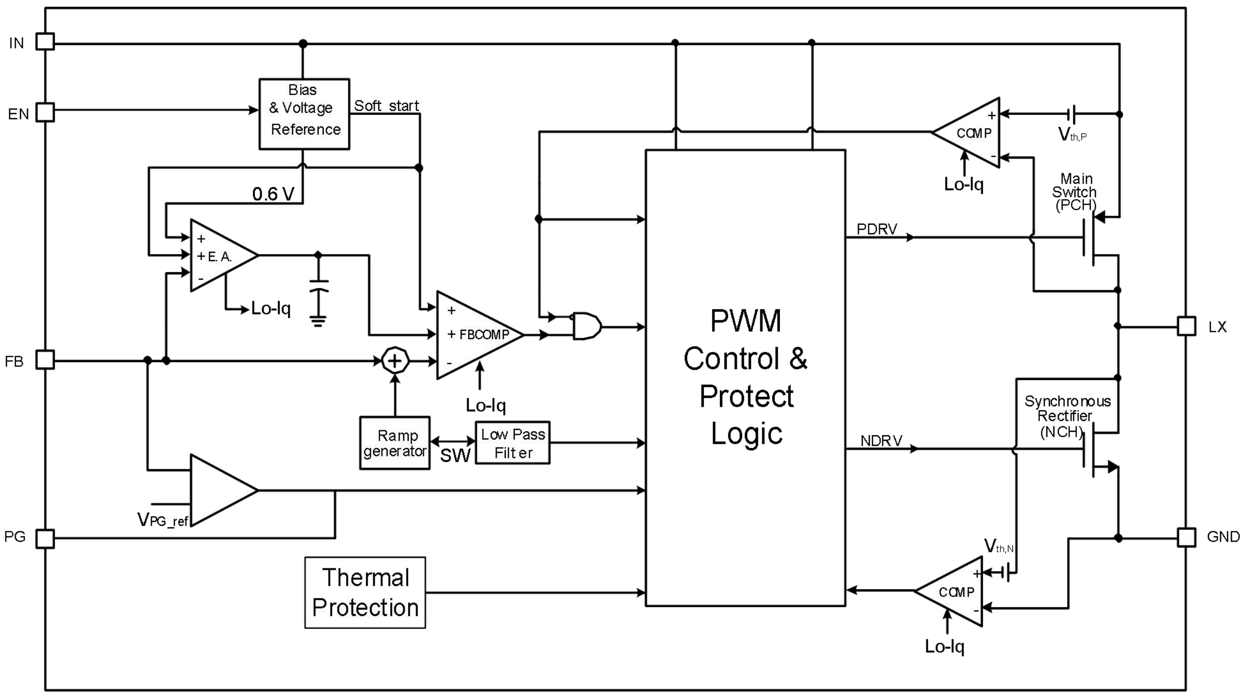


Figure 16. Efficiency vs. Load current

7. Block Diagram



8. Application Information

Important notice: Validation and testing are the most reliable ways to confirm system functionality. The application information is not part of the specification and is for reference purposes only.

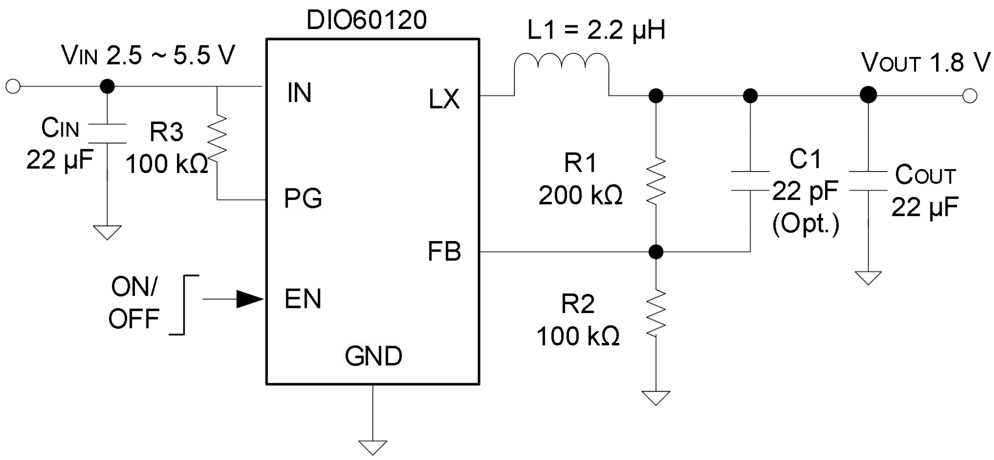


Figure 17. Typical application

The DIO60120 is a synchronous buck regulator IC that integrates the adaptive constant on-time (COT) control, and top and bottom switches on the same die to minimize the switching transition loss and conduction loss. With ultra-low $R_{DS(ON)}$ power switches and proprietary COT control, this regulator IC can achieve the highest efficiency and the highest switch frequency simultaneously to minimize the external inductor and capacitor size, thus achieving the minimum solution footprint. Under PWM mode, the converter operates with a typical 1 MHz switching frequency to minimize the size of the inductor and capacitor. As the load current decreases, the converter enters PSM (Power Save Mode), reducing the switching frequency to keep high efficiency over the entire load current range.

Under Auto Mode, the DIO60120 enters PWM mode for medium to heavy load conditions or enters PSM (Power Save Mode) for a light load.

Because of the high integration in the DIO60120 IC, the application circuit based on this regulator IC is rather simple. Only the input capacitor, C_{IN}, output capacitor, C_{OUT}, output inductor, L1, feedback capacitor, C_1, and feedback resistors (R1 and R2) need to be selected for the targeted application specifications.

8.1. Enable

When disabled, the device shutdown supply current is only 0.1 µA. When applying a voltage greater than the EN logic high threshold, the DIO60120 enables all functions and the device initiates the soft-start phase. The DIO60120 has a built-in 0.55 ms soft-start time to prevent output voltage overshoot and inrush current. When the EN voltage falls below its logic low threshold, the device operation is disabled and the 1 kΩ active discharge is enabled to discharge the output voltage to ground.

8.2. Power-good (PG) indicator

The PG pin of DIO60120 is actively held low during the soft-start period until the output voltage reaches 95% of its target value. When the output voltage is outside of its regulation by +20% or -10%, PG pulls low until the output returns within 5% of its set value.

8.3. Undervoltage lockout

Undervoltage lockout protects the IC from insufficient input voltages. The DIO60120 is disabled if the input voltage falls below 2.15 V (typ). In this UVLO event, both the high-side and low-side power MOSFETs turn off.

8.4. Thermal shutdown

If the junction temperature of the device reaches the thermal shutdown limit of 150°C, the DIO60120 shuts down both high-side and low-side power MOSFETs. When the junction temperature reduces to the required level (130°C typ), the device initiates a normal power-up cycle with soft-start.

8.5. Switch current limit and short-circuit protection

The protection function prevents the device from drawing excessive current in case of externally-caused overcurrent or short-circuit conditions. If the current limit threshold is reached, the device delivers its maximum output current. Detecting this condition for 32 switching cycles, the device turns off the high-side MOSFET for about 500 μs and then restarts again with a soft-start cycle. As long as the overload condition is present, the device hiccups that way, limiting the output power.

8.6. Feedback resistor dividers R1 and R2

Choose R1 and R2 to program the proper output voltage. To minimize the power consumption under light loads, choose large resistance values for both R1 and R2. It is recommended that the resistance value of R1 is below 30 kΩ, then R2 can be calculated from Equation (1).

$$R_2 = \frac{0.6V}{V_{OUT} - 0.6V} \times R_1 \quad (1)$$

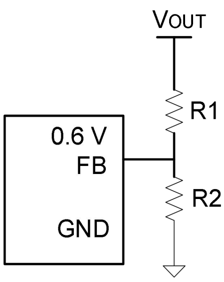


Figure 18. Feedback resistor dividers R1 and R2

8.7. Input capacitor C_{IN}

With the maximum load current at 2 A, the maximum ripple current through the input capacitor is about 1 A. A typical X7R or better grade ceramic capacitor with 6 V rating and greater than 10 μF capacitance can handle this ripple current well. To minimize the potential noise problem, place this ceramic capacitor really close to the IN and GND pins. Carefully minimize the loop area formed by C_{IN}, and IN/GND pins.

8.8. Output capacitor C_{OUT}

The output capacitor is selected to handle the output ripple noise requirements. Both steady-state ripple and transient requirements must be taken into consideration when selecting this capacitor. For the best performance, use X5R or a better grade ceramic capacitor with 6 V rating and greater than 10 μF capacitance.

8.9. Output inductor L1

There are several considerations in choosing this inductor.

(1) Choose the inductance to provide the desired ripple current. Choose the ripple current to be approximately 40% of the maximum output current. The inductance is calculated from Equation (2).

$$L1 = \frac{V_{OUT} \times (1 - V_{OUT}/V_{IN,MAX})}{f_{SW} \times I_{OUT,MAX} \times 40\%} \quad (2)$$

where f_{SW} is the switching frequency and $I_{OUT,MAX}$ is the maximum load current. The DIO60120 regulator IC is quite tolerant of different ripple current amplitudes. Consequently, the final choice of inductance can be slightly off the calculation value without significantly impacting the performance.

(2) The saturation current rating of the inductor must be greater than the peak inductor current under full load conditions.

$$I_{SAT,MIN} > I_{OUT,MAX} + \frac{V_{OUT} \times (1 - V_{OUT}/V_{IN,MAX})}{2 \times f_{SW} \times L1} \quad (3)$$

(3) The DC resistance (DCR) of the inductor and the core loss at the switching frequency must be low enough to achieve the desired efficiency requirement. Choose an inductor with a DCR lower than 50 mΩ to achieve a good overall efficiency.

8.10. Load transient considerations

The DIO60120 regulator IC integrates the compensation components to achieve good stability and fast transient responses. In some applications, recommend using a 22 pF ceramic capacitor in parallel with R1 may further speed up the load transient responses and is thus recommended for applications with large load transient step requirements.

9. Layout Design

The layout design of the DIO60120 regulator is relatively simple. For the best efficiency and minimum noise problems, place four components close to the IC: C_{IN}, L1, R1, and R2.

(1) Maximize the PCB copper area connected to the GND pin to achieve the best thermal and noise performance. If the board space allows, a ground plane is highly desirable.

(2) Place C_{IN} close to pins IN and GND. Minimize the loop area formed by C_{IN} and GND.

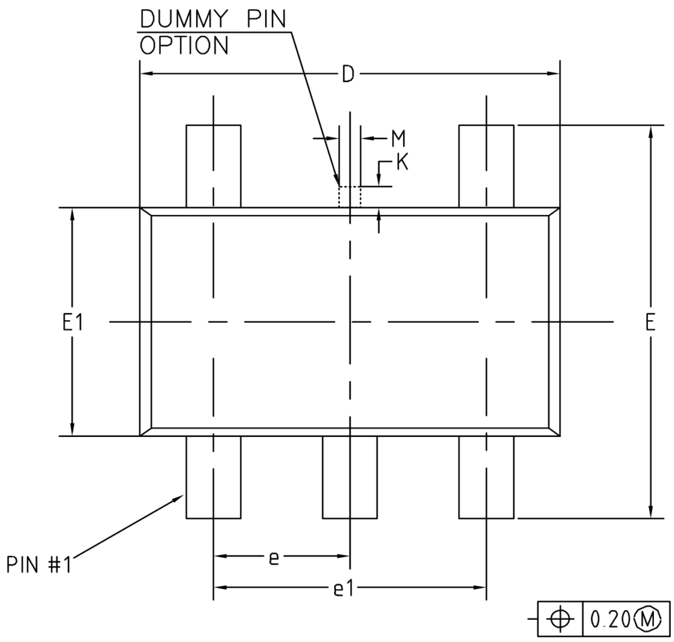
(3) Minimize the PCB copper area associated with LX pin to avoid the potential noise problem.

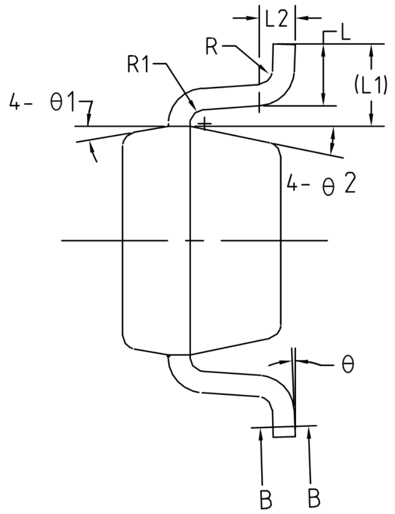
(4) Avoid placing the components R1 and R2 and the trace connected to the FB pin adjacent to the LX net on the PCB layout to prevent the noise problem.

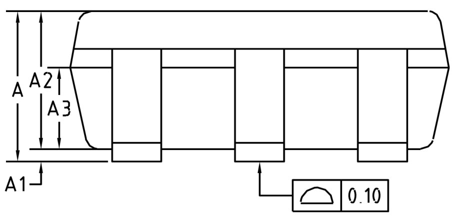
(5) If the system chip interfaced with the EN pin has a high impedance state at shutdown mode and the IN pin is connected directly to a power source such as a Li-Ion battery, it is desirable to add a pull-down 1 MΩ resistor between the EN and GND pins to prevent the noise from falsely turning on the regulator at shutdown mode.

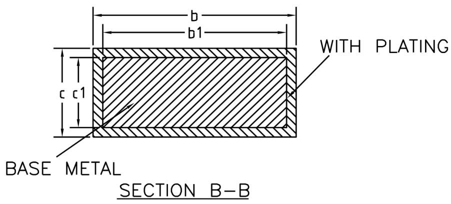
10. Physical Dimensions

10.1. SOT23-5



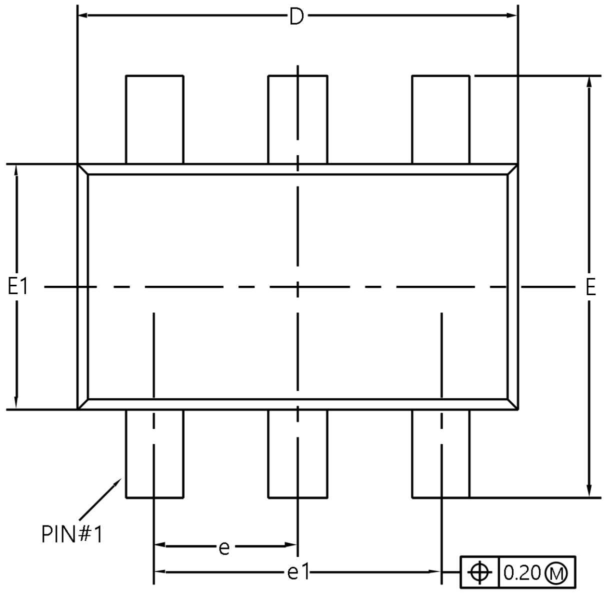


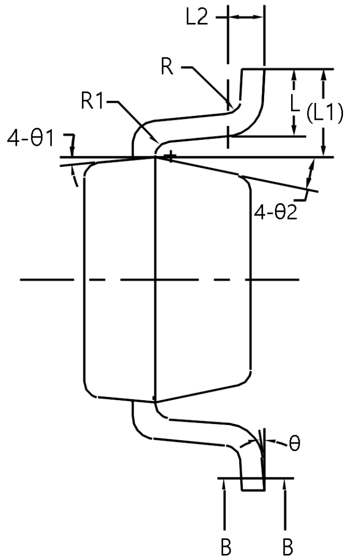


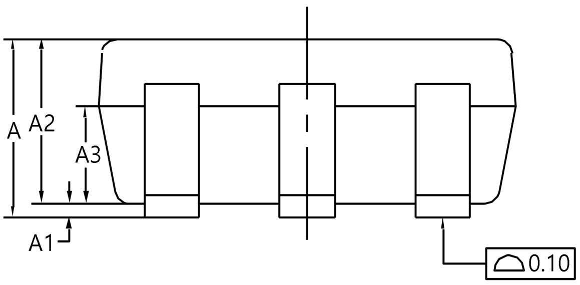


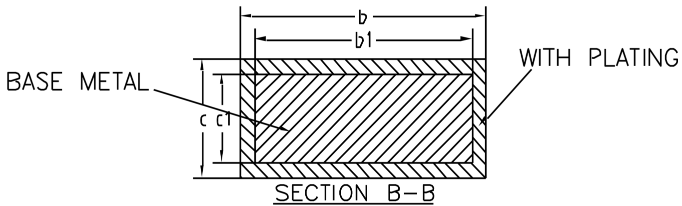
Common Dimensions (Units of measure = Millimeter)			
Symbol	Min	Nom	Max
A	-	-	1.25
A1	0	-	0.15
A2	1.00	1.10	1.20
A3	0.60	0.65	0.70
b	0.36	-	0.45
b1	0.35	0.38	0.41
c	0.14	-	0.20
c1	0.14	0.15	0.16
D	2.826	2.926	3.026
E	2.60	2.80	3.00
E1	1.526	1.626	1.726
e	0.90	0.95	1.00
e 1	1.80	1.90	2.00
K	0	-	0.25
L	0.30	0.40	0.60
L1	0.59 REF		
L2	0.25 BSC		
M	0.10	0.15	0.25
R	0.05	-	0.20
R1	0.05	-	0.20
θ	0°	-	8°
θ1	8°	10°	12°
θ2	10°	12°	14°

10.2. SOT23-6



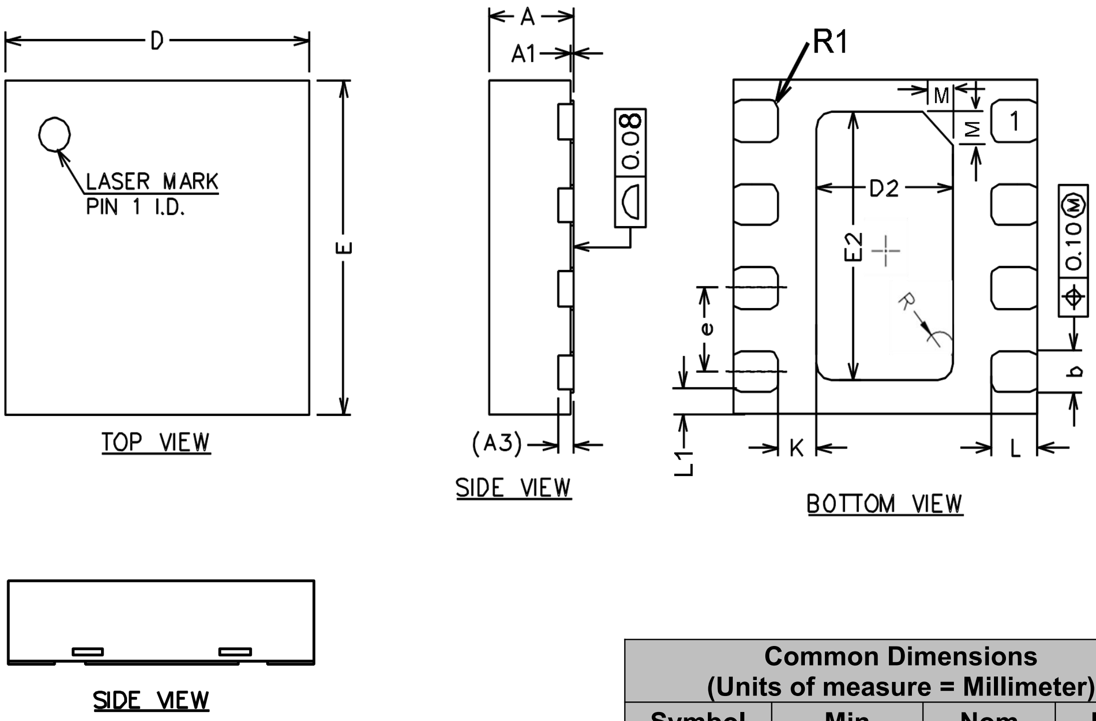






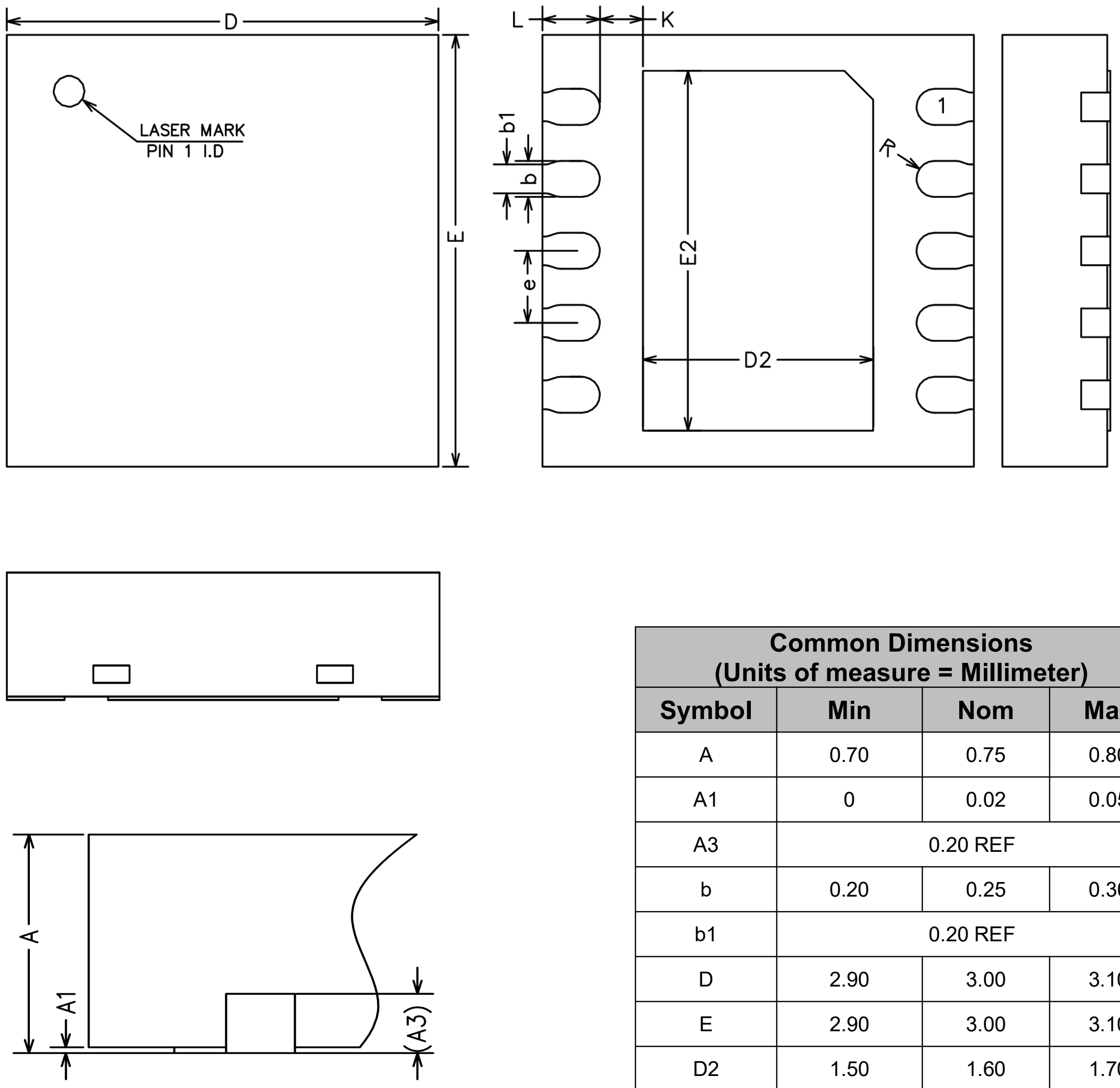
Common Dimensions (Units of measure = Millimeter)			
Symbol	Min	Nom	Max
A	-	-	1.25
A1	0	-	0.15
A2	1.00	1.10	1.20
A3	0.60	0.65	0.70
b	0.34	-	0.45
b1	0.34	0.38	0.41
c	0.12	-	0.20
c1	0.12	0.15	0.16
D	2.826	2.926	3.026
E	2.60	2.80	3.00
E1	1.526	1.626	1.700
e	0.90	0.95	1.00
e1	1.80	1.90	2.00
L	0.30	0.40	0.60
L1		0.59 REF	
L2		0.25 BSC	
R	0.05	-	0.20
R1	0.05	-	0.20
θ	0°	-	8°
θ1	8°	10°	12°
θ2	10°	12°	14°

10.3. DFN2*2-8



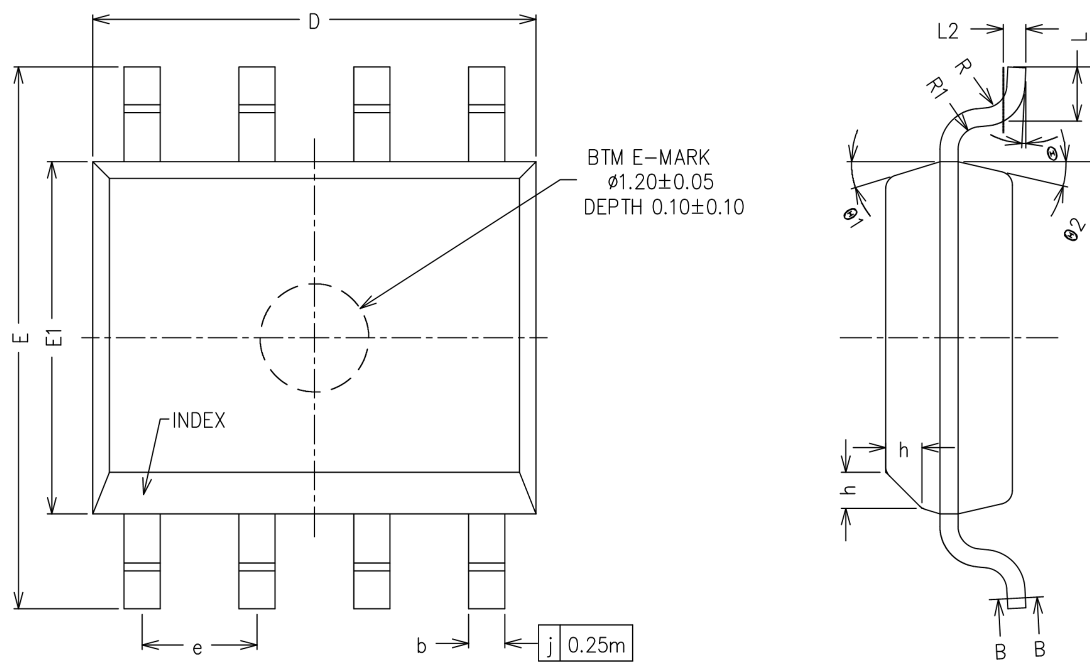
Common Dimensions (Units of measure = Millimeter)			
Symbol	Min	Nom	Max
A	0.50	0.55	0.60
A1	0.00	0.02	0.05
A3	0.127 REF		
b	0.20	0.25	0.30
D	1.95	2.00	2.05
E	1.95	2.00	2.05
D2	0.80	0.90	1.00
E2	1.50	1.60	1.70
e	0.45	0.50	0.55
K	0.15	0.25	0.35
L	0.25	0.30	0.35
L1	0.075	0.125	0.175
M	0.20 REF		
R	0.10 REF		
R1	0.05 REF		

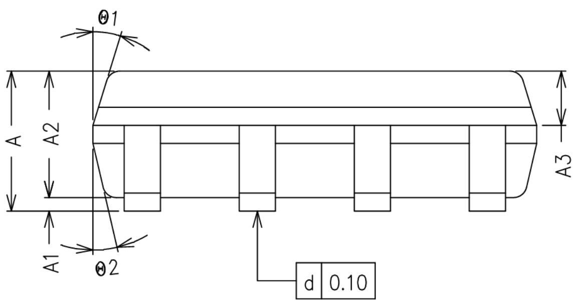
10.4. DFN3*3-10

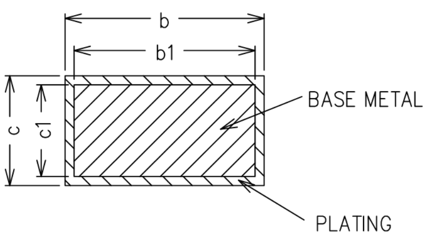


Common Dimensions (Units of measure = Millimeter)			
Symbol	Min	Nom	Max
A	0.70	0.75	0.80
A1	0	0.02	0.05
A3	0.20 REF		
b	0.20	0.25	0.30
b1	0.20 REF		
D	2.90	3.00	3.10
E	2.90	3.00	3.10
D2	1.50	1.60	1.70
E2	2.40	2.50	2.60
e	0.40	0.50	0.60
K	0.20	-	-
L	0.30	0.40	0.50
R	0.13	-	-

10.5. SOIC-8







Common Dimensions (Units of measure = Millimeter)			
Symbol	**Min**	**Nom**	**Max**
A	1.35	1.55	1.75
A1	0.10	-	0.25
A2	1.30	1.40	1.50
A3	0.50	0.60	0.70
b	0.38	-	0.47
b1	0.37	0.40	0.43
c	0.17	-	0.25
c1	0.17	0.20	0.23
D	4.80	4.90	5.00
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e	1.17	1.27	1.37
L	0.45	0.60	0.80
L1	1.04 REF		
L2	0.25 BSC		
R	0.07	-	-
R1	0.07	-	-
h	0.30	0.40	0.50
θ	0°	-	8°
θ1	15°	17°	19°
θ2	11°	13°	15°

Disclaimer

This specification and information contained herein are provided on an “AS IS” basis and WITH ALL FAULTS. All product specifications, statements, information, and data (collectively, the“Information”) in this datasheet or made available on the website of www.dioo.com are subject to change without notice. The customer is responsible for checking and verifying the extent to which the Information contained in this publication is applicable to his/her application. All Information given herein is believed to be accurate and reliable, but it is presented without guarantee, warranty, or responsibility of any kind, express or implied.

