

## High Efficiency, 1MHz, 4A Synchronous Step Down Regulator

### General Description

The SY8884A is a high efficiency 1MHz synchronous step down DC/DC regulator, which is capable of delivering up to 4A output current. It can operate over a wide input voltage range from 2.5V to 5.5V and integrate main switch and synchronous switch with very low  $R_{DS(ON)}$  to minimize the conduction loss.

The low output voltage ripple, the small external inductor and the capacitor sizes are achieved with 1MHz switching frequency.

### Ordering Information

SY8884 □(□□)□  
 □ Temperature Code  
 □ Package Code  
 □ Optional Spec Code

Ordering Number	Package type	Note
SY8884ADFC	DFN2×2-8	--

### Features

- 2.5V to 5.5V Input Voltage Range
- 55μA Low Quiescent Current
- Low  $R_{DS(ON)}$  for Internal Switches (Top/Bottom): 85mΩ /60mΩ
- High Switching Frequency 1MHz Minimizes the External Components
- Internal Soft-start Limits the Inrush Current
- 100% Dropout Operation
- Power Good Indicator
- Hic-cup for Short Circuit Protection
- Output Auto Discharge Function
- RoHS Compliant and Halogen Free
- Compact Package: DFN2×2-8

### Applications

- Set Top Box
- USB Dongle
- Media Player
- Smart Phone

### Typical Application

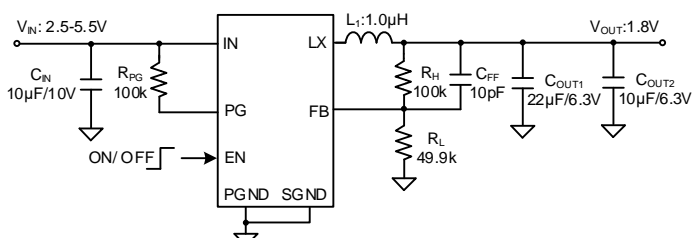


Figure1. Typical Application Circuit

Inductor and C<sub>OUT</sub> Selection Table

V <sub>OUT</sub> [V]	L [μH]	C <sub>OUT</sub> [μF]			
		10	22	32	44
1.2	1.0		✓	✓	☆
	1.5			✓	✓
1.8	1.0		✓	☆	✓
	1.5		✓	✓	✓
3.3	1.0		✓	☆	✓
	1.5		✓	✓	✓

Note: '☆' means recommended for most applications.

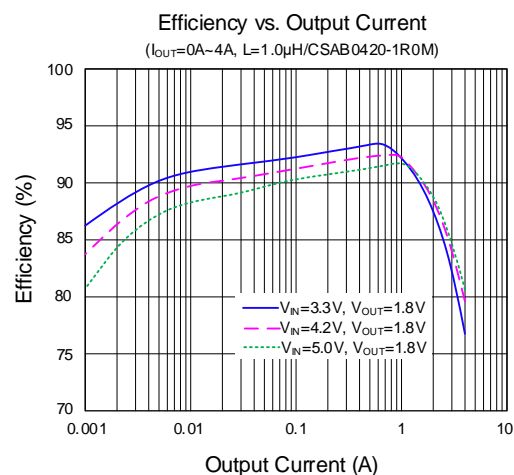
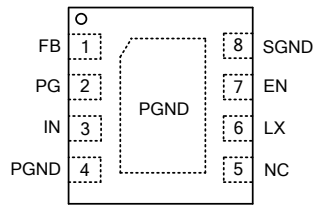


Figure2. Efficiency vs. Output Current

## Pin out (Top View)

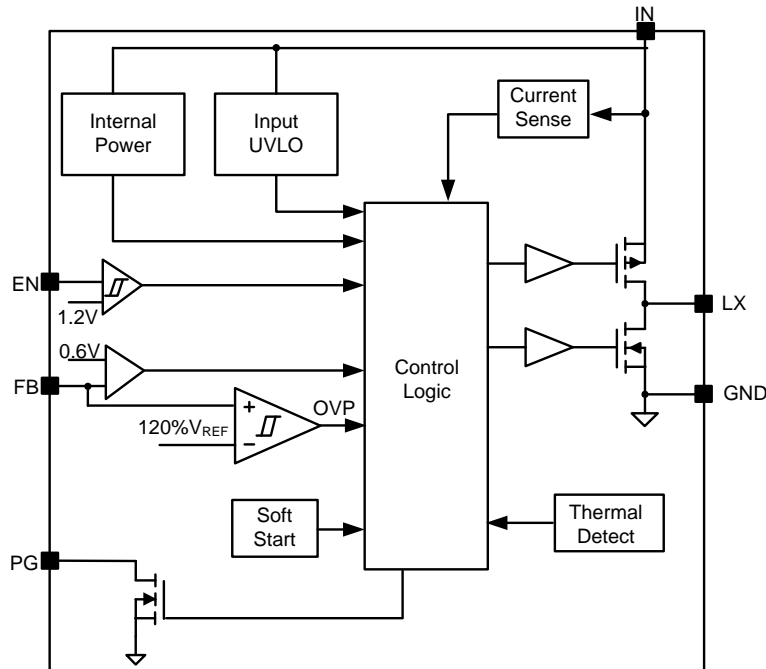


(DFN2x2-8)

**Top Mark:** t2xyz (device code: t2, x=year code, y=week code, z= lot number code)

Pin Name	Pin No.	Pin Description
FB	1	Output feedback pin. Connect this pin to the center point of the output resistor divider (as shown in Figure 1) to program the output voltage: $V_{OUT}=0.6 \times (1+R_H/R_L)$ .
PG	2	Power good indicator (open drain output). Low if the output < 90% or the output > 120% of regulation voltage; High otherwise. Connect a pull-up resistor to the input.
IN	3	Input pin. Decouple this pin to GND pin with at least a 10μF ceramic capacitor.
PGND	4/Exposed Paddle	Power ground pin.
NC	5	No connection.
LX	6	Inductor pin. Connect this pin to the switching node of inductor.
EN	7	Enable control. Pull high to turn on. Do not leave it floating.
SGND	8	Analog ground pin.

## Block Diagram



**Figure3. Block Diagram**



**SILERGY**

**SY8884A**

## Absolute Maximum Ratings (Note 1)

Supply Input Voltage	-----	-0.3V to 6.0V
FB, EN, PG Voltage	-----	-0.3V to $V_{IN} + 0.6V$
LX Voltage	-----	-0.3V <sup>(*1)</sup> to 6.0V <sup>(*2)</sup>
Power Dissipation, $P_D$ @ $T_A = 25^\circ C$	-----	1.4W
Package Thermal Resistance (Note 2)		
$\theta_{JA}$	-----	70°C/W
$\theta_{JC}$	-----	25°C/W
Junction Temperature Range	-----	-40°C to 150°C
Lead Temperature (Soldering, 10 sec.)	-----	260°C
Storage Temperature Range	-----	-65°C to 150°C
<sup>(*1)</sup> LX Voltage Tested Down to -3V <20ns		
<sup>(*2)</sup> LX Voltage Tested Up to +7V <20ns		

## Recommended Operating Conditions (Note 3)

Supply Input Voltage	-----	2.5V to 5.5V
Junction Temperature Range	-----	-40°C to 125°C
Ambient Temperature Range	-----	-40°C to 85°C

## Electrical Characteristics

( $V_{IN} = 5V$ ,  $V_{OUT} = 1.8V$ ,  $L = 1.0\mu H$ ,  $C_{OUT} = 32\mu F$ ,  $T_A = 25^\circ C$ , unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Input Voltage Range	$V_{IN}$		2.5		5.5	V
Input UVLO Threshold	$V_{UVLO}$			2.45	2.5	V
Input UVLO Hysteresis	$V_{HYS}$			150		mV
Quiescent Current	$I_Q$	$V_{FB} = 105\% \times V_{REF}$		55		$\mu A$
Shutdown Current	$I_{SHDN}$	$V_{EN} = 0V$		0.1	1	$\mu A$
Feedback Reference Voltage	$V_{REF}$	$I_{OUT} = 0.5A$ , CCM	0.591	0.6	0.609	V
LX Node Discharge Resistance	$R_{DIS}$			50		$\Omega$
Top FET $R_{ON}$	$R_{DS(ON)1}$			85		m $\Omega$
Bottom FET $R_{ON}$	$R_{DS(ON)2}$			60		m $\Omega$
EN Input Voltage High	$V_{EN,H}$		1.2			V
EN Input Voltage Low	$V_{EN,L}$				0.4	V
EN Leakage Current	$I_{EN}$				2	$\mu A$
PG Threshold for Under Voltage Detection	$V_{PG,UV P}$			90		%
PG Low Delay Time for Under Voltage Detection	$t_{UVP,DLY}$			10		us
PG Threshold for Over Voltage Detection	$V_{PG,OV P}$			120		%
PG Low Delay Time for Over Voltage Detection	$t_{OVP,DLY}$			20		us
Min ON Time	$t_{ON,MIN}$			50		ns
Maximum Duty Cycle	$D_{MAX}$		100			%
Turn on Delay Time	$t_{ON,DLY}$	from EN high to LX start switching		0.5		ms
Soft-start Time	$t_{SS}$	$V_{OUT}$ from 0% to 100%		1		ms
Switching Frequency	$f_{SW}$	$I_{OUT} = 0.5A$ , CCM		1.0		MHz
Top FET Current Limit	$I_{LMT, TOP}$		4.7			A
Output Under Voltage Protection Threshold	$V_{UVP}$			50		% $V_{REF}$
Output UVP Delay	$t_{UVP,DLY}$			10		$\mu s$
UVP Hic-cup ON Time	$t_{UVP, ON}$			3.5		ms
UVP Hic-cup OFF Time	$t_{UVP, OFF}$			3.5		ms
Thermal Shutdown Temperature	$T_{SD}$			160		$^\circ C$
Thermal Shutdown Hysteresis	$T_{HYS}$			20		$^\circ C$

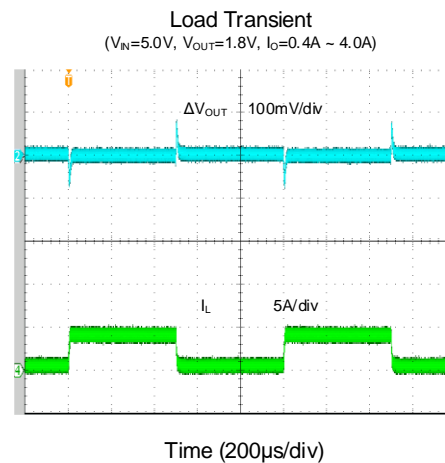
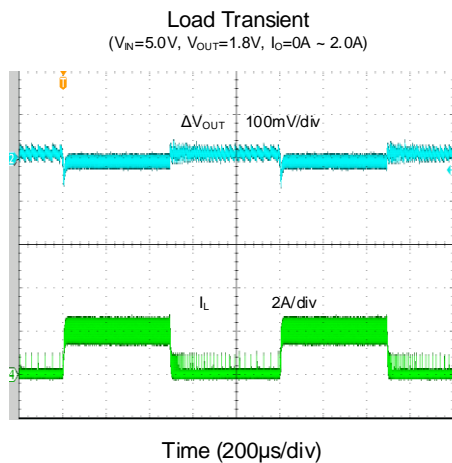
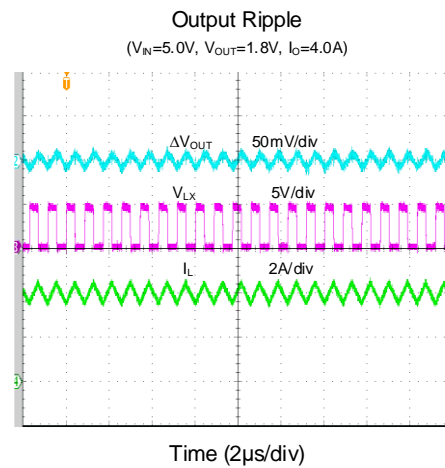
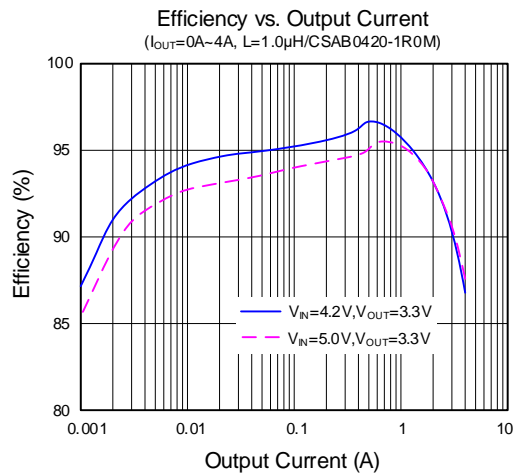
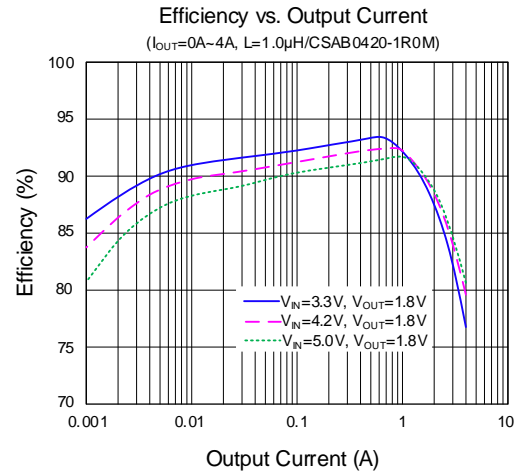
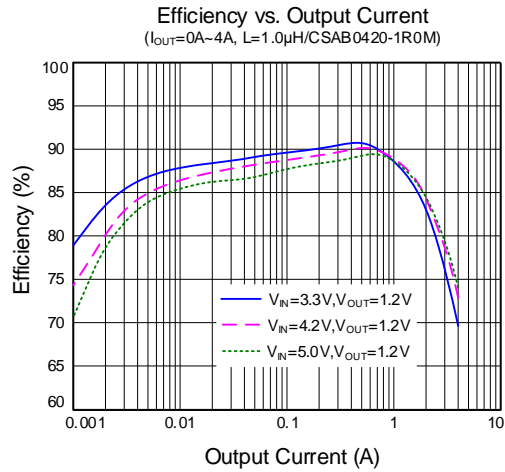
**Note 1:** Stresses beyond the “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

**Note 2:**  $\theta_{JA}$  of SY8884ADFC is measured in the natural convection at  $T_A = 25^\circ C$  on a 2-oz two-layer Silergy evaluation board. Paddle of DFN2x2-8 package is the case position for  $\theta_{JC}$  measurement.

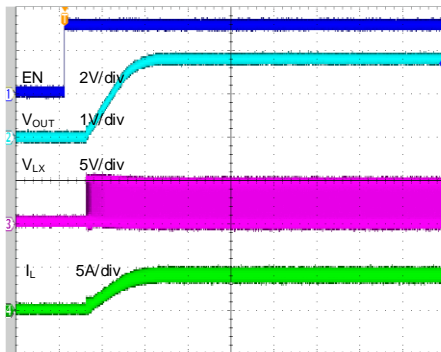
**Note 3:** The device is not guaranteed to function outside its operating conditions.

## Typical Performance Characteristics

( $T_A = 25^\circ\text{C}$ ,  $V_{IN} = 5\text{V}$ ,  $V_{OUT} = 1.8\text{V}$ ,  $L = 1.0\mu\text{H}$ ,  $C_{OUT} = 32\mu\text{F}$ , unless otherwise noted)

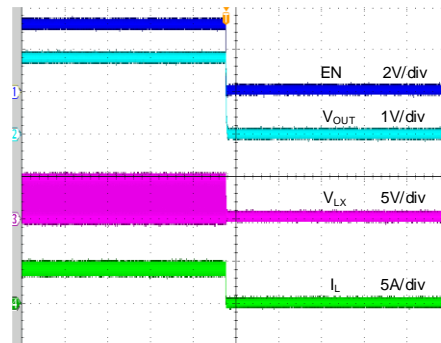


**Startup from Enable**  
( $V_{IN}=5.0V$ ,  $V_{OUT}=1.8V$ ,  $R_{LOAD}=0.45\Omega$ )



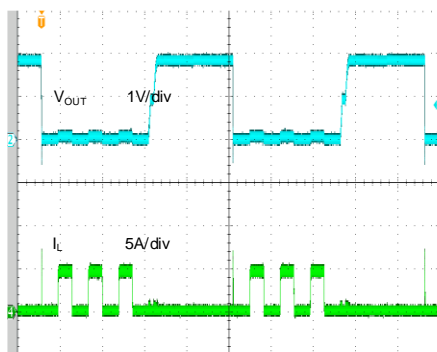
Time (800 $\mu$ s/div)

**Shutdown from Enable**  
( $V_{IN}=5.0V$ ,  $V_{OUT}=1.8V$ ,  $R_{LOAD}=0.45\Omega$ )



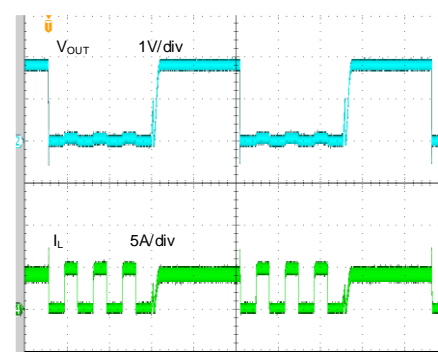
Time (800 $\mu$ s/div)

**Short Circuit Protection**  
( $V_{IN}=5.0V$ ,  $V_{OUT}=1.8V$ ,  $I_O=0A \sim$  Short)



Time (10ms/div)

**Short Circuit Protection**  
( $V_{IN}=5.0V$ ,  $V_{OUT}=1.8V$ ,  $I_O=4.0A \sim$  Short)



Time (10ms/div)

## Operation

The SY8884A is a high efficiency 1MHz synchronous step down DC/DC regulator, which is capable of delivering up to 4A output current. It can operate over a wide input voltage range from 2.5V to 5.5V and integrate main switch and synchronous switch with very low  $R_{DS(ON)}$  to minimize the conduction loss.

The low output voltage ripple, the small external inductor and the capacitor sizes are achieved with 1MHz switching frequency.

## Applications Information

Because of the high integration in the SY8884A, the application circuit based on this IC is rather simple. Only the input capacitor  $C_{IN}$ , the output capacitor  $C_{OUT}$ , the output inductor  $L$  and the feedback resistors ( $R_H$  and  $R_L$ ) need to be selected for the targeted applications specifications.

### Feedback Resistor Dividers $R_H$ and $R_L$

Choose  $R_H$  and  $R_L$  to program the proper output voltage. To minimize the power consumption under light loads, it is desirable to choose large resistance values for both  $R_H$  and  $R_L$ . A value of between 1k $\Omega$  and 1M $\Omega$  is highly recommended for  $R_L$ . If  $R_L=100k\Omega$  is chosen, then  $R_H$  can be calculated to be:

$$R_H = \frac{(V_{OUT} - 0.6V) \times R_L}{0.6V}$$

### Input Capacitor $C_{IN}$

A typical X5R or better grade ceramic capacitor with 10V rating and greater than 10 $\mu$ F capacitance is recommended. This ceramic capacitor need to be placed really close to the IN and GND pins to minimize the potential noise problem. Care should be taken to minimize the loop area formed by  $C_{IN}$ , and the IN/GND pins.

### 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, it is recommended to use an X5R or better grade ceramic capacitor with 6.3V rating and greater than 32 $\mu$ F capacitance.

### Output Inductor $L$

There are several considerations in choosing this inductor.

- 1) Choose the inductance to provide the desired ripple current. It is suggested to choose the ripple current to be about 40% of the maximum output current. The inductance is calculated as:

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

Where  $f_{SW}$  is the switching frequency and  $I_{OUT,MAX}$  is the maximum load current.

The SY8884A is quite tolerant of different ripple current amplitude. 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 selected to be greater than the peak inductor current under full load conditions.

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

- 3) The DCR of the inductor and the core loss at the switching frequency must be low enough to achieve the desired efficiency requirement. It is desirable to choose an inductor with DCR<60m $\Omega$  to achieve a good overall efficiency.

### Load Transient Considerations

The SY8884A integrates the compensation components to achieve good stability and fast transient responses. In some application, adding a ceramic capacitor (feed-forward capacitor,  $C_{ff}$ ) in parallel with  $R_H$  may further speed up the load transient responses and is thus recommended for applications with large load transient step requirements. Typically, for 1.2V/1.8V/3.3V output, the  $R_H$ ,  $R_L$ ,  $C_{ff}$  is recommended as below:

Recommended Component Selection

$V_{OUT}$	$R_H$	$R_L$	$C_{ff}$
1.2V	49.9k $\Omega$	49.9k $\Omega$	22pF
1.8V	100k $\Omega$	49.9k $\Omega$	10pF
3.3V	100k $\Omega$	22.1k $\Omega$	10pF

### OCP & SCP Method

With load current increasing, as soon as the high side FET current gets higher than peak current limit threshold, the high side FET will turn off. If the load current continues to increase, the output voltage will drop. When the output voltage falls below 50% of the

regulation level, the output UVP will be detected and the SY8884A will operate in hic-cup mode. The hic-cup frequency is 140Hz, the hic-cup duty cycle is 50%. If the hard short is removed, the IC will return to normal operation.

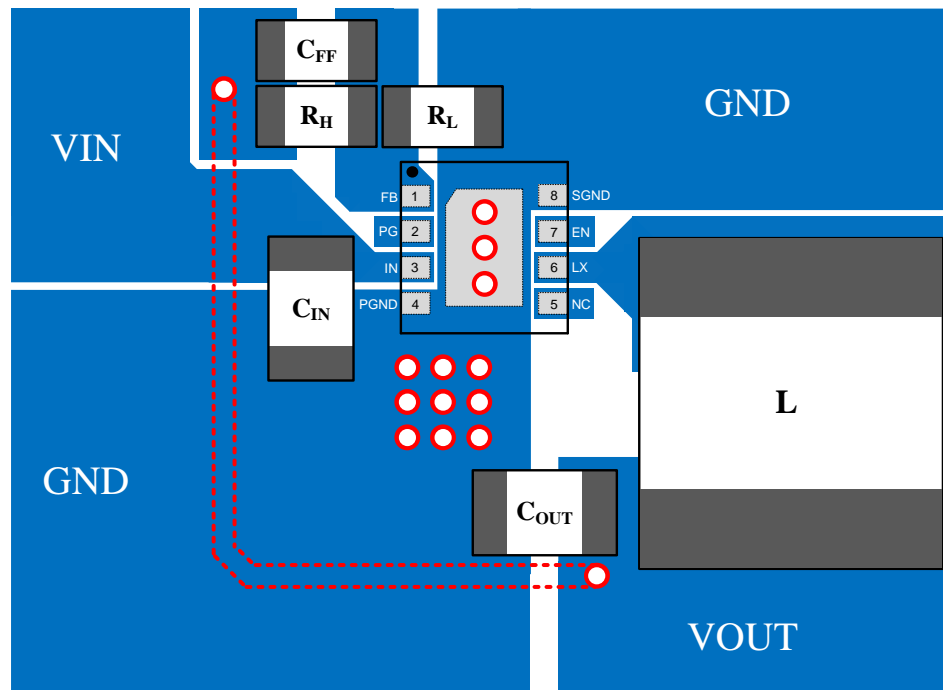
## Layout Design

The layout design of the SY8884A regulator is relatively simple. For the best efficiency and minimum noise problems, the following components should be placed close to the IC:  $C_{IN}$ , L,  $R_H$  and  $R_L$ .

- 1) It is desirable to maximize the PCB copper area connecting to the GND pin to achieve the best thermal and noise performance. If the board

space allowed, a ground plane is highly desirable.

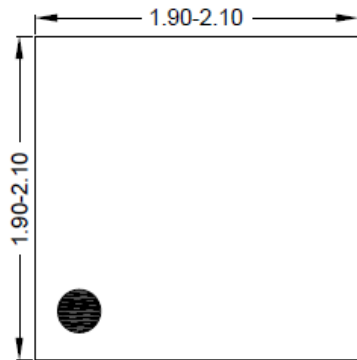
- 2)  $C_{IN}$  must be close to the Pins IN and GND. The loop area formed by  $C_{IN}$  and GND must be minimized.
- 3) The PCB copper area associated with the LX pin must be minimized to avoid the potential noise problem.
- 4) The components  $R_H$ ,  $R_L$  and the trace connecting to the FB pin must NOT be adjacent to the LX net on the PCB layout to avoid the noise problem.



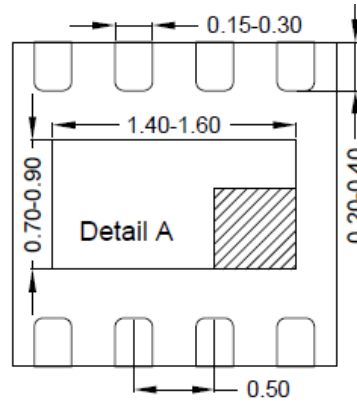
**Figure4. PCB Layout Suggestion**



## DFN2×2-8 Package Outline Drawing



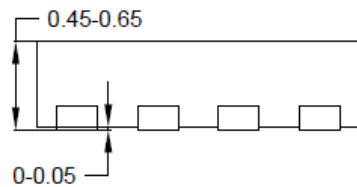
**Top View**



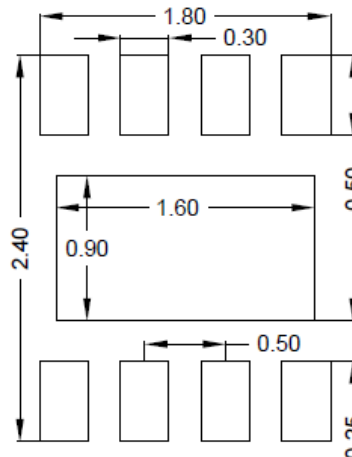
**Bottom View**



**Detail A**  
Pin1 Identifier(Two options)



**Side View**

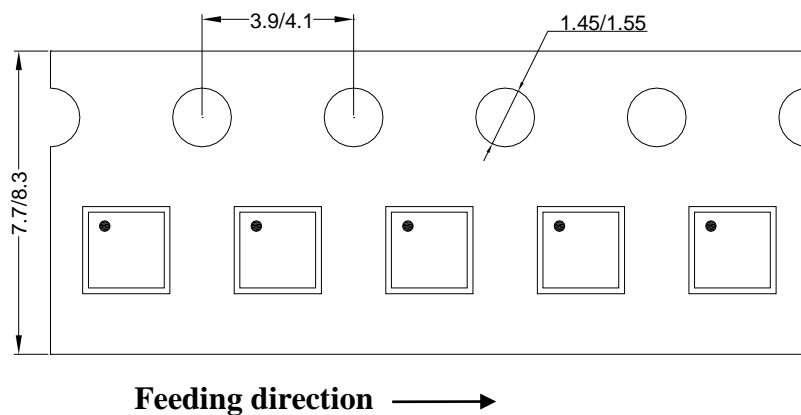


**Recommended PCB Layout (Reference)**

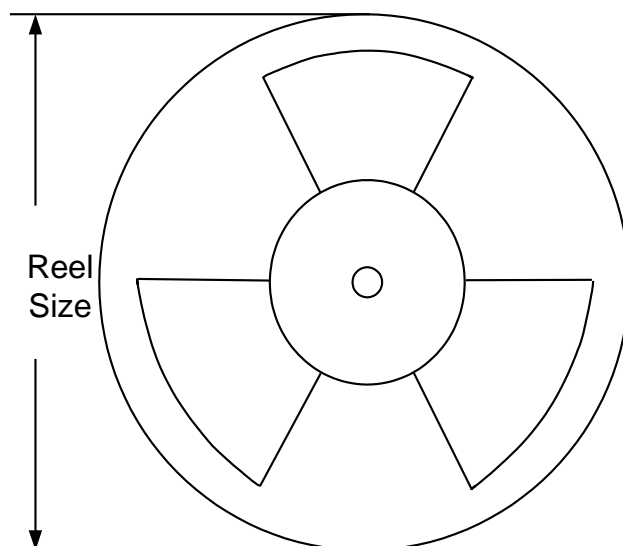
**Notes:** All dimensions are in millimeters and don't include mold flash & metal burr.

## Taping & Reel Specification

### 1. DFN2×2



### 2. Carrier Tape & Reel specification for packages



Package types	Tape width (mm)	Pocket pitch(mm)	Reel size (Inch)	Trailer length(mm)	Leader length (mm)	Qty per reel
DFN2×2	8	4	7"	400	160	3000

### 3. Others: NA

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## Revision History

The revision history provided is for informational purpose only and is believed to be accurate, however, not warranted. Please make sure that you have the latest revision.

Date	Revision	Change
Nov.10, 2021	Revision 0.9	Initial Release

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