AsahiKASEI MICRODEVICES

SH240703

Ultra-Low Power Step-up DC/DC Converter with Microwave Rectifier

1. Overview

This product is an LSI that integrates an ultra-low-power, low-voltage step-up DC/DC converter with a maximum power point tracking (MPPT) function suitable for energy harvesting, power management functions for supplying power to an external system and charging/discharging a large-capacity energy storage device such as a battery, and a rectifier that converts microwave power into DC power.

The DC/DC converter achieves step-up operation even with a DC input power of only 2 µW due to its low power consumption.

The power management function supports both intermittent power supply for IoT devices under ultra-low-power conditions when the battery voltage is low and charging of a large-capacity energy storage device when surplus power is available. This enables stable IoT networks even under unstable power conditions caused by energy harvesting.

The built-in rectifier is suitable for 920 MHz spatial wireless power transfer. In combination with the step-up DC/DC converter, it can convert microwave power from -19 dBm to +10 dBm into DC power and supply it to an external system.

The step-up DC/DC converter of this product is suitable for boosting power from several µW to several handreds of mW, making it ideal for applications such as spatial wireless power transfer and self-powered sensor nodes using various energy-harvesting power sources.

2. Features

- ☐ Step-up startup input voltage/power during cold start: 0.2 V / 1 µW typical
- ☐ Selectable MPPT control by pin setting
- ☐ Step-up input voltage / temperature range: 0.1 to 5.0 V / -30 to +85ºC
- ☐ Current consumption
  - Quiescent current: 290 nA typical at VBOOST = 3.3 V
- ☐ Power Good pin function
- ☐ Selectable step-up voltage control by pin setting
- ☐ Device protection functions: overvoltage protection for step-up input/output pins
- ☐ Built-in 920 MHz microwave rectifier
- ☐ Package: 24-pin QFN (4.0 mm × 4.0 mm × 0.75 mm, 0.5 mm pitch)

3. Applications

- ☐ Spatial wireless power transfer
- ☐ Energy harvesting
- ☐ Self-powered wireless sensor nodes
- ☐ Wearable devices and portable devices

4. Table of Contents

5. Block Diagram and Block Function Description

5.1. Block Diagram

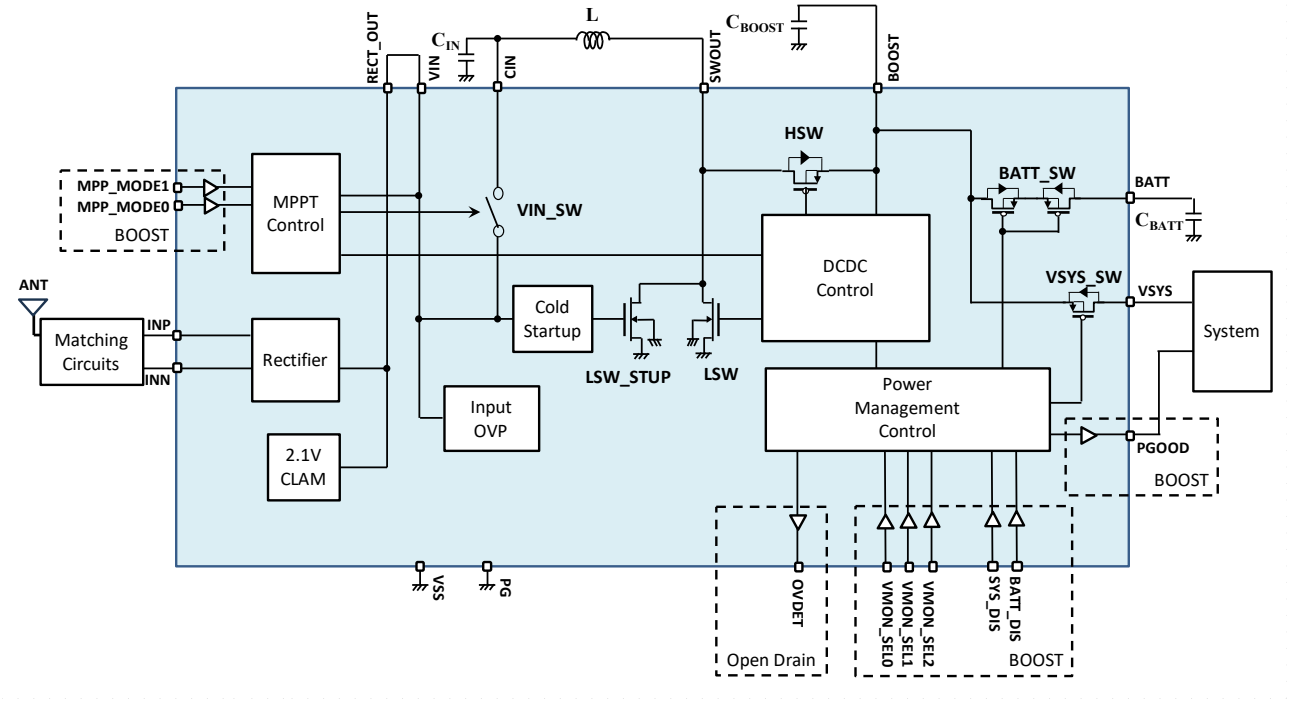


Figure 5.1.1 Block Diagram and External Connection Example

5.2. Block Function Description

Block	Function Description
Rectifier	A rectifier that performs AC-DC conversion of a 920 MHz signal in combination with external matching components.
MPPT Control	Operates during synchronous rectification. Controls the DCDC converter to extract maximum power from the harvesting power source connected to the VIN pin.
Cold Startup	Cold-startup circuit using the VIN pin as input. It generates an internal voltage by boosting the VIN pin voltage and drives the DCDC converter. The DCDC converter operates in asynchronous rectification. This block is powered down during synchronous rectification.
DCDC Control	Control circuit for synchronous rectification of the DCDC converter. This block is powered down during cold startup.
Power Management Control	Control circuit that switches the operating mode. It controls the DCDC converter and each switch in the power path.
2.1V CLAMP	Limits the RECT_OUT pin voltage to 2.3 V or lower to protect the internal circuits.
Input OVP	Overvoltage protection circuit for the VIN pin. When the DC-DC converter stops due to overvoltage protection, this circuit prevents the VIN pin from rising to a high voltage.

6. Pin Function Description

6.1. Pin Function Description

AI: Analog input pin, AO: Analog output pin, DI: Digital input pin, DO: Digital output pin
P: Power pin, G: Ground pin
Do not leave any digital input pin floating.

Table 6.2.1 Pin Function Description

Pin #	Pin Name	I/O	Function Overview
1	PG	G	Ground for DCDC
2	CIN	AO	Input capacitor connection pin for step-up operation Connect a capacitor between this pin and ground.
3	VSS	G	Ground
4	VIN	P	DC-DC converter input pin
5	RECT_OUT	AO	Rectifier output
6	OVDET	DO	Overvoltage protection state output pin (open drain)
7	VSS	G	Ground
8	INP	AI	Rectifier input
9	VSS	G	Ground
10	INN	AI	Rectifier input
11	VSS	G	Ground
12	VSS	G	Ground
13	PGOOD	DO	Power Good output Outputs H when power supply from the BATT pin is valid.
14	VSYS	AO	Output pin for supplying the boosted voltage to the system load
15	BATT	P	BATT pin Connect a rechargeable battery, supercapacitor, or similar device.
16	MPP_MODE0	DI	Pin for MPPT mode setting
17	MPP_MODE1	DI	Same as above
18	VMON_SEL0	DI	Pin for setting the control threshold of the DCDC converter
19	VMON_SEL1	DI	Same as above
20	VMON_SEL2	DI	Same as above
21	BATT_DIS	DI	BATT pin disable pin
22	VSS	G	Ground
23	BOOST	AO	Step-up output pin Connect a capacitor between this pin and ground.
24	SWOUT	AIO	SW pin Connect the step-up power inductor between this pin and the CIN pin.
-	EPAD	-	It is recommended that the exposed pad (EPAD) on the back side of the package be soldered to the board ground.

7. Absolute Maximum Ratings

7.1. Absolute Maximum Ratings

Caution: Operation under conditions exceeding these values may damage the device, and normal operation is not guaranteed. If stress exceeding the values specified in the absolute maximum ratings is applied even once, normal operation thereafter is not guaranteed.

Table 7.1.1 Absolute Maximum Ratings

(VSS=0V; *1)

Parameter		Symbol	Min.	Max.	Unit
Input Power (Differential power between INP* and INN*)	INP INN	$P_{IN\ RF}$	-	+20	dBm
	VIN	P_{IN_VIN}	-	300	mW
Pin Current	BATT	I_{BATT}	-	80	mA
	BOOST VSYS	I_{OUT}	-	80	mA
Pin Voltage	INP INN	V_1	-0.3	2.5	V
	VIN SWOUT, BOOST BATT OVDET	V_2	-0.3	5.5	V
	CIN MPP_MODE0 MPP_MODE1 VMON_SEL0 VMON_SEL1 VMON_SEL2 MPP_SEL BATT_DIS TEST1 TEST2 TEST3 TEST4	V_3	-0.3	BOOST+0.3	V
	PG	V_4	-0.3	0.3	V
Power Dissipation*2		Pd	-	0.99	W
Storage Temperature Range		T_{STG}	-55	+150	℃
Junction Temperature Range		T_J	-40	+125	℃

Notes:

*1. All voltages are referenced to ground.

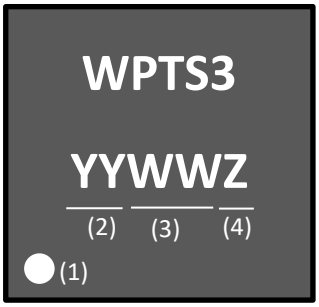
*2. When using a 74 mm square, 1.6t, 4-layer FR-4 board and Sn-3.0Ag-0.5Cu solder.

8. Marking Diagram

8.1. Marking

Package type : HVQFN
Number of pins : 24 pins
Part number : WPTS3
Date code : YYWWZ (5 digits)
1-pin indication : Dot mark (●)

YY: Last two digits of the calendar year (2024 -> 24)
WW: Manufacturing week
Z: Management code used to distinguish wafer lots within the same manufacturing week for each product (A, B, C, ...)
Assigned sequentially from A for each lot.



(1) 1 Pin Indication
(2) Year code (last 2 digits)
(3) Week code
(4) Management code

Figure 8.1.1 Marking Diagram

9. Package Outline Drawing

9.1. Package Outline

24-pin HVQFN (4.0 x 4.0mm, 0.5mm pitch)

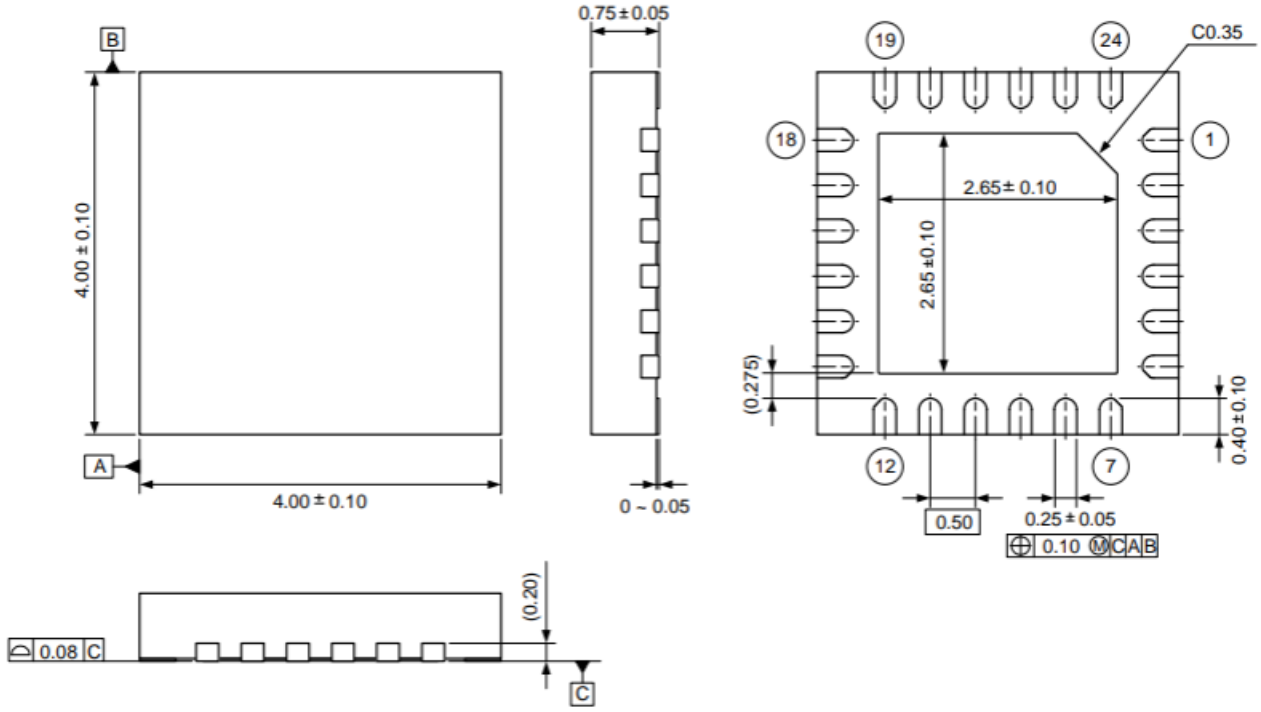


Figure 9.1.1 Package Outline Drawing

* It is recommended that the exposed pad at the center of the back side of the package be soldered to the board ground.

10. Measurement result

10.1. Reference Circuit Example and Measurement Results

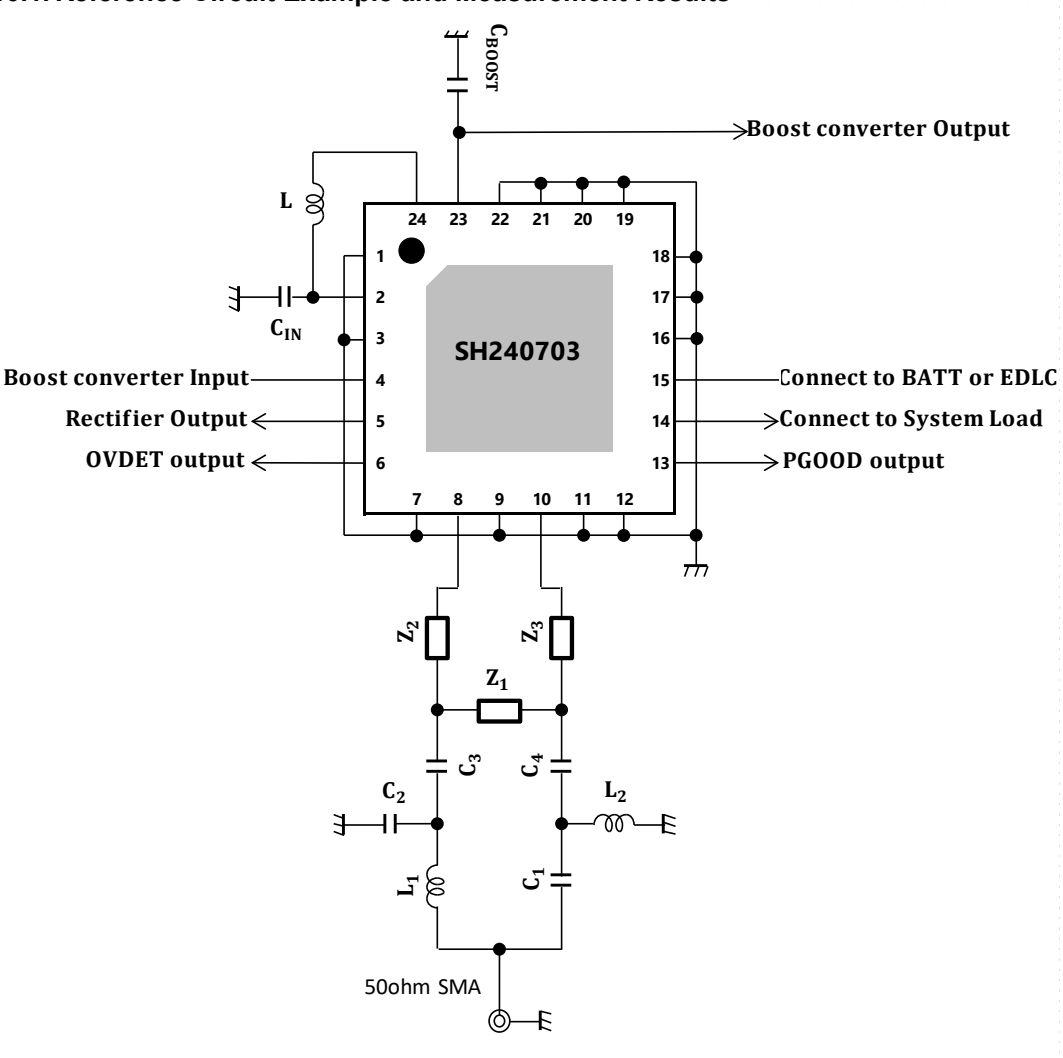


Figure 10.1.1 External Circuit Example (920 MHz)

Table 10.1.1 Component Values for 920 MHz Matching Circuit

Symbol	Value	Remarks
L_1	11nH	LQW15Axx
L_2	11nH	LQW15Axx
Z_1	12nH	LQW15Axx
Z_2	30nH	LQW15Axx
Z_3	30nH	LQW15Axx
C_1	2.4pF	GJM155xx
C_2	2.4pF	GJM155xx
C_3	68pF	GRM155xx
C_4	68pF	GRM155xx

Table 10.1.2 Component Values for External Step-up Circuit

Symbol	Value	Remarks
L	33uH	LSXND4040MKL330MDG
C_{IN}	22uF	GRM21Bxx
C_{BOOST}	22uF	GRM21Bxx

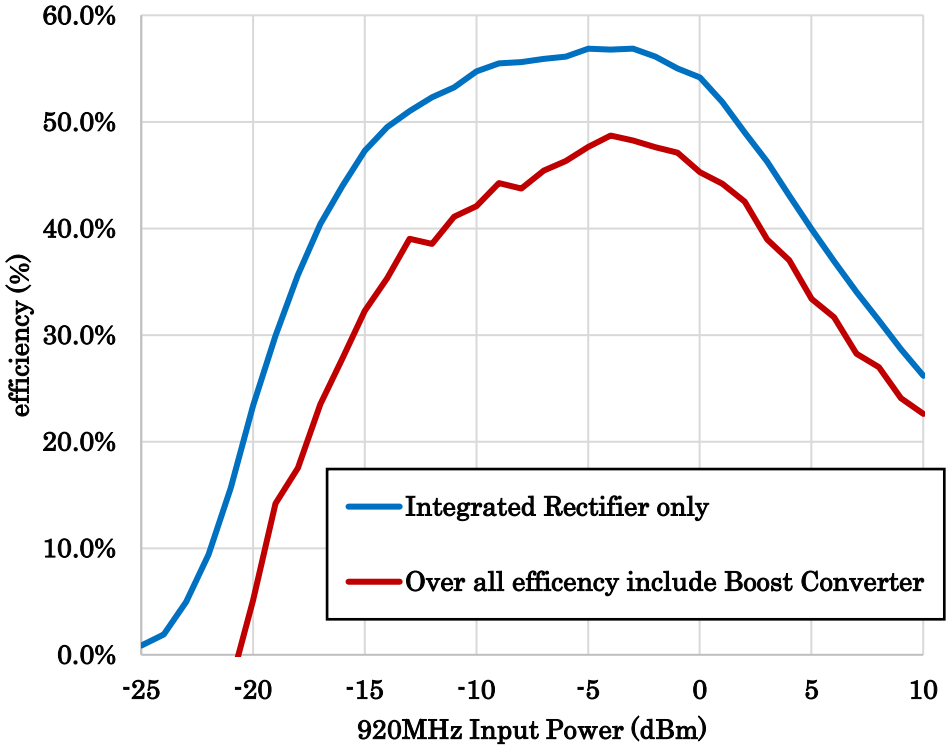


Figure 10.1.2 Measurement Results of RF-DC Conversion Efficiency (920 MHz)