SY20763

High Efficiency, 1A, Three-Cell Boost Li-Ion Battery Charger

General Description

The SY20763 is a three-cell synchronous boost Li-Ion battery charger designed for a 3.6-12.8V input voltage range, delivering a charge current of up to 1A. The charge current can be adjusted using an external resistor, offering flexibility for various portable applications.

The SY20763 uses a 500kHz switching frequency and includes full protection functions, including short-circuit, charge timeout, and temperature protection for reliable operation.

The charger features programmable charge timeout and adaptive input power limit functions, enhancing the safety of battery charging operations. The device includes 18V rated power switching and reverse blocking MOSFETs with extremely low ON resistance, ensuring high charge efficiency and simple peripheral circuit design.

The SY20763 is available in a compact QFN3×3 package.

Features

- Adaptive Input Power Limit for 3.6-12.8V Range
- Integrated Synchronous Boost with 18V Rating Low R_{DSON} MOSFETs for High Efficiency
- Maximum 1A Constant Charge Current
- Constant Current / Constant Voltage / Trickle Current Charging Modes
- Programmable Charge Timeout
- Programmable Constant Charge Current
- Selectable Constant Voltage
- ±0.5% Battery Voltage Accuracy
- Thermal Regulation Protection
- Input Voltage UVLO and OVP
- Overtemperature Protection
- Output Short-Circuit Protection
- Normal Synchronous Boost Operation when the Battery is Removed
- Low Profile QFN3×3-16 Package for Portable Applications

Applications

- Mobile Phones and Tablets
- Digital Cameras
- Battery Operated IoT devices
- Game Players
- Notebooks

Typical Application

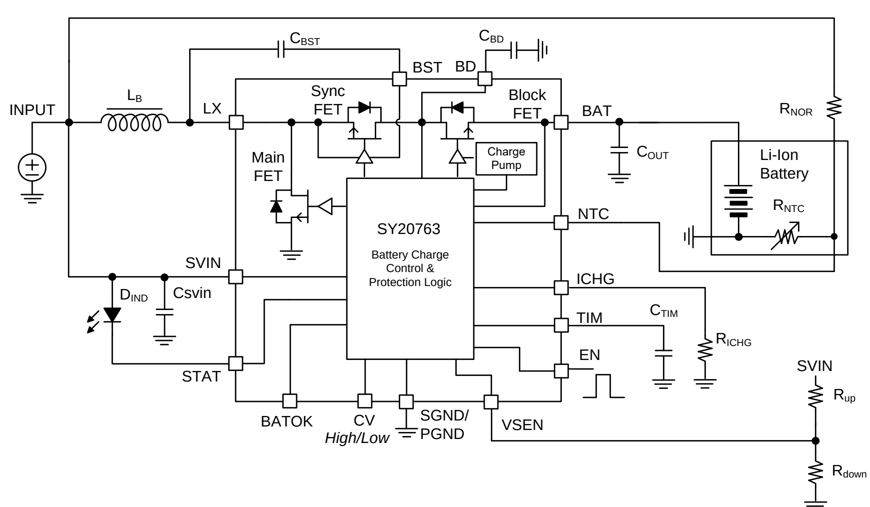


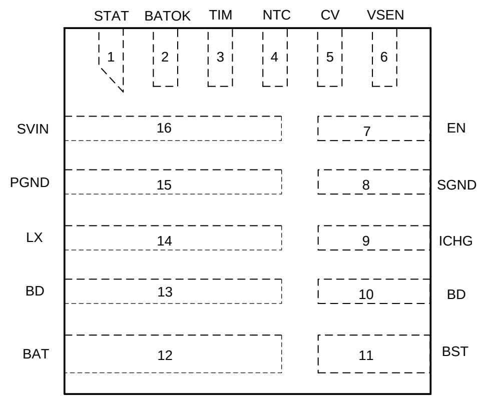
Figure 1. Schematic Diagram

Ordering Information

SY20763 □(□□)□
- Temperature Code
- Package Code
- Optional Spec Code

Ordering Number	Package Type	Top Mark
SY20763QDC	QFN3×3-16	**BQW*xyz***

Device code: **BQW**
x=year code, y=week code, z= lot number code



(QFN3×3-16)

Pinout (Top View)

Pin Name	Pin Number	Pin Description
STAT	1	Charge status indication pin. Open drain output. Pull high to SVIN through a LED to indicate that charging is in progress. When charging is complete, the LED turns off.
BATOK	2	Good battery presence indication pin. When V_{BAT} is lower than 9.1V, or NTC is pulled up to SVIN, the BATOK pin outputs a low logic level. Otherwise, the BATOK pin is in a high logic state.
TIM	3	Charge time limit pin. Connect this pin with a capacitor to the ground. The internal current source charges TC and CC mode capacitors to program the charging time limit. TC charge time limit is about 1/9 of the CC charge time limit.
NTC	4	Thermal protection pin. The UTP threshold is typically 76% of V_{SVIN}, and the OTP threshold is typically 46.5% of V_{SVIN}. Pulling up to SVIN can disable charging and make the device operate as a normal boost regulator. Pulling down to the ground shuts down the device.
CV	5	Battery CV voltage selection pin. Connect to GND for 12.6V charge termination voltage. Pull high for 13.05V charge termination voltage.
VSEN	6	Voltage sense pin for SVIN. If the voltage drops below the internal 1.195V reference voltage, tSVIN will be clamped to the setting value, and the input current will be limited.
EN	7	Enable control pin. Drive to logic high to enable operation and low logic to disable.
SGND	8	Signal ground pin.
ICHG	9	Charge current programming pin. Connect to GND with a resistor R_{ICHG}. The mirror current of about 1/10000 of the blocking MOSFET current is converted to a voltage using the external RC network and compared to the internal reference 1V. I_{CC}=(1V/ R_{ICHG})×10k, I_{TC}=(1V/ R_{ICHG})×1k+0.03.
BD	10, 13	Connected to the drain of internal blocking MOSFET. Bypass with at least a 4.7µF ceramic cap to GND.
BST	11	MOSFET gate driver. Connect to the LX pin using a 0.1µF ceramic capacitor
BAT	12	Battery positive pin.
LX	14	Switch node pin. Connect it to the external inductor.
PGND	15	Power ground pin.
SVIN	16	Analog power input pin. Connect a MLCC from this pin to the ground to decouple high frequency noise..

Absolute Maximum Ratings (Note1)

STAT, NTC, CV, VSEN, EN, ICHG, BD, BAT, LX, SVIN-- 18V
BATOK, TIM, BST-LX -- 4V
LX Pin Current Continuous -- 5A
Power Dissipation, P_D @ T_A = 25°C, QFN3×3 -- 2.6W
Package Thermal Resistance (Note2)
θ_{JA} -- 38°C/W
θ_{JC} -- 4°C/W
Junction Temperature Range -- -40°C to 125°C
Lead Temperature (Soldering, 10 sec.) -- 260°C
Storage Temperature Range -- -65°C to 125°C

Recommended Operating Conditions (Note3)

SVIN -- 3.6V to 12.8V
STAT, NTC, CV, VSEN, EN, ICHG, BD, BAT, LX, -- -0.3V to 16V
BATOK, TIM, BST-LX -- -0.3V to 3.3V
LX Pin Current Continuous -- 5A
Junction Temperature Range -- -40°C to 125°C
Ambient Temperature Range -- -40°C to 85°C

Electrical Characteristics

(T_A=25°C, V_{IN}=5V, GND=0V, C_{IN}=4.7μF, L=2.2μH, R_{ICHG}=10kΩ, C_{TIM}=470nF, unless otherwise specified.)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Bias Supply (V_{SVIN})						
Supply Voltage	V_{SVIN}		3.6		16	V
V_{SVIN} Under Voltage Lockout Threshold	V_{UVLO}	V_{SVIN} rising and measured from V_{SVIN} to GND			3.5	V
V_{SVIN} Under Voltage Lockout Hysteresis	ΔV_{UVLO}	Measured from V_{SVIN} to GND		100		mV
Input Overvoltage Protection	V_{OVP}	V_{SVIN} rising and measured from V_{SVIN} to GND	12.9			V
Input Overvoltage Protection Hysteresis	ΔV_{OVP}	Measured from V_{SVIN} to GND		0.45		V
Quiescent Current						
Battery Discharge Current	I_{BAT}	Shutdown IC, EN=NTC=0			10	μA
Input Quiescent Current	I_{IN}	Disable Charge, EN=1,NTC=0			1	mA
Oscillator and PWM						
Switching Frequency	f_{SW}			500		kHz
Main N-FET Minimum OFF Time	t_{MIN_OFF}	With 18V rating		100		ns
Main N-FET Maximum OFF Time	t_{MAX_OFF}	With 18V rating		30		μs
Main N-FET Minimum ON Time	t_{MIN_ON}	With 18V rating		100		ns
Power MOSFET						
$R_{DS(ON)}$ of Main N-FET	R_{NFET_M}			80		mΩ
$R_{DS(ON)}$ of Rectified N-FET	R_{NFET_R}			40		mΩ
$R_{DS(ON)}$ of Blocking N-FET	R_{NFET_B}			40		mΩ
Voltage Regulation						
Battery Charge Voltage	V_{BAT_REG}	V_{CV}<1V	12.537	12.6	12.663	V
		V_{CV}>2V	12.985	13.05	13.115	
High Level Logic for CV	V_{CV_H}		2			V
Low Level Logic for CV	V_{CV_L}				1	V
Recharge Threshold Refer to V_{BAT_REG}	ΔV_{RCH}		150	300	450	mV
Trickle Current Charge Mode Battery Voltage Threshold	V_{TRK}		8.1	8.4		V

Battery Connect Detection						
NTC Voltage Threshold for Battery Detect	V_{DET}	NTC falling edge	85%		95%	V_{SVIN}
Detect Delay Time	t_{DET}			30		ms
Charge Current						
Internal Charge Current Accuracy for Constant Current Mode		I_{CC}=1000mA	-10%		10%	
Internal Charge Current Accuracy for Trickle Current Mode		I_{TC}=130mA	-50%		50%	
Termination Current	I_{TERM}	I_{CC}=1000mA	50	100	150	mA
Output Voltage OVP						
Output Voltage OVP Threshold	V_{OVP}		105%	110%	115%	V_{BAT_REG}
Input Voltage Threshold for Adaptive Current Limit						
Voltage Reference of VSEN	V_{SEN}	V_{SVIN} ≤6V	1.171	1.195	1.219	V
The Adaptive Input Power Limit Reference is V_{SVIN}-ΔV_{AICL}	ΔV_{AICL}	V_{SVIN} >6V		0.53		V
Timer						
Trickle Current Charge Timeout	t_{TC}	C_{TIM}=330nF	0.4	0.5	0.65	hour
Constant Current Charge Timeout	t_{CC}		3.8	4.5	5.82	hour
Charge Mode Change Delay Time	t_{MC}			30		ms
Termination Delay Time	t_{TERM}			30		ms
Recharge Time Delay	t_{RCHG}			30		ms
Short Circuit Protection						
Output Short Protection Threshold is V_{SVIN} -ΔV_{SHORT}	ΔV_{SHORT}			2.3		V
BATOK Indication						
BATOK High Voltage Output	V_{BATOK_H}			3		V
BATOK Low Voltage Output	V_{BATOK_L}			0		V
Linear Charger Mode						
Battery Charger Current when the Blocking FET is in Linear Mode	I_{SC}	V_{BAT}< V_{SVIN} -ΔV_{SHORT} when Icc=1000mA		130		mA
BD Voltage Regulation	V_{BD}			9.24		V
Enable ON/OFF Control						
High Level Logic for Enable Control	V_{EN_H}		1.5			V
Low Level Logic for Enable Control	V_{EN_L}				0.4	V

Battery Thermal Protection NTC						
Under Temperature Protection	V_{NTC_UTP}		75%	76%	77%	V_{SVIN}
Under Temperature Protection Hysteresis	$V_{NTC\_UTP\_HYS}$	Falling edge		6%		
Over Temperature Protection	V_{NTC_OTP}		45.5%	46.5%	47.5%	
Over Temperature Protection Hysteresis	$V_{NTC\_OTP\_HYS}$	Rising edge		2%		
Thermal Fold-back and Thermal Shutdown						
Thermal Fold-back Threshold	T_{Fold}	Rising edge		120		ºC
Thermal Fold-back Threshold Hysteresis	T_{Fold_HYS}			20		ºC
Thermal Fold-back Ratio				0.25		I_{CC}
Thermal Shutdown Temperature	T_{SD}	Rising edge		160		ºC
Thermal Shutdown Temperature Hysteresis	T_{SD_HYS}			30		ºC

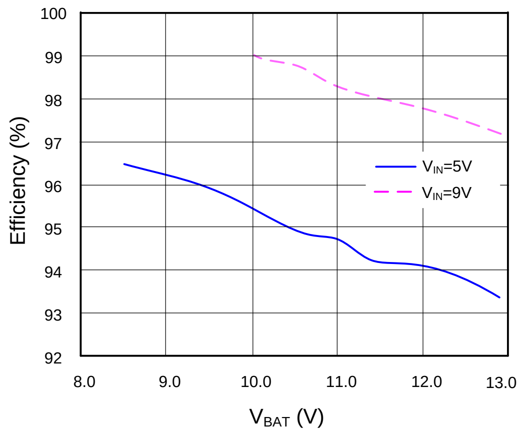
Note 1: Stresses beyond the "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification is not implied. Exposure to absolute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

Note 2: θ_{JA} is measured in the natural convection at T_A = 25°C on a low effective four-layer thermal conductivity test board of JEDEC 51-3 thermal measurement standard.

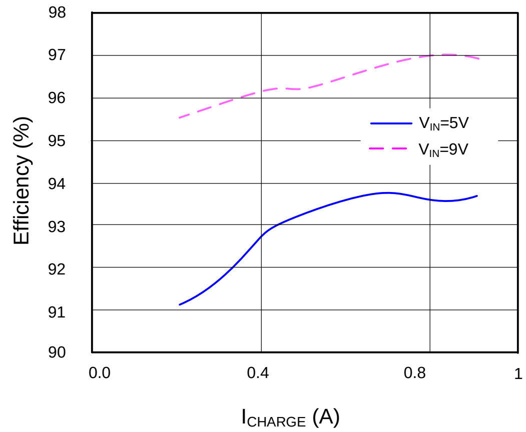
Note 3: The device is not guaranteed to function outside its operating conditions

Typical Performance Characteristics

Efficiency VS BAT Voltage (CC mode)

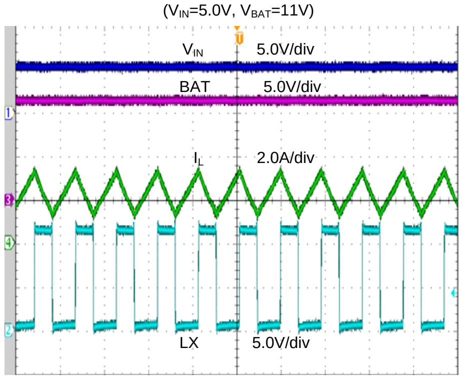


Efficiency VS Charge Current(CV mode)



Steady Waveforms (CC Mode)

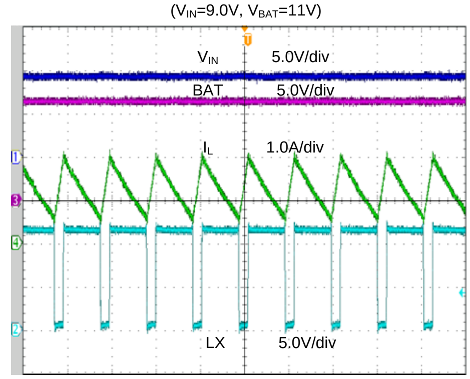
(V_{IN}=5.0V, V_{BAT}=11V)



Time (2.0us/div)

Steady Waveforms (CC Mode)

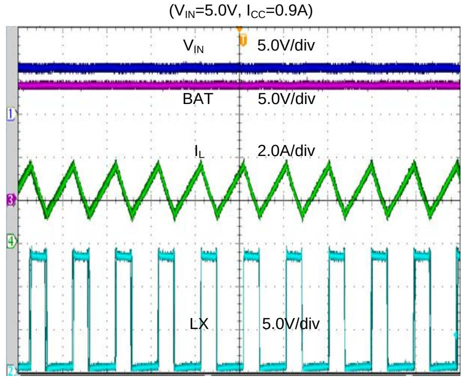
(V_{IN}=9.0V, V_{BAT}=11V)



Time (2.0us/div)

Steady Waveforms (CV Mode)

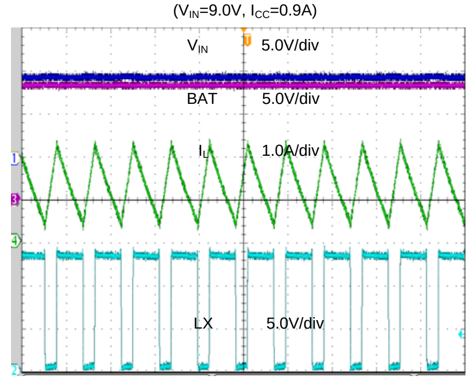
(V_{IN}=5.0V, I_{CC}=0.9A)



Time (2.0us/div)

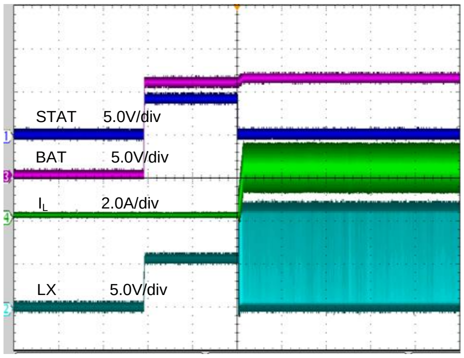
Steady Waveforms (CV Mode)

(V_{IN}=9.0V, I_{CC}=0.9A)



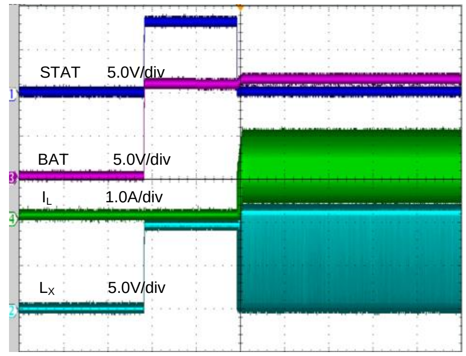
Time (2.0us/div)

Power ON (CC Mode)
(V_{IN}=5.0V, V_{BAT}=11V)



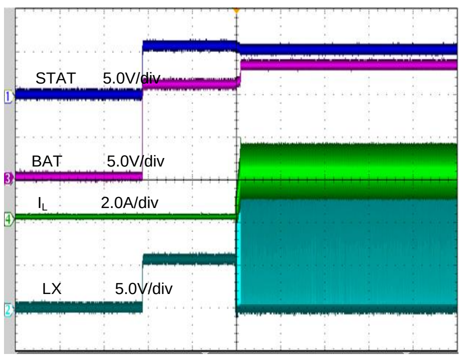
Time (400ms/div)

Power ON (CC Mode)
(V_{IN}=9.0V, V_{BAT}=11V)



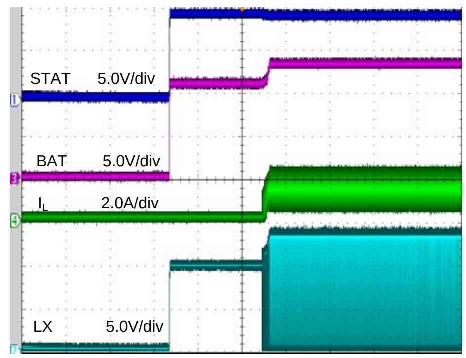
Time (400ms/div)

Power ON (CV Mode)
(V_{IN}=5.0V, I_{CC}=0.9A)



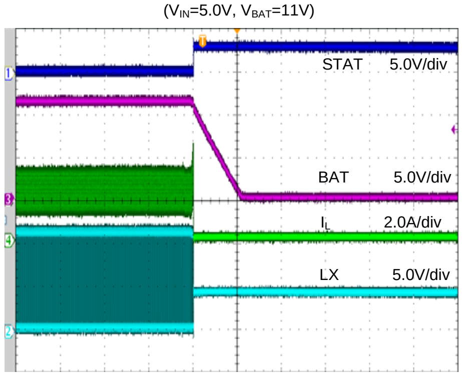
Time (400ms/div)

Power ON (CV Mode)
(V_{IN}=9.0V, I_{CC}=0.9A)



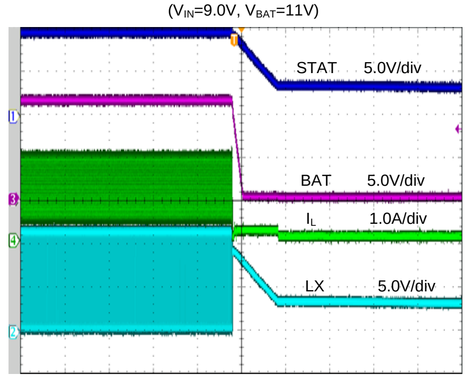
Time (400ms/div)

Power OFF (CC Mode)
(V_{IN}=5.0V, V_{BAT}=11V)



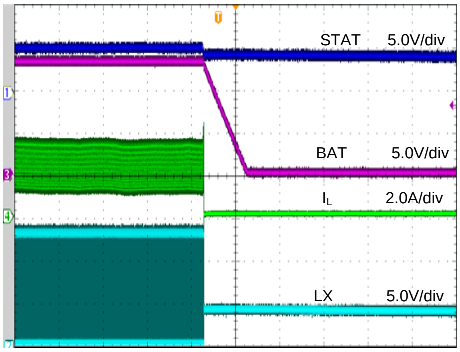
Time (2ms/div)

Power OFF (CC Mode)
(V_{IN}=9.0V, V_{BAT}=11V)



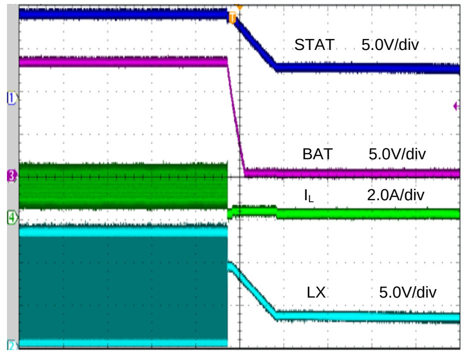
Time (10ms/div)

Power OFF (CV Mode)
(V_{IN}=5.0V, I_{CC}=0.9A)



Time (4ms/div)

Power OFF (CV Mode)
(V_{IN}=9.0V, V_{BAT}=11V)



Time (10ms/div)

Application Information

The SY20763 is a three-cell synchronous boost Li-Ion battery charger designed for 3.6-12.8V input voltage range, delivering a charge current of up to 1A. The charge current can be adjusted using an external resistor, offering flexibility for various portable applications.

The SY20763 uses 500kHz switching frequency and integrates protection functions, including short-circuit, charge timeout, and temperature protection for reliable operation.

The charger features programmable charging timeout and adaptive input power limit functions, enhancing the safety of battery charging operations. The device includes 18V rated power switching and reverse blocking MOSFETs with extremely low ON resistance, ensuring high charging efficiency and simple circuit design for USB input applications. The device can operate and provide power to the system with or without a Li-Ion battery connected.

Charging Status Indication Description:

1. **Charge-in-Process:**
   a) STAT pin is pulled low.
2. **Charge Done:**
   a) STAT pin is high impedance.
3. **Fault Mode:**
   a) In Fault Mode, the LED alternates between high and low voltage at a frequency of 1.3Hz.

Connect an LED from SVIN to the STAT pin.

- LED on indicates charging-in-process.
- LED off indicates charging is done.
- LED flashing at 1.3Hz indicates fault mode.

Switching Mode Boost Charger Operation

Switching Mode Control:

The SY20763 is a fixed switching frequency boost charger for USB power input applications. The frequency is fixed at 500kHz, allowing for minimized peripheral circuit design for size optimization.

Operation:

The SY20763 can operate with or without a Li-Ion battery.

Battery Present:

When the battery is present, the SY20763 will adapt to various charging modes based on battery state, including constant current charge mode, constant voltage charge mode, and trickle charge mode.

Battery Absent:

If no battery connection is detected through the NTC pin, SY20763 will operate as a normal switching mode boost converter. The internal constant current loop and voltage loop are both active.

Protections Features:

The SY20763 includes battery charging protection features. When the input or output overvoltage protection, thermal protection, or timeout protection are triggered, the boost charger stops switching immediately. The short circuit protection is triggered when VBAT is lower than VSVIN -ΔVSHORT. The main MOSFET will be turned off immediately. The blocking MOSFET will enter linear mode with 1/10 I_{CC}+0.03 charging current. When V_{BAT} rises higher than V_{SVIN} -ΔV_{SHORT}, the boost charger will restart operation at light load and regulate V_{BD} to 9.24V (typ.). A linear charging current is used, with a value of 1/10 I_{CC}+0.03. When V_{BAT} goes above V_{TRK}, the boost switching charger takes over.

Adaptive Input Current Limit:

The SY20763 can limit the input power on the fly, and adjust this threshold according to the input voltage. It automatically decreases the charge current when V_{SVIN} voltage drops to the adaptive input power limit reference Vref.

For a typical 5V adapter, Vref is set by the VSEN pin. The Vref is calculated using the equation:

$$Vref = 1.195 \times \frac{R_{UP} + R_{DN}}{R_{DN}}$$

If V_{SVIN} voltage is higher than 6V, Vref is calculated using the equation:

$$Vref = V_{SVIN} - \Delta V_{AICL}$$

Where: ΔV_{AICL} is 0.53V, and V_{SVIN} is the input voltage when the adapter is inserted.

Constant Voltage Threshold Programming:

The SY20763 can program the constant voltage threshold using the CV pin. When V_{CV} is higher than 2V, the constant voltage threshold is set to 13.05V; when V_{CV} is lower than 1V, the constant voltage threshold is set to 12.6V.

Design Procedure

The following paragraphs provide information on the selection process for the input capacitor (C_{IN}), output capacitor (C_{OUT}), inductor (L), NTC resistors (R1 and R2), input voltage threshold resistors (R_{up} and R_{down}), and timer capacitor (C_{TIM}) based on the target application specifications.

NTC Resistor:

The SY20763 monitors battery temperature by measuring the input voltage and NTC voltage. The controller triggers the UTP or OTP when K ($K = V_{NTC}/V_{SVIN}$) reaches the threshold for UTP (K_{UT}) or OTP (K_{OT}). The temperature sensing network is shown below:

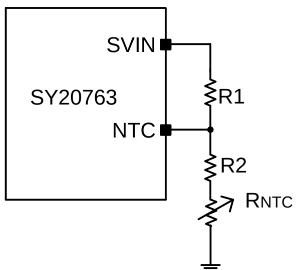


Figure 2. UTP /OTP configuration using R1 and R2

The calculation steps are:

1. Define K_{UT}, K_{UT} =75~77%
2. Define K_{OT}, K_{OT} =45.5~47.5%
3. Assume the resistance of the battery NTC thermistor is R_{UT} at the UTP threshold and R_{OT} at the OTP threshold.
4. Calculate R2:

$$R2=\frac{K_{OT}(1-K_{UT})R_{UT}-K_{UT}(1-K_{OT})R_{OT}}{K_{UT}-K_{OT}}$$

5. Calculate R1:

$$R1=(1/K_{OT}-1)(R2+R_{OT})$$

When typical values (K_{UT} =76% and K_{OT}=46.5%) are used, substituting the equations become :

$$R2 = 0.378R_{UT} - 1.378R_{OT}$$

$$R1=1.151(R2+R_{OT})$$

Timer Capacitor C_{TIM}:

The charger provides a programmable safety charging timer. The charging time is programmed using a capacitor connected between the TIM and GND pins. The capacitance is calculated as follows:

$$C_{TIM}=2\times10^{-11}S\times T_{CC}$$

Where:

- T_{CC} is the target constant charge time, unit: s.
- Units are in F.

Input Capacitor C_{IN}:

The ripple current through the input capacitor can be estimated using the following equation:

$$I_{C_{IN}\_RMS}=\frac{V_{IN}\times(V_{OUT}-V_{IN})}{2\sqrt{3}\times L\times F_{SW}\times V_{OUT}}$$

To handle this ripple current, X5R or X7R ceramic capacitors with greater than 4.7µF capacitance are recommended.

Output Capacitor C_{OUT}:

The output capacitor is selected to handle the output ripple requirements. The ripple voltage is related to the capacitance and its equivalent series resistance (ESR). Using X5R or a better grade low ESR ceramic capacitor is recommended for best performance. The voltage rating of the output capacitor should be higher than the maximum output voltage. The minimum required capacitance can be calculated with the following equation:

$$C_{OUT}=\frac{I_{CC}\times(V_{OUT}-V_{IN})}{F_{SW}\times V_{OUT}\times V_{RIPPLE}}$$

Where

- V_{RIPPLE} is the peak to peak output ripple.
- I_{CC} is the set charge current.

During normal operation, the output capacitor is in parallel with C_{BD}. A capacitance of more than 10µF is recommended for C_{OUT} and. C_{BD}.

Inductor L:

When selecting the inductor, consider the following factors:

1. Choose the inductance to achieve the desired ripple current. It is suggested that the ripple current be approximately 40% of the average input current.
2. The inductance is calculated as follows:

$$L=\left(\frac{V_{IN}}{V_{OUT}}\right)^2\frac{(V_{OUT}-V_{IN})}{I_{CC}\times F_{SW}\times 40\%}$$

Where:

- F_{SW} is the switching frequency.
- I_{CC} is the set charging current.

The SY20763 is tolerant to different ripple current amplitudes. Therefore, the final inductance selection can deviate slightly from the calculated value without significantly affecting performance.

3. The saturation current rating of the inductor must be selected to be greater than the peak inductor current under full load conditions.

$$I_{SAT,MIN} > \left(\frac{V_{OUT}}{V_{IN}}\right) \times I_{CC} + \left(\frac{V_{IN}}{V_{OUT}}\right)^2 \frac{(V_{OUT} - V_{IN})}{2 \times F_{SW} \times L}$$

4. The DC resistance (DCR) of the inductor and the core loss at the switching frequency should be sufficiently low to meet the desired efficiency requirements. It is recommended to select an inductor with DCR < 10mΩ.

PCB Layout Guide:

For best performance of the SY20763, the following guidelines must be followed:

1. Enhance thermal dissipation and reduce noise by maximizing the PCB copper area connected to the GND pin.
2. To minimize noise and improve efficiency, place the following components close to the IC: C_{SVIN}, L, C_{BD}.
3. The loop of the main MOSFET, rectifier diode, and C_{BD} must be minimized.
4. Place C_{SVIN} close to the SVIN and GND pins.
5. Minimize the PCB copper area associated with the LX pin to reduce EMI.
6. Place the small signal components (R_{ICHG}, R_{up}, and R_{down}) close to the device but not adjacent to the LX net on the PCB layout to avoid crosstalk.

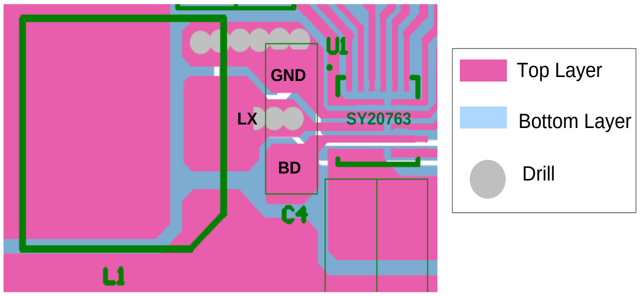
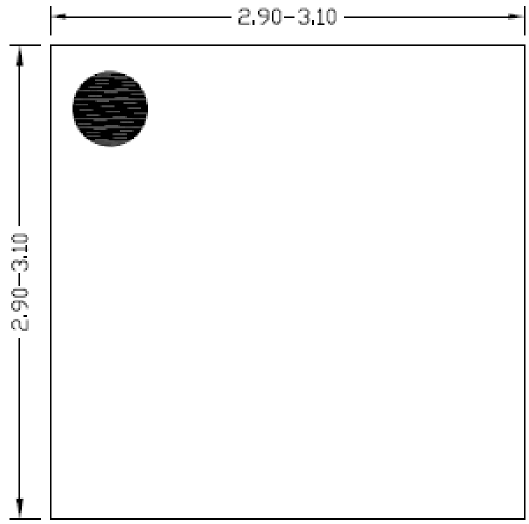
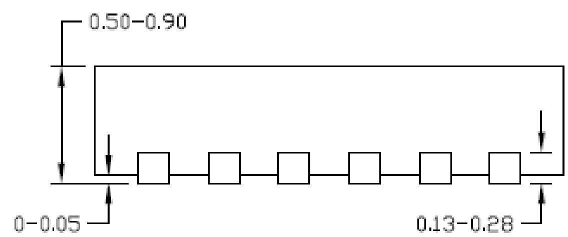


Figure 3. PCB Layout Suggestion

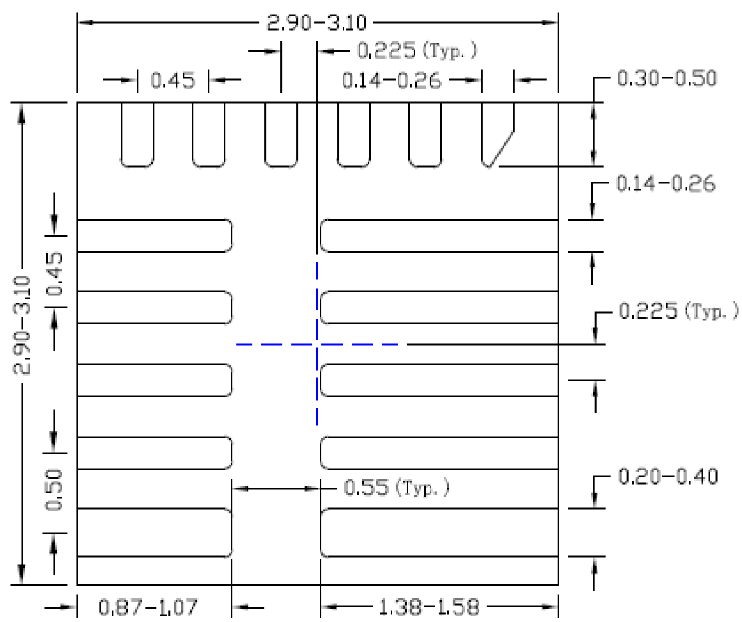
QFN3×3-16 Package Outline Drawing



Top View



Side View

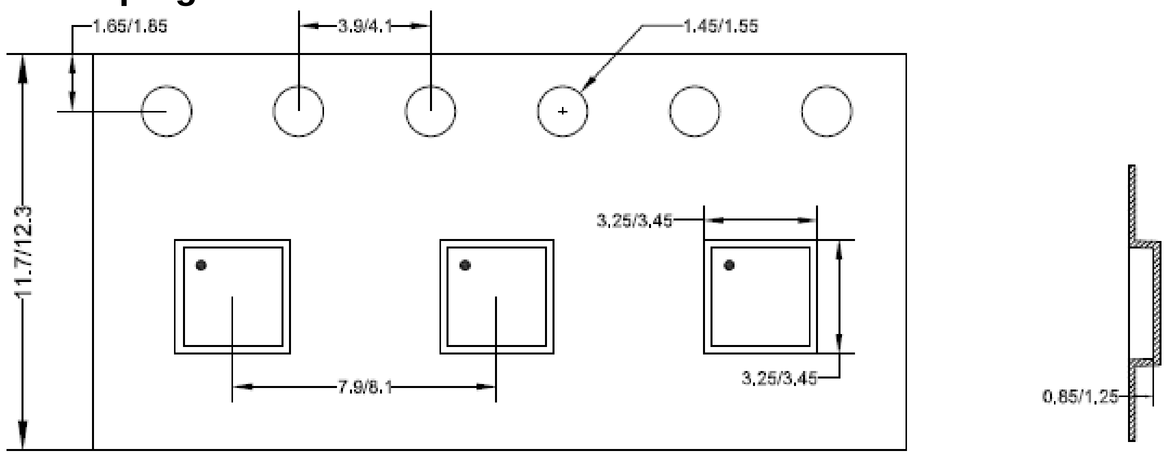


Bottom View

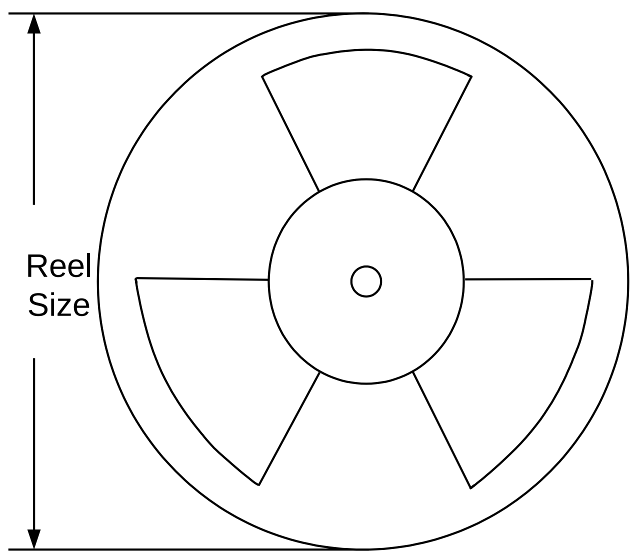
Note: All dimensions are in millimeters and exclude mold flash and metal burr.

Taping & Reel Specification

1. QFN3×3 Taping Orientation



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
QFN3×3	12	8	13"	400	400	5000

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