MKS3062

DATASHEET

Version: 1.4
Release date: 2025-09-10

1 Description

MKS3062 is an integrated energy management circuit. The chip can start operating with an input voltage as low as 350mV voltage and 2 μW power. It extracts DC power from a harvesting source to store energy in a storage element, simultaneously supply an application circuit.

2 Features

- Ultra-low power start-up

- Cold start from 350 mV input voltage and 2μW input power.

- Ultra-low power boost regulator

- Configurable MPPT with 2-pin programming.
- Selectable voltage ratios of 70%, 75%, 80% or 85%.
- Open-circuit voltage sensing for MPPT every 5s.
- MPPT voltage operation range from 150 mV to 5V.

- Regulated output for application circuit

- Buck regulator with efficiency above 90 %.
- Selectable output voltage (2.2V, 2.5V or 3.3V).
- Output current up to 120mA.

- Energy storage management

- Selectable or adjustable overcharge and overdischarge protection for any type of rechargeable battery or supercapacitor.

- Shipping mode

- Disables charging and discharging of the battery during shipment.

- External 5 V charging capability

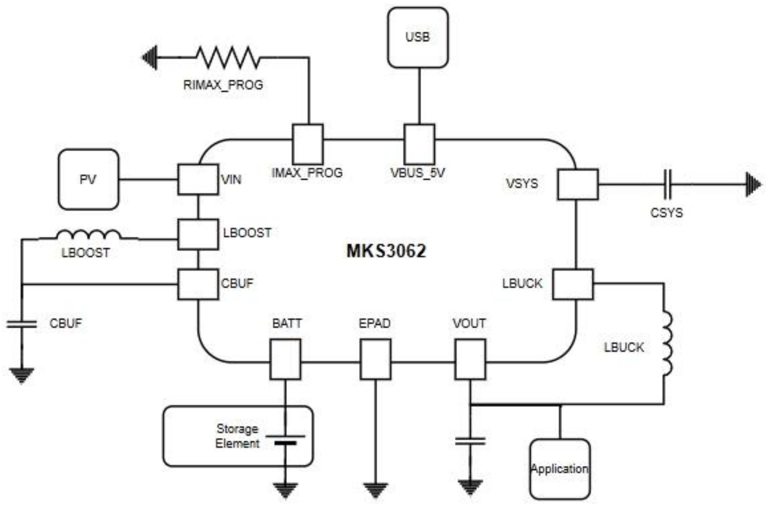
- Extra charging input for 5V power supplies.
- CC/CV charging with configurable current limit in CC mode (max. 200 mA).
- Provides a fast charge alternative when no source is available for a long time.

3 Applications

- Industrial monitoring
- Smart remote control
- Wireless sensor node
- PC Peripheral
- Home automation
- Electronic health monitoring

Device Information

Part Number	Package	Body size
MKS3062	QFN 24-pin	4x4mm



4 Package Diagram

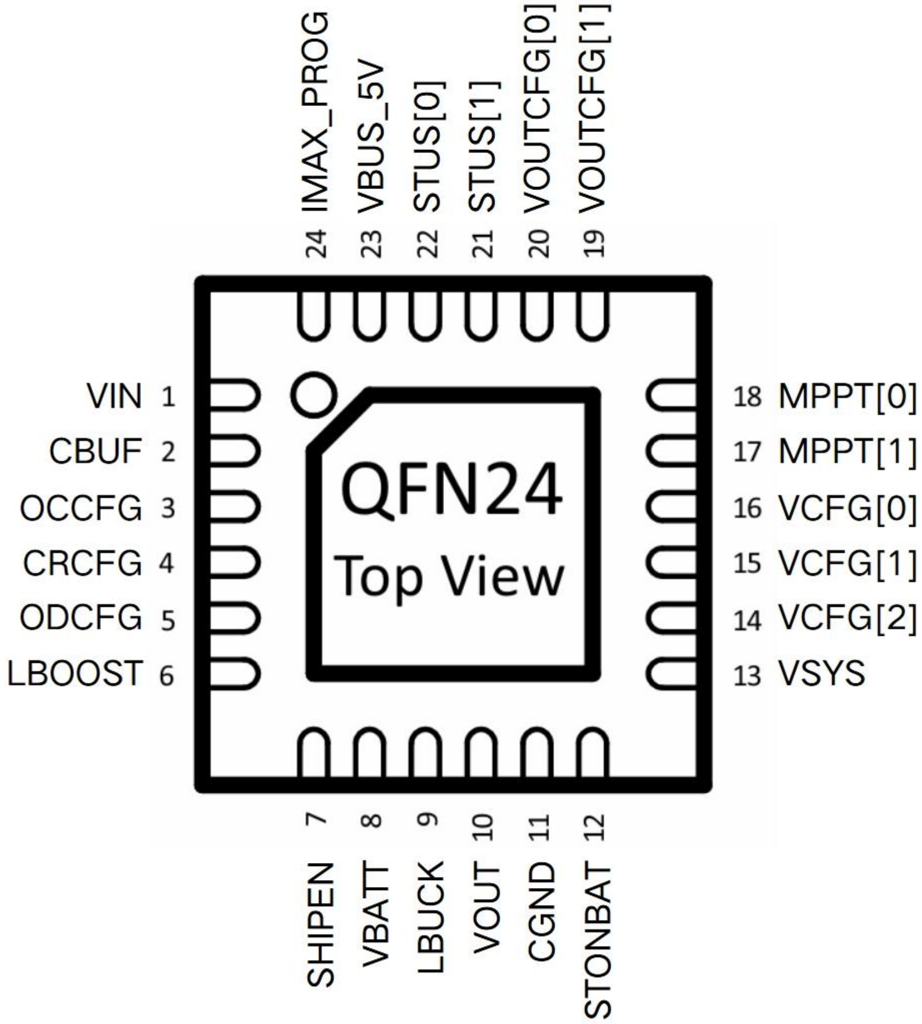


Figure 1: Pinout diagram

5 Pin Configuration

Table 1: Pins description

Name	Pin #	Function
Power pins		
VIN	1	Input of the boost converter Connection to the harvest energy source.
CBUF	2	Connection to an external capacitor buffering the boost converter input.
LBOOST	6	Switching node of boost converter.
VBATT	8	Connected to the energy storage elements, such as battery or capacitor. Cannot be left floating.
LBUCK	9	Switching node of the buck converter.
VOUT	10	Output of the buck Converter.
VSYS	13	Internal power supply (do not connect any external circuit on VSYS). Connection for CSYS buffering capacitor.
VBUS_5V	23	Input of the 5V DC power supply (optional). Leave floating if not used.
Configuration pins		
VCFG [2]	14	Used for the configuration of the threshold voltages of the energy storage element.
VCFG [1]	15	
VCFG [0]	16	
MPPT [1]	17	Used for the configuration of the MPPT ratio.
MPPT [0]	18	
VOUTCFG[1]	19	Used to configure the LOAD output regulation voltage.
VOUTCFG[0]	20	
OCCFG	3	Used for the configuration of the threshold voltages for the energy storage element when in custom mode (optional). If the custom mode is not used: leave them floating.
CRCFG	4	
ODCFG	5	
CGND	11	
IMAX_PROG	24	Connect to an external resistor to set the charging current from the VBUS_5V supply. Leave floating if the VBUS_5V power supply is not used.
SHIPEN	7	Logic input. When HIGH: - Minimum consumption from the storage element. - Storage element charge is disabled (boost converter is disabled). - Buck (VOUT) is disabled. -VSYS is charged only if energy is available on VIN. Read as LOW if left floating.
STONBAT	12	Logic input. When HIGH: - The chip startup from battery when VBATT>Vod. - The Buck(VOUT) can be enable when VBATT>Vcr. Need to pull down to GND if not used (floating forbidden).
Status pins		
STUS [1]	21	Logic output. Asserted if STO voltage falls below Vod.
STUS [0]	22	Logic output. Asserted when STO is ready for supply.
Other pins		
GND	Exposed pad	Ground connection, should be solidly tied to the PCB ground plane.

6 Typical Electrical Characteristics

Table2: Electrical characteristics

Symbols	Parameter	Condition	Minimum Value	Typical value	Maximum value	Unit
Power conversion						
PVIN	Source power required to cold start.	During cold start	2	/	/	μW
VVIN	Input voltage of the energy source (maximum given by the open-circuit voltage).	During cold start	0.35	/	5.5	V
		After cold start	0.15	/	5	V
IVIN	Harvested current from the energy source.				170	mA
Vboost	Output voltage of the boost converter.	During normal work	2.2	/	4.5	V
VVOUT	Output voltage of the buck converter.	During normal work	2.2	2.5	3.3	V
IVOUT	Load current supplied by the buck converter	During normal work	0		120	mA
VVBUS_5V	Voltage on the VBUS_5V pin to allow for charging the battery.		4.30		6.50	V
I5V,CC	Maximum charging current of 5V charger when in constant current (CC) mode. This is programmed by the resistor on the IMAX_PROG pin.	During normal work	10		200	mA
Energy storage components						
Vbat	Voltage on the storage element.	Rechargeable battery	2.2	/	4.5	V
		Capacitance	0	/	4.5	V
Tdly	Time when STUS [1] takes effect to shutdown		400	600	800	ms
Voc	Maximum voltage accepted on the storage element before disabling the boost converter.	/	2.3	/	4.5	V
Vcr	Minimum voltage required on the storage element before enabling the VOUT(BUCK) when coming from WAKE-UP MODE.	/	2.25	/	4.45	V
Vod	Minimum voltage threshold of STO to enter SHUTDOWN MODE.	/	2.2	/	4.4	V
Internal system supply & quiescent current						
VVSYS	Internal voltage supply.	/	2.2	2.25	2.3	V
IVSYS	Quiescent current on VSYS in NORMAL STATE.			400		nA
ISHIP	Quiescent current on VBAT when the shipping mode functionality is enabled (SHIPEN set HIGH).	/		20		nA
Logic output pin						
STUS [1: 0]	Logic output levels on the status pins.	Logic High (VOH)	1.98	Vbat	/	V
		Logic Low (VOL)	-0.1	/	0.1	V

7 Recommended Operation Conditions

Table3: Recommended external components

Symbols	Parameter	Minimum Value	Typical value	Maximum value	Unit
External components					
CBUF	VIN pin decoupling capacitor.	8	10	/	μF
LBOOST	Inductor of the boost converter.	4	10	/	μH
CBUCK	Output capacitor of the buck converter.	8	22	/	μF
LBUCK	Inductor of the buck converter.	4	22	/	μH
CSYS	Capacitor decoupling the VSYS terminal	8	10	/	μF
R5V_IMAX	Resistor for configuring the 5V charger current when in constant current mode (CC) (Optional).	/	220	/	Ω
Logic input pin					
MPPT [1: 0]	Configuration pins for the MPPT ratio	Logic High (VOH)	Connect to VSYS (internal connect, set floating)		
		Logic Low (VOL)	Connect GND		
VCFG [2: 0]	Configuration pins for the storage element protection threshold voltages	Logic High (VOH)	Connect to VSYS (internal connect, set floating)		
		Logic Low (VOL)	Connect GND		
VOUTCFG [1: 0]	Configuration of the VOUT buck output voltage regulator.	Logic High (VOH)	Connect to VSYS (internal connect, set floating)		
		Logic Low (VOL)	Connect GND		
SHIPEN	Ship mode enable	Logic High (VOH)	Connect VBAT		
		Logic Low (VOL)	Connect GND		
STONBAT	Startup form battery enable	Logic High (VOH)	Connect VBAT		
		Logic Low (VOL)	Connect GND		

Table 4: Absolute maximum ratings

Parameter	Scope
VVIN	5.5 V
Operating junction temperature	-40 °C to + 125 °C
Storage Temperature	-65 °C to + 150 °C

8 Functional Block Diagram

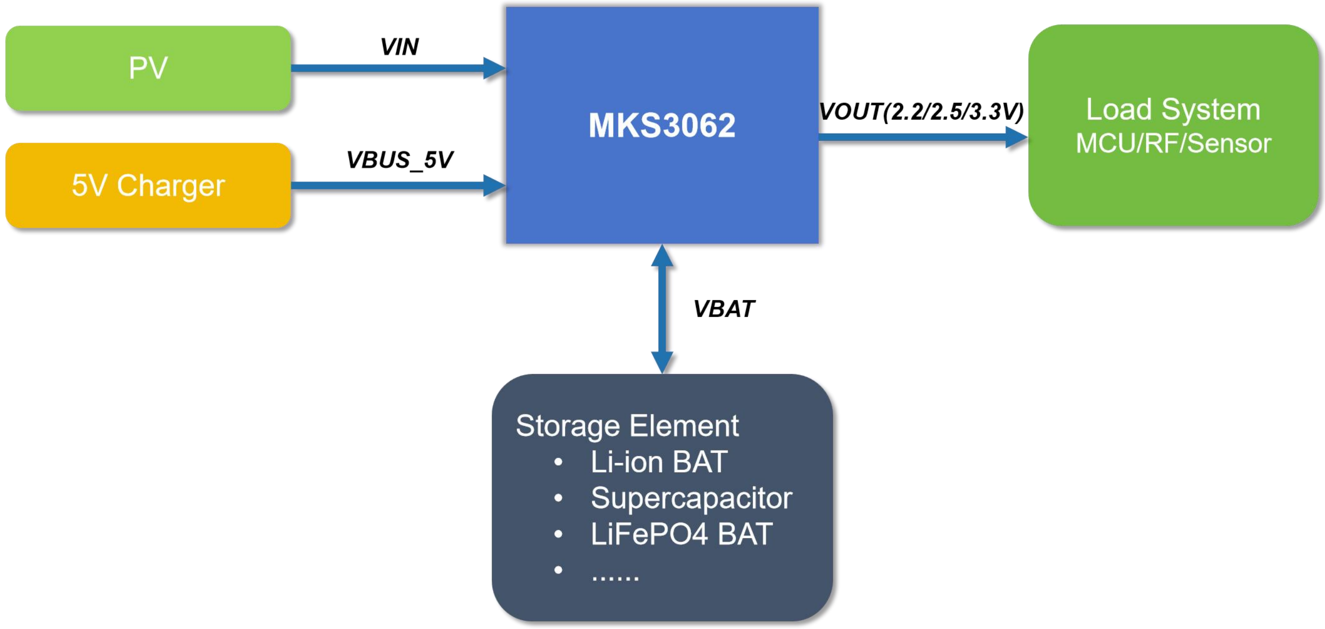


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Figure 2: Functional block diagram

9 Theory of Operation

9.1 Boost

The boost converter raises the voltage available on the input source to a level suitable for charging the storage element, in the range of 2.2V to 4.5V. The reactive power components of this converter are the external inductor LBOOST.

The storage element is connected to the VBAT pin. In the process of energy harvesting, the boost converter will provide a current that is shared between the battery and the BUCK.

9.2 Buck converter

The buck converter lowers the voltage from VBAT to a constant Vbuck value, which is available through the VOUT pin. The companion components of the buck converter are an external inductor LBUCK and a capacitor CBUCK.

The chip has a BUCK that provides different operating voltages: the BUCK powers the load through the VOUT. This BUCK supplies a voltage across the VOUT with a maximum current of 120 mA. Output voltage of 2.2V,2.5V,3.3V or disabled can be configured by pins VOUTCFG[1:0].

9.3 Deep sleep mode and wake-up mode

The DEEP SLEEP MODE is a state where all nodes are deeply discharged and there is no available energy to be harvested. As soon as the required cold-start voltage of 350 mV and the required power of 2μW becomes available on VIN, the WAKE-UP MODE is activated. The boost converter charges VBAT from the input source. When Vbat below Vcr, the BUCK is disabled and STUS[0] is set to low. When Vbat reaches Vcr, the circuit enters NORMAL MODE, STUS[0] is asserted and the VOUT(BUCK) can be enabled by the using VOUTCFG[1:0].

9.4 Normal mode

Once the chip enters NORMAL MODE, it stays in this mode as long as the following condition is met:

Vod< Vbat< Voc

The chip will switch to another mode in the following cases:

(1) Vbat increases above Voc because the source provides more power than the load consumes. The circuit enters OVERCHARGE MODE,

(2) Vbat falls below Vod due to not enough power available from the source. In this case, the circuit enters SHUTDOWN MODE.

9.5 Over voltage mode

When Vbat reaches Voc, the charging is complete. The chip component maintains the Vbat voltage around Voc with a hysteresis of a few mV to prevent damage to the energy storage element and internal circuitry. In this configuration, the boost converter is periodically activated to maintain Vbat, and the VOUT(BUCK) is still available.

9.6 Shutdown Mode

When Vbat drops below Vod, the chip will enter SHUTDOWN MODE to prevent damage to storage element and VOUT(BUCK) instability caused by deep discharge. The chip asserts STUS[1] to warn the application that a shutdown may occur. The VOUT(BUCK) remain enabled during the next 600ms.

The load can be interrupted by the low-to-high transition of STUS[1] when the load is powered by VOUT, and then to take all appropriate actions before the VOUT is disabled.

If Vbat returns to Vcr within Tdly (about 600 ms), the chip switch to NORMAL MODE. However, if Vbat does not reach Vcr after Tdly, the chip switch to DEEP SLEEP MODE. VOUT(BUCK) is disabled and VBAT is disconnected from VIN to avoid damaging the battery due to over-discharge. From now on, the chip will have to perform the wake-up process described in the Deep sleep and Wake-up mode section.

9.7 Maximum power point tracking

During NORMAL MODE, SHUTDOWN MODE and WAKEUP mode, the boost converter is regulated with the internal MPPT (Maximum Power Point Tracking) module.

The MPPT module evaluates Vmpp as a constant fraction of the open-circuit voltage of the source VOC(voltage of open circuit). The ratio between Vmppt and VOC can be configured with the MPPT[1:0] pins. The chip periodically measures VOC by stopping to draw current from the source (VIN pin) to make the source rise to its open-circuit voltage in 80ms every 5 seconds. The source target voltage Vmppt is then redefined as a fraction of the previously measured VOC. In this way, the MPPT module adapts to the harvester variations due to varying ambient conditions. The chip support wide Vmppt voltage range from 0.15 V to 5 V.

9.8 5V Charger

The MKS3062 is equipped with a 5V charger for fast charging the battery that connected on the VBAT pin. When a voltage higher than 4.3V and V_{BAT} is detected on the VBUS_5V pin, the charger starts charging the battery, implementing a constant current / constant voltage operation (CC/CV):

(1) Constant current (CC) operation:
  - (a) When V_{BAT} is not close to Voc.
  - (b) Battery charging current $I_{5V,CC}$ is configured by the value of the R_{IMAX_PROG} resistor connected to the IMAX_PROG pin. $I_{5V,CC}$ is 200 mA.

(2) Constant voltage (CV) operation:
  - (a) When V_{VBAT} is close to Voc.
  - (b) The charging current $I_{5V,CV}$ gradually decreases to zero as the V_{VBAT} reaches Voc.

Using the 5V charger is not mandatory. When not used, leave both VBUS_5V and IMAX_PROG pins floating.

9.9 Shipping Mode

(1) When SHIPEN is HIGH, shipping mode is enabled.

(2) When SHIPEN is LOW, shipping mode is disabled.

9.10 Startup from battery

(1) Logic input on the STONBAT pin. When HIGH:
  - (a) The chip startup from battery without PV input when VBATT>Vod.
  - (b) The Buck(VOUT) can be enable when VBATT>Vcr.

(2) Must pull down to GND if not used (floating forbidden).

10 System configuration

10.1 Storage Element Thresholds

Predefined mode:

By configuring three pins (VCFG[2: 0]), users can set the specified working mode, which can meet the requirements of most application scenarios. For relevant configurations, please refer to the table below.

Table 5: Configuration application of VCFG [2: 0]

Configuration pins			Energy storage device voltage			Typical Applications
VCFG[2]	VCFG[1]	VCFG[0]	Voc	Vcr	Vod	/
1	1	1	4.12V	3.67V	3.60V	Lithium-ion Super Capacitor (LiC)
1	1	0	4.12V	4.04V	3.60V	LiPo battery
1	0	1	4.12V	3.67V	3.01V	Lithium-ion
1	0	0	2.70 V	2.30 V	2.20 V	Single core supercapacitor
0	1	1	4.50V	3.67V	2.80V	Dual-core supercapacitor
0	1	0	4.50V	3.92V	3.60V	Dual-core supercapacitor
0	0	1	3.63 V	3.10 V	2.80 V	LiFePO4 battery

The three voltage threshold levels are defined as:

Voc: the maximum acceptable voltage on the energy storage element;

Vcr: the lowest voltage required on the energy storage element after cold start, before the VOUT (BUCK) is enabled;

Vod: The minimum voltage of STO before entering the shutdown state.

Once the predefined configuration is selected, the resistor pins dedicated to the custom configuration should be floated (OCCFG, CRCFG, ODCFG, CGND). Custom mode allows the user to define the Voc, Vcr, Vod voltages.

Custom mode:

Configure VCFG [2:0] grounding, and the 4 matchable resistors need to be connected according to Figure 3. The configuration calculation formula is as follows:

(1) Voc,Vcr,Vod are configured by R1 to R4, RT = R1+R2+R3+R4, then R1 to R4 are calculated according to the following formula:

- **1M Ω ≤ RT ≤ 100M Ω**
- **R1 = RT (1V/Voc)**
- **R2 = RT (1V/Vcr-1V/Voc)**
- **R3 = RT (1V/Vod − 1V/Vcr)**
- **R4 = RT (1-1V/Vod)**

(2) Try to choose the resistance value as large as possible so that the power consumption can be negligible. The configuration should conform the following constraints to ensure the chip function.

- **Vcr + 0.05 V ≤ Voc ≤ 4.5 V**
- **Vod+0. 05 V ≤ Vcr ≤ Voc-0. 05 V. Vod+0. 05 V**
- **2.2 V ≤ Vod**

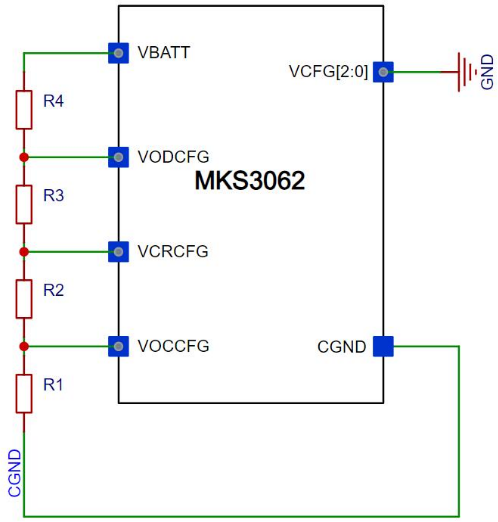


Figure 3: Custom configuration connection diagram

10.2 MPPT Configuration

Two parameters are necessary to configure the Maximum Power Point Tracking (MPPT). The first parameter is the MPPT tracking voltage ratio, which is selected according to the characteristics of the input power source. This parameter is set by the configuration pins MPPT[1:0]. It provides choices of four values for Vmppt/Voc (input source open circuit voltage) by configuring pin MPPT [1:0], as shown in the table.

Table 6: MPPT Pin Configuration Table

MPPT [1]	MPPT [0]	Vmppt/Vov
0	0	80%
0	1	70%
1	0	75%
1	1	85%

10.3 VOUT (BUCK converter)

Table 7: Configuration of VOUT (buck voltage) with VOUTCFG[1:0] pins

Configuration pins		VOUT voltage [V]
VOUTCFG[1:0]		VVOUT
L	L	OFF
L	H	2.2
H	L	2.5
H	H	3.3

The VOUT (buck voltage) cannot be selected higher than Vod. In such situation, the system will not start the buck converter.

10.4 5V Charger

(1) The 5V charger implements CC/CV operation. When in CC, the maximum charging current $I_{5V,CC}$=200mA.

(2) The reference resistor for RIMAX_PROG is 220Ω.

10.5 Energy storage component configuration

The energy storage component supported by the MKS3062 can be rechargeable battery, supercapacitor or large capacitor, and its voltage should not drop below Vod even when the load current occasionally peaks. The leakage current of the capacitor should be as small as possible, because the leakage current will directly affect the quiescent current of the subsystem. When selecting energy storage components, you should pay attention to:

The CBUF capacitor acts as an energy buffer at the input of the boost converter, which can prevent large voltage fluctuations when the boost converter is switched, with a recommended value of 10 μF +/-20%.

The CVSYS capacitor is used as the energy buffer of the system. The recommended value is 10 μF +/-20%.

CBUCK capacitor acts as an energy buffer at the input of the buck converter, which can prevent large voltage fluctuations when the buck converter is switched, with a recommended value of 10 μF +/-20%.

11 Typical Applications Circuit

11.1 Example Circuit 1

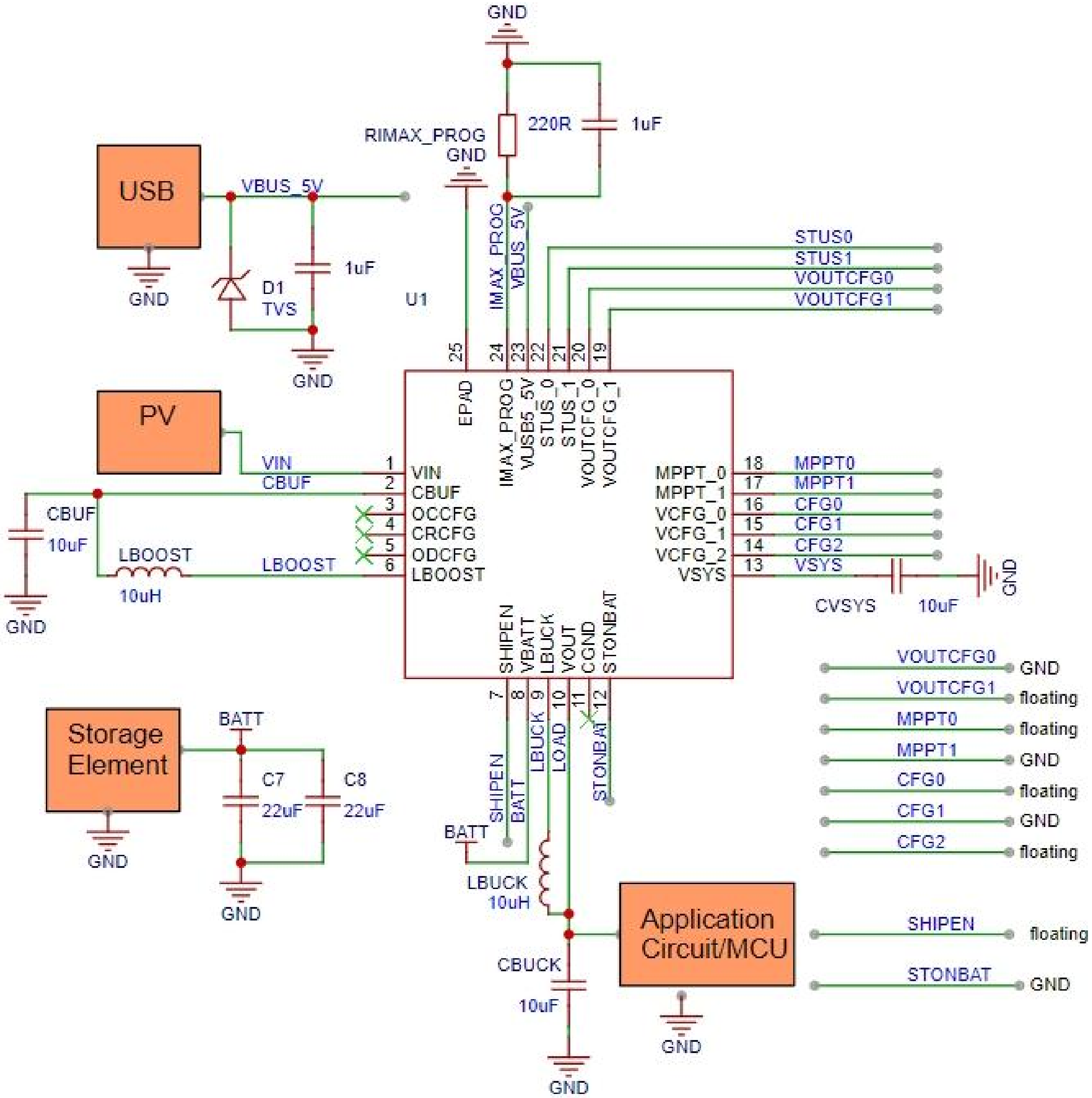


Figure 4: Typical application circuit

The figure shows a typical application circuit of the MKS3062.

Configuration of VIN: The second energy source is a PV cell which has a 70% MPPT ratio. The Configuration pin MPPT[1:0]=2'b01.

Configuration of storage element: The circuit uses a predefined operating mode (VCFG [2: 0] = 3'b101). In this mode, the threshold voltages are Voc = 4.12 V, Vcr = 3.67 V, and Vod = 3.01 V. The storage element is a standard Li-ion battery cell.

Configuration of VOUT: The application circuit is supplied with 2.5V with current peaks up to 120mA. The buck converter is configured to VOUTCFG[1:0]=2'b10.

Configuration of 5V_IN: The maximum allowed current to charge the storage element is 200mA. Closest standard series resistor is 220Ω, which leads to a 200mA maximum current.

Configuration of SHIPEN: Shipping mode is floating when disable.

11.2 Example Circuit 2

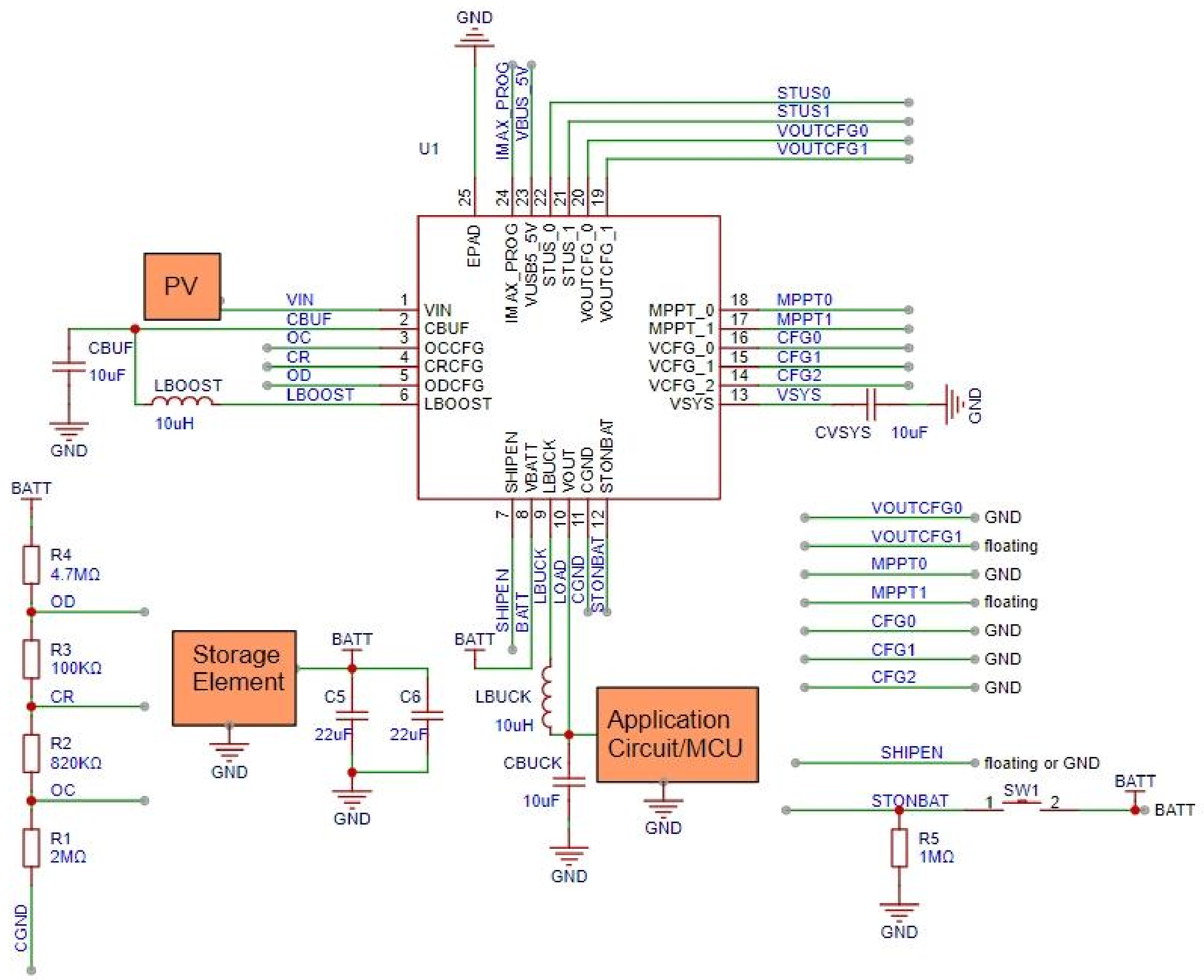


Figure 5: Typical application circuit 2

The figure shows a typical application circuit of the MKS3062.

Configuration of VIN: The second energy source is a PV cell which has a 75% MPPT ratio. The Configuration pin MPPT[1:0]=2'b10.

Configuration of storage element: The circuit uses a customer operating mode (VCFG [2: 0] = 3'b000). In this mode, the threshold voltages are Voc = 3.80 V, Vcr = 2.70 V, and Vod = 2.60 V. The storage element is a supercapacitor.

Configuration of VOUT: The application circuit is supplied with 2.5V with current peaks up to 120mA. The buck converter is configured to VOUTCFG[1:0]=2'b10.

Configuration of 5V_IN: Floating when disable.

Configuration of STONBAT: Connected to the battery voltage via the control button, and the chip fast startup.

Configuration of SHIPEN: Shipping mode is floating when disable.

12 Layout Guidelines

Figure 6 shows an example of PCB layout with MKS3062.The following guidelines must be applied for best performances:

1) Make sure that ground and power signals are routed with large tracks. If an internal ground plane is used, place via as close as possible to the components, especially for decoupling capacitors.

2) Reactive components related to the boost/buck converter must be placed as close as possible to the corresponding pins (LBOOST, CBUF, VBAT, LBUCK and VOUT), and be routed with large tracks/polygons.

3) PCB track capacitance must be reduced as much as possible on the boost converter switching node LBOOST/LBUCK. This is done as follows:

a) Keep the connection between the LBOOST/LBUCK pins and the corresponding inductor short.

b) Remove the ground and power planes under the LBOOST/LBUCK nodes.

c) Increase the distance between LBOOST/LBUCK and the ground polygon on the external PCB layer where the MKS3062 is mounted.

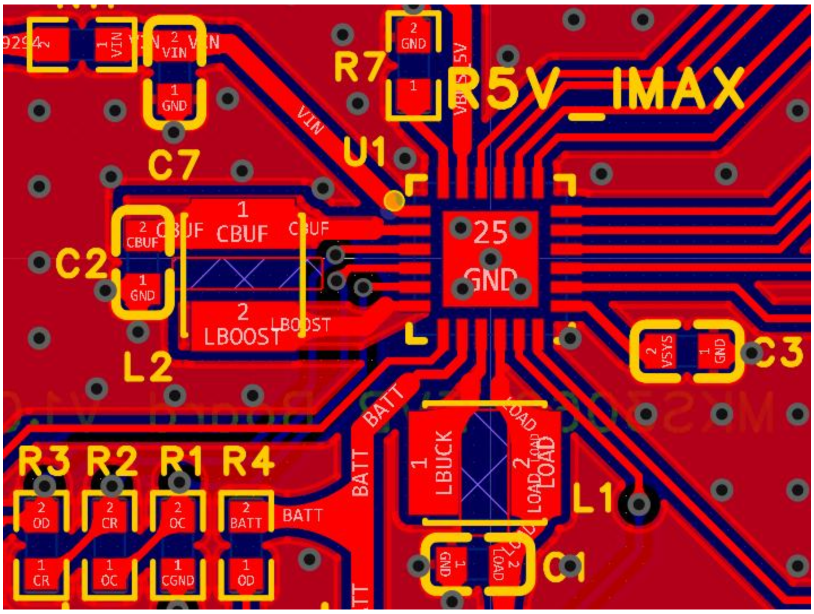
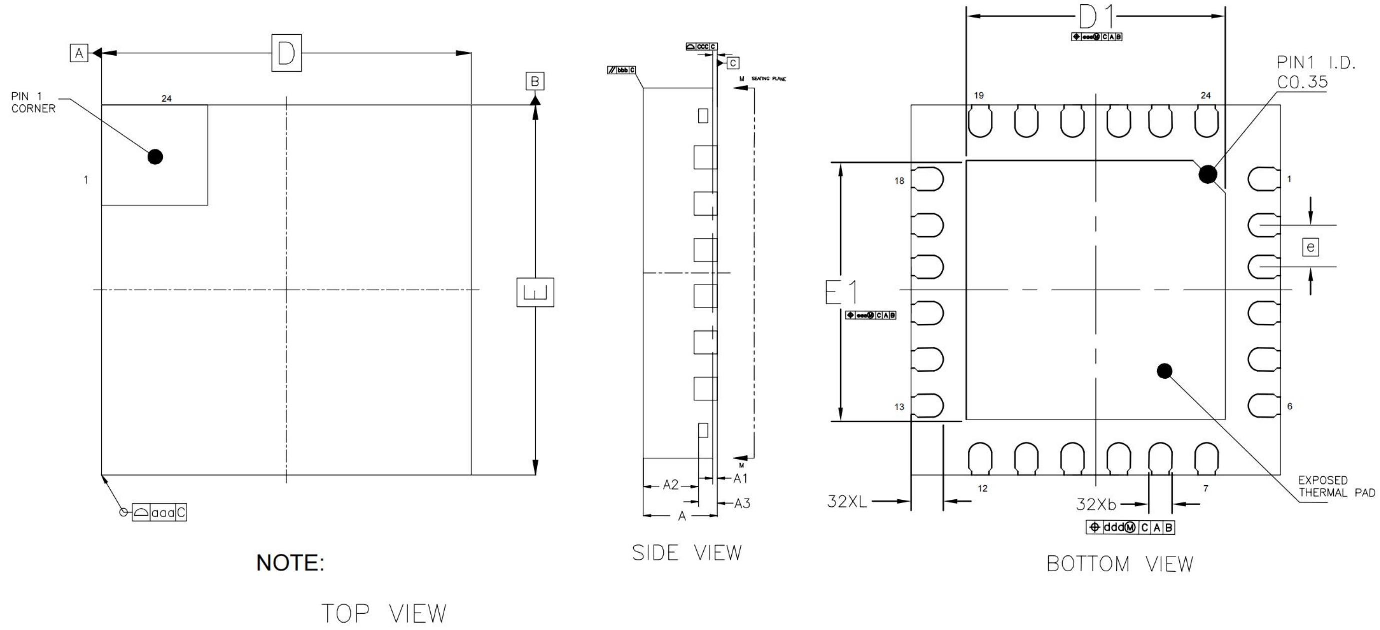


Figure 6: Layout example for the MKS3062

13 Package Information

The MKS3062 chip package is packaged in a QFN24 4x4mm package as shown in the figure.



DESCRIPTION		SYMBOL	MILLIMETER		
			MIN	NOM	MAX
TOTAL THICKNESS		A	0.70	0.75	0.80
STAND OFF		A1	0.00	0.02	0.05
MOLD THICKNESS		A2	- - -	0.6	- - -
L/F THICKNESS		A3	0.203REF		
BODY SIZE	X	D	3.90	4.00	4.10
	Y	E	3.90	4.00	4.10
LEAD PITCH		e	0.50 BSC		
LEAD WIDTH		b	0.20	0.25	0.30
LEAD LENGTH		L	0.30	0.40	0.50
EP SIZE		D1	2.35	2.45	2.55
		E1	2.35	2.45	2.55
Tolerance of form and position					
PACKAGE EDGE TOLERANCE		aaa	0.1		
MOLD FLATNESS		bbb	0.1		
LEAD COPLANARITY		ccc	0.08		
LEAD POSITION OFFSET		ddd	0.1		
EXPOSED PAD OFFSET		eee	0.1		

Figure 7: Schematic diagram of chip packaging