

# High Performance, Single Synchronous Step-Up Converter for Bluetooth Speakers

## General Description

The uP6020 is a high-efficiency, single synchronous boost converter in Bluetooth Speakers. The proprietary RCOT™ technology provides fast transient response and high noise immunity. It supports ceramic output capacitors. This combination is ideal for building modern low duty ratio, ultra-fast load step response DC-DC converters. The output voltage ranges from 9V to 24V, and the conversion input voltage ranges is from 6V to 9V. The switching frequency is fixed 450kHz. It is available in a space saving WQFN4x4-26L package.

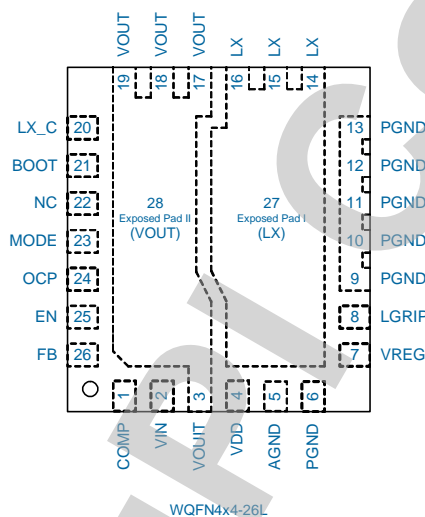
## Ordering Information

Order Number	Package Type	Remark
uP6020PQMY	WQFN4x 4-26L	

Note:

- Please check the sample/production availability with uPI representatives.
- uPI products are compatible with the current IPC/JEDEC J-STD-020 requirement. They are halogen-free, RoHS compliant and 100% matte tin (Sn) plating that are suitable for use in SnPb or Pb-free soldering processes.

## Pin Configuration



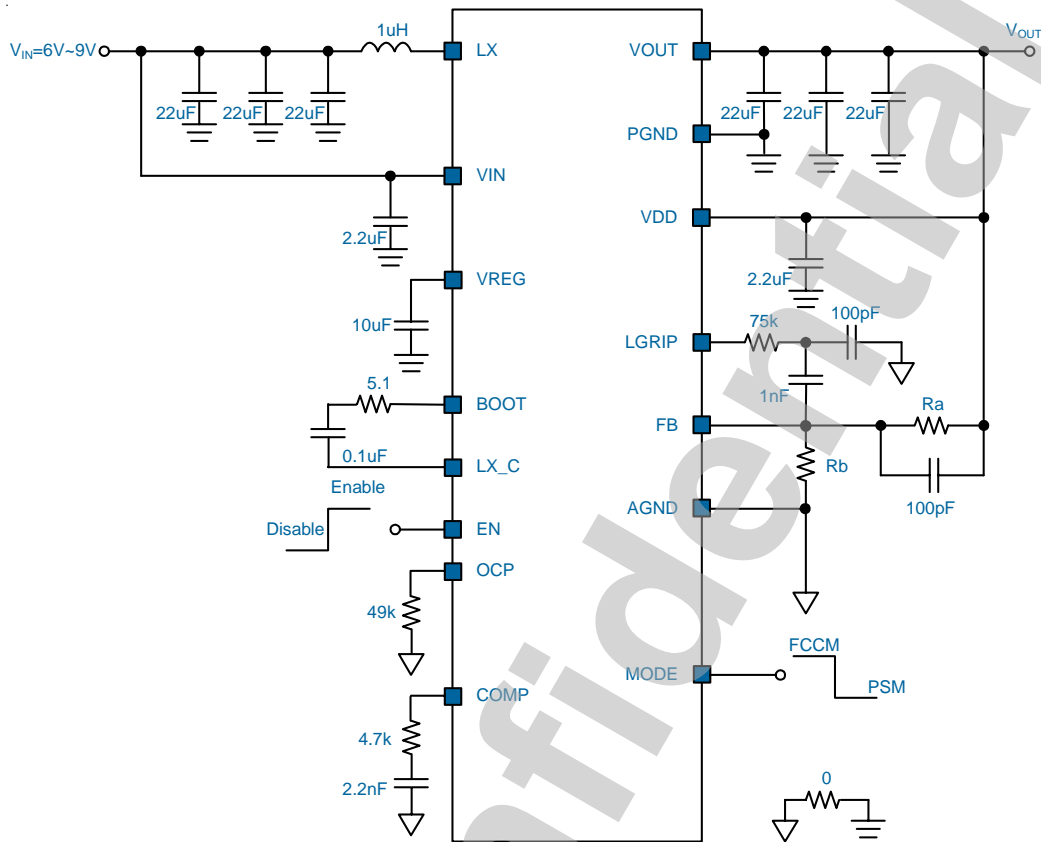
## Features

- ❑ Input Voltage Range: 6V to 9V
- ❑ Output Voltage Range: 9V to 24V
- ❑ Built-In 1% 1V Reference
- ❑ Built-In LDO Linear Voltage Regulator
- ❑ RCOT™ (Robust Constant On-Time) Control Architecture
- ❑ 450kHz Switching Frequency
- ❑ 4000ppm/°C  $R_{DS(ON)}$  Current Sensing
- ❑ 8ms Soft Start
- ❑ Built-in OVP/UVP/OCP/OTP
- ❑ WQFN4x4-26L Package
- ❑ RoHS Compliant and Halogen Free

## Applications

- ❑ Bluetooth™ Speakers
- ❑ Portable Charging Devices
- ❑ I/O Supplies
- ❑ System Power Supplies

Typical Application Circuit

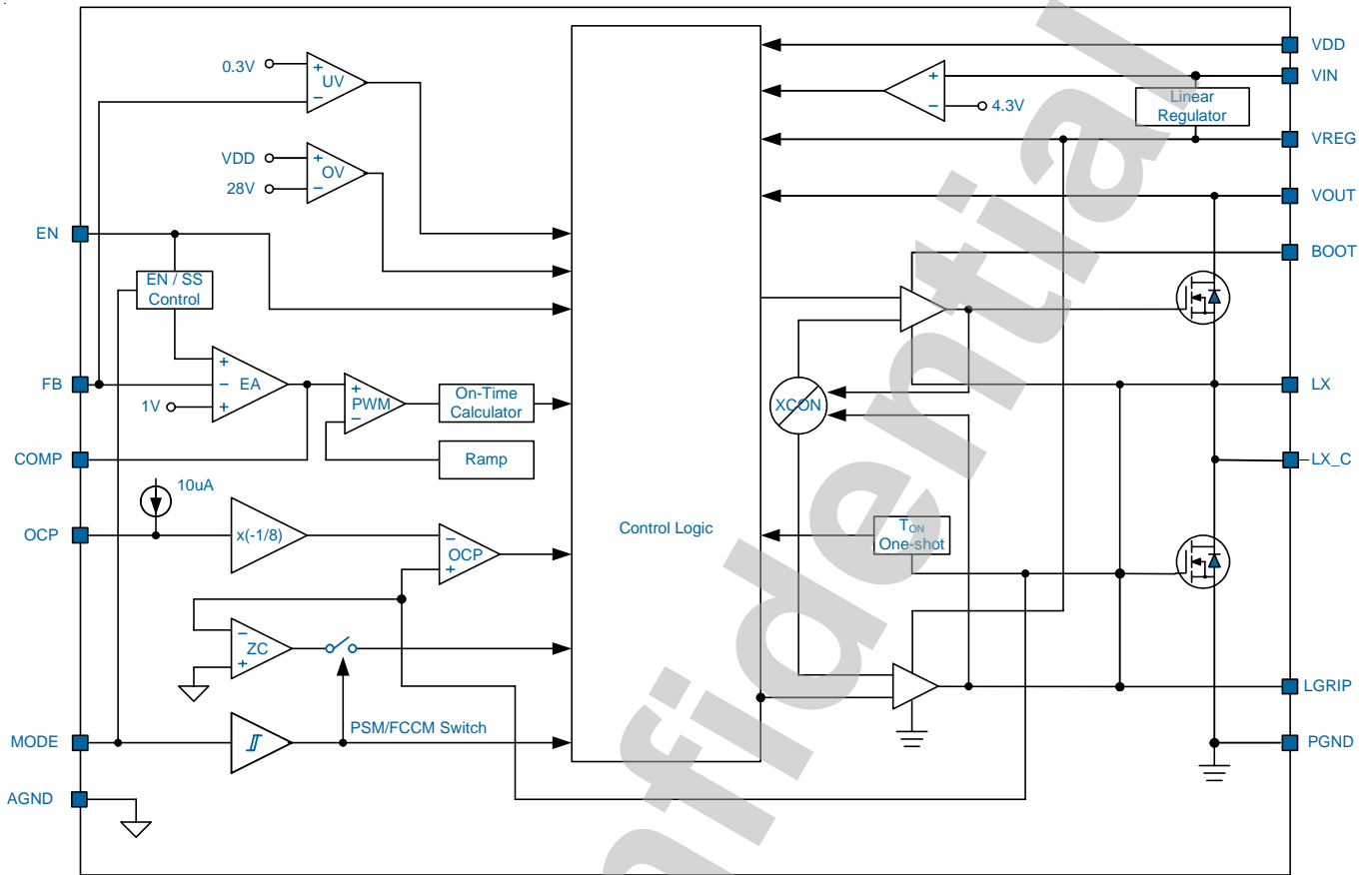


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Functional Pin Description

Pin No.	Pin Name	Pin Function
1	COMP	<b>Boost Converter Compensation.</b> Connect a compensation network to ground.
2	VIN	<b>Power Supply Input.</b> Input voltage that supplies current to the output voltage. This pin provides bias voltage for the IC and powers the internal 5V linear regulators.
3, 17-19, 28	VOUT	<b>Converter Output Pins.</b> Bypass output voltage with a minimum 22uFx3 ceramic capacitor.
4	VDD	<b>Converter Power Input.</b> Connect this pin to VOUT
5	AGND	<b>Signal Ground.</b>
6, 9-13	PGND	<b>Converter Power GND Pin.</b>
7	VREG	<b>5V LDO Output and Gate Drive Supply Voltage Input.</b>
8	LGRIP	<b>Low Side Gate Driver Ripple Injection.</b> Connect a series RC form LGRIP to GND and FB to compensate the control loop.
14-16, 27	LX	<b>Internal Switches Output.</b> Connect this pin to the output inductor.
20	LX_C	<b>Internal Switches Output.</b> Connect the bootstrap capacitor $C_{BOOT}$ to BOOT pin.
21	BOOT	<b>Bootstrap Supply for the Floating Upper MOSFET Gate Driver.</b> Connect the bootstrap capacitor $C_{BOOT}$ between BOOT pin and the LX_C pin to form a bootstrap circuit. The bootstrap capacitor provides the charge to turn on the upper MOSFET. Ensure that $C_{BOOT}$ is placed near the IC.
22	NC	<b>Not Internally Connected.</b>
23	MODE	<b>Operation mode selection pin for the device in light load condition.</b> When this pin is connected to ground, the device works in Pulse-skip mode. When this pin is pulled high, the device works in Force CCM mode.
24	OCP	<b>Over Current Protection Setting.</b> Connect a resistor from this pin to GND to set the over current protection level.
25	EN	<b>Chip Enable.</b> Short to GND to disable the device.
26	FB	<b>Feedback Input.</b> This pin is the inverting input to the error amplifier. A resistor divider from output to GND is used to set regulator voltage.

Functional Block Diagram



Functional Description

The uP6020 implements a unique RCOT<sub>TM</sub> control topology for the synchronous boost. The RCOT<sub>TM</sub> supports extremely low ESR output capacitors and makes the design easier and robust. The output voltage ranges from 9V to 24V. The conversion input voltage ranges from 6V up to 9V.

Adaptive on-time control tracks the preset switching frequency over a wide input and output voltage range while allowing the switching frequency to increase at the step-up of the load.

The uP6020 has a MODE pin to select between Force CCM and Pulse-skip for light load conditions. The strong gate drivers allow low R<sub>DS(ON)</sub> FETs for high-current applications.

**Enable and Soft Start**

When the EN pin voltage rises above the enable threshold voltage (typically 1.8V), the converter enters its start-up sequence. The internal LDO regulator starts immediately and regulates to 5V at the VREG pin. In the second phase, an internal DAC starts ramping up the reference voltage from 0V to 1V. Smooth and constant ramp-up of the output voltage is maintained during start-up regardless of load current.

**On-Time Control and Frequency**

The uP6020 does not have a dedicated oscillator that determines switching frequency. However, the device runs with pseudo-constant frequency by feed-forwarding the input and output voltages into its on-time one-shot timer. The RCOT<sub>TM</sub> control adjusts the on-time to be inversely proportional to the input voltage and proportional to the output voltage. This makes the switching frequency fairly constant in steady state conditions over wide input voltage range.

The off-time is modulated by a PWM comparator. The FB node voltage (the mid-point of resistor divider) is compared to the internal 1V reference voltage added with a ramp signal. When both signals match, the PWM comparator asserts a set signal to terminate the off-time (turn off the low-side MOSFET and turn on high-side MOSFET). The set signal is valid if the inductor current level is below the OCP threshold, otherwise the off-time is extended until the current level falls below the threshold.

**Light Load Condition in Pulse-Skip Operation**

While the MODE pin is connected to ground, uP6020 automatically reduces the switching frequency at light load conditions to maintain high efficiency. This reduction of the frequency is achieved smoothly and without increasing VOUT ripples or load regulation. As the load current is further decreased, it takes longer time to discharge the output capacitor to the level than requires the next ON cycle.

The transition pin from discontinuous to continuous

conduction mode can be calculated as:

$$I_{OUT} = \frac{1}{2 \times f_{OSC} \times L_{OUT}} \times \frac{V_{IN}^2}{V_{OUT}} \times \left(1 - \frac{V_{IN}}{V_{OUT}}\right)$$

**Over Current Limit**

the uP6020 monitors the inductor peak current by low side MOSFET R<sub>DS(ON)</sub> when it turns on. The over current limit is triggered once the sensing current level is higher than V<sub>OCSET</sub>. When triggered, the over current limit will keep low side MOSFET off even the voltage loop commands it to turn on.

The output voltage will decrease if the load continuously demands more current than current limit level and consequently causes V<sub>OUT</sub> to decrease faster until UVP occurs and shuts down the uP6020.

The peak current limit threshold is set by connecting a resistor from OCP to GND. The OCP pin will source a 10uA current and create a voltage drop across R<sub>OCP</sub> as the V<sub>OCSET</sub>. V<sub>OCSET</sub> = 10uA x R<sub>OCP</sub>. When the voltage drop across the low side MOSFET equals the voltage across the setting resistor, the peak current limit will be activated.

The voltage across LX and GND pins is compared with V<sub>OCSET</sub> for current limit. The peak current limit level is calculated as:

$$I_{PEAK\_LIM} = \frac{V_{OCSET}}{8 \times R_{DS(ON)}} + \frac{I_{RIPPLE}}{2}$$

where I<sub>RIIPPLE</sub> is the peak-to-peak inductor ripple current at steady state.

**Over Voltage/Under Voltage Protection**

The uP6020 monitors output voltage to detect over voltage and under voltage. When the output voltage becomes higher than 28V, the OVP is triggered, low side MOSFET is off and the high side MOSFET is on. When the FB voltage is lower than 0.3V, the UVP is triggered, then high side MOSFET and low side MOSFET are latched. This function is enabled after 5ms following EN has become high.

**UVLO Protection**

The uP6020 uses VIN under voltage lockout protection (UVLO). When the VIN voltage is lower than the UVLO threshold voltage, the switch mode power supply shuts off. This is non-latch protection.

**Over Temperature Protection**

The uP6020 monitors the temperature of itself. If the temperature exceeds typical 130°C, the uP6020 will be turned off. This is the non-latch protection. It will be recovered once temperature is lower than 100°C.

**Absolute Maximum Rating**

(Note 1)

VOUT and VDD	-----	-0.3V to +26V
LX Pin Voltage to GND	-----	-0.3V to (VOUT+ -0.3V)
BOOT Pin Voltage	-----	$V_{LX}$ -0.3V to $V_{LX}$ +6V
VIN Pin Voltage	-----	-0.3V to +9.5V
VREG Pin Voltage	-----	-0.3V to +6V
Other Pins to GND	-----	-0.3V to +6V
Storage Temperature Range	-----	-55°C to +150°C
Lead Temperature (Soldering, 10 sec)	-----	260°C
ESD Rating (Note 2)		
HBM (Human Body Mode)	-----	2kV
MM (Machine Mode)	-----	200V

**Thermal Information**

Package Thermal Resistance (Note 3)

WQFN4x4-26L $\theta_{JA, \text{controller and HS}}$	-----	TBD
WQFN4x4-26L $\theta_{JA, LS}$	-----	TBD
WQFN4x4-26L $\theta_{JC, \text{controller and HS}}$	-----	TBD
WQFN4x4-26L $\theta_{JC, LS}$	-----	TBD
Power Dissipation, $P_D$ @ $T_A = 25^\circ\text{C}$		
WQFN4x4-26L $P_{D, \text{controller and HS}}$	-----	TBD
WQFN4x4-26L $P_{D, LS}$	-----	TBD

**Recommended Operation Conditions**

(Note 4)

Input Voltage, $V_{IN}$	-----	6V to 9V
Output Voltage, $V_{OUT}$	-----	9V to 24V
Operating Junction Temperature Range	-----	-40°C to +125°C
Operating Ambient Temperature Range	-----	-40°C to +85°C

- Note 1.** Stresses listed as the above *Absolute Maximum Ratings* may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.
- Note 2.** Devices are ESD sensitive. Handling precaution recommended.
- Note 3.**  $\theta_{JA}$  is measured in the natural convection at  $T_A = 25^\circ\text{C}$  on a low effective thermal conductivity test board of JEDEC 51-3 thermal measurement standard.
- Note 4.** The device is not guaranteed to function outside its operating conditions.

Electrical Characteristics

( $V_{DD} = 5V, T_A = 25^\circ C$ , unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
<b>Power Supply</b>						
VIN UVLO Threshold	$V_{UVLOVIN}$	Rising	--	4.3	--	V
		Hysteresis	--	0.2	--	V
VIN Supply Current	$I_{VIN}$	$V_{EN} = 5V, V_{FB} = 1.1V, I_{OUT} = \text{No Load}$	--	0.6	1	mA
VDD Supply Current	$I_{VDD}$	$V_{EN} = 5V, V_{FB} = 1.1V, I_{OUT} = \text{No Load}$	--	0.36	1	mA
VIN Shutdown Current	$I_{VIN\_SD}$	$V_{EN} = 0V, I_{OUT} = \text{No Load}$	--	--	10	uA
VDD Shutdown Current	$I_{VDD\_SD}$	$V_{EN} = 0V, I_{OUT} = \text{No Load}$	--	--	30	uA
<b>Internal Reference Voltage</b>						
Feedback Voltage	$V_{FB}$	CCM condition, $T_A = 25^\circ C$	0.99	1	1.01	V
VFB Input Current	$I_{FB}$	$V_{FB} = 1V, T_A = 25^\circ C$	--	0.01	0.2	uA
VFB of VOUT Discharge	$V_{FB\_DIS}$	VOUT discharge	--	1.1	--	V
		Hysteresis	--	0.05	--	
<b>Power Switches</b>						
Upper Switch Resistance	$R_{UG,DSON}$		--	22	24.5	mΩ
Lower Switch Resistance	$R_{LG,DSON}$		--	6.5	9	mΩ
<b>Duty and Frequency Control</b>						
Minimum Off-time	$T_{OFF\_MIN}$	$V_{IN} = 6V, V_{OUT} = 12V$	--	430	--	ns
Minimum On-Time	$T_{ON\_MIN}$	$V_{IN} = 6V$	--	230	--	ns
Frequency	$F_{SW}$	$V_{IN} = 6V, V_{OUT} = 9V$ at CCM	--	480	--	kHz
<b>Soft Start</b>						
Soft Start Time	$T_{SS}$	From VEN high to VOUT = 95%	--	8	--	ms
<b>Logic Threshold</b>						
EN Pin Threshold Voltage	$V_{EN}$	Enable	1.8	--	--	V
		Disable	--	--	0.5	
On-Time	$T_{ON}$	$R_{RT} = \text{open}, f_{LX} = 520\text{kHz}$ $V_{IN} = 9V, V_{OUT} = 24V, I_{OUT} = \text{No Load}$	--	1.22	--	us
EN Input Current	$I_{EN}$	$V_{EN} = 5V$	--	--	1	uA
<b>Protection: Current Sense</b>						
OCP Source Current	$I_{CS}$	$V_{OCP} = 1V$	9	10	11	uA
		Temp coef	--	4000	--	ppm/°C

Electrical Characteristics

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
<b>Protection: UVP and OVP</b>						
OVP Threshold Voltage	$V_{OVP}$	Rising	--	28	--	V
UVP Threshold Voltage	$V_{UVP}$	$V_{FB}$	--	0.3	--	V
UVP Propagation Delay Time	$T_{UVPDEL}$		--	3.3	--	ms
Output UVP Delay Time	$T_{UVPEN}$	From Enable to UVP Workable	--	13.5	--	ms
<b>VREG LDO Voltage</b>						
LDO Output Voltage	$V_{REG}$		4.625	5.0	5.375	V
LDO Output Current	$I_{REG}$		--	--	50	mA
LDO Drop Out Voltage	$V_{DROP}$	$V_{IN} = 4.5V, I_{REG} = 20mA$	--	300	--	mV
<b>Thermal Shutdown</b>						
Thermal Shutdown Threshold	$T_{SDN}$	Shutdown Temperature	--	130	--	°C
		Hysteresis	--	30	--	°C

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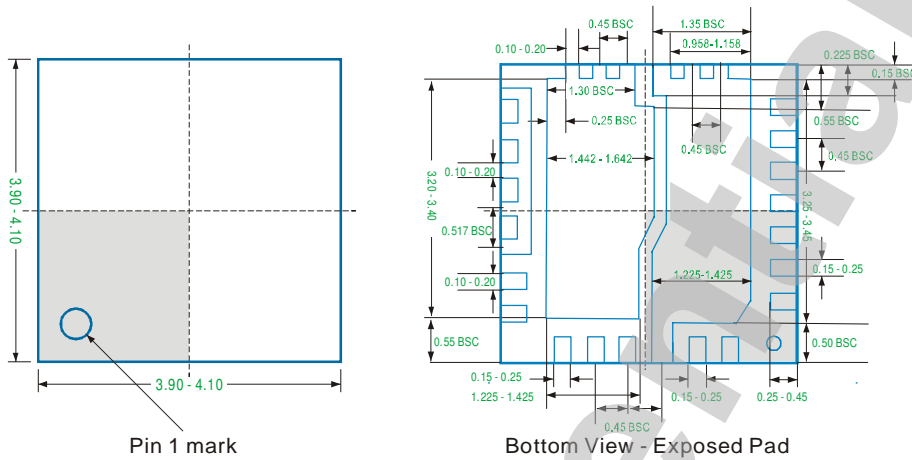
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WQFN4x4 - 26L



Note

1. Package Outline Unit Description:

BSC: Basic. Represents theoretical exact dimension or dimension target

MIN: Minimum dimension specified.

MAX: Maximum dimension specified.

REF: Reference. Represents dimension for reference use only. This value is not a device specification.

TYP: Typical. Provided as a general value. This value is not a device specification.

2. Dimensions in Millimeters.

3. Drawing not to scale.

4. These dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm.

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