NH2D0245
Energy Harvesting PMIC

1. Description

The NH2D0245 is a high-performance energy harvesting solution for low-power applications. The NH2D0245 harvests energy generated by a source, for instance, photo-voltaic (PV) cell, or a piezo-electric harvester with a rectifier. The energy charges a storage element such as a rechargeable battery or a supercapacitor.

Nowi's advanced maximum power point tracking (MPPT) uses an embedded hill-climbing algorithm to deliver the maximum power to the load. The MPPT is designed to be independent of specific characteristics of the harvesters, therefore any harvester that fits the specifications of the chip can be used. Moreover, the MPPT circuit can detect the maximum power point with an interval of 1 second resulting in maximum efficiency in various environments where energy can rapidly change over time. The NH2D0245 is available in a 16-lead, 3mm x 3mm QFN package.

2. Key Features

- High-efficiency low-power DC-DC converter
- Harvesting power range 10 µW to 2 mW
- Advanced MPPT to maximize efficiency
- Ultra-fast MPPT interval of 1 second
- Small BOM with no external coil required
- Multiple battery and storage elements compatibility

3. Applications

- Wireless IoT devices
- Smart remote controls
- Electronic shelf labels
- Wearable devices
- Industrial and environmental monitoring
- Consumer electronics
- Beacons

4. Typical Application

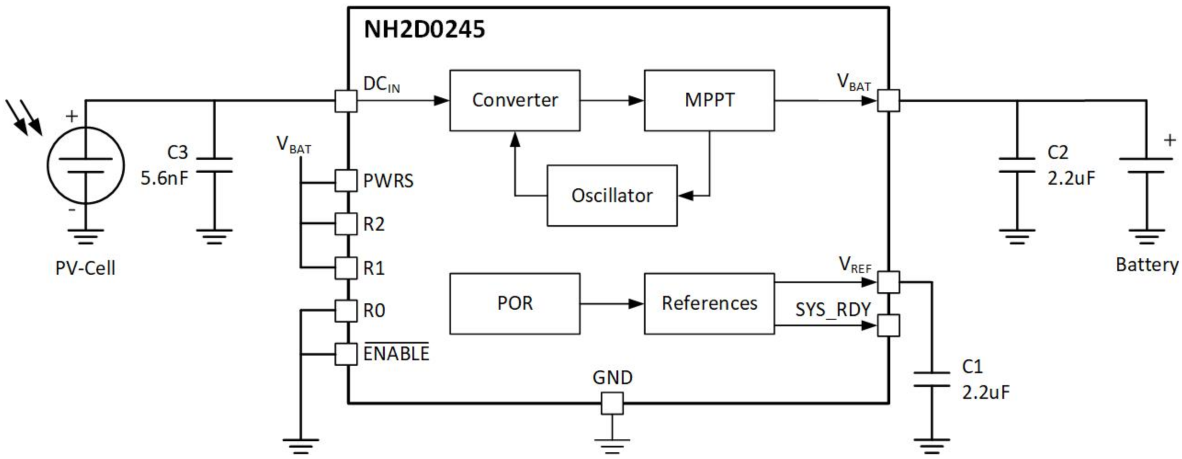

Figure 1: *Typical PV-Cell Application*

5. Package Diagram and Pin Description

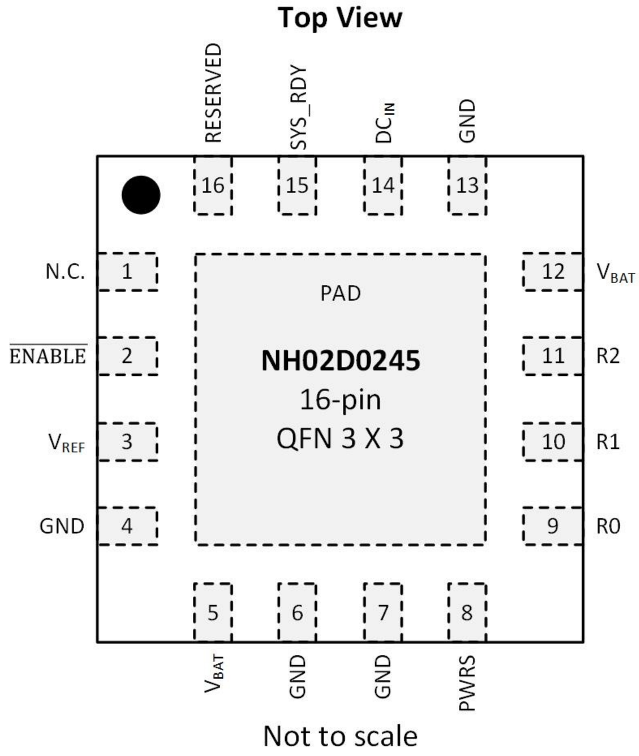

Figure 2: *QFN16 3x3 mm package*

Table 1: *Pin Description*

PIN #	PIN NAME	DESCRIPTION
1	N.C.	Not connected. Can be left floating or grounded
2	$\overline{\text{ENABLE}}$	Enable pin, active low
3	V_{REF}	Decoupling for internal supply generation. No external load supported
4	GND	Ground
5	V_{BAT}	Output of the energy harvester and device supply
6	GND	Ground
7	GND	Ground
8	PWRS	Control input for power-range setting
9	R0	Control input for power-range setting
10	R1	Control input for power-range setting
11	R2	Control input for power-range setting
12	V_{BAT}	Output of the energy harvester and device supply
13	GND	Ground
14	DC_{IN}	DC input of energy harvester

Continuation of Table 1		
PIN #	**PIN NAME**	**DESCRIPTION**
15	SYS_RDY	System Ready output. Indicates (HIGH) when start-up of device is ready
16	Reserved	Reserved, should be left floating
PAD	GND	Ground

6. Power Settings

Table 2: *Power Settings*

MODE	INPUT POWER RANGE	PWRS	R2	R1	R0
Low Power	10 µW to 1 mW	0	0	0	0
High Power	20 µW to 2 mW	1	1	1	0
Other combinations are not supported					

7. Block Diagram

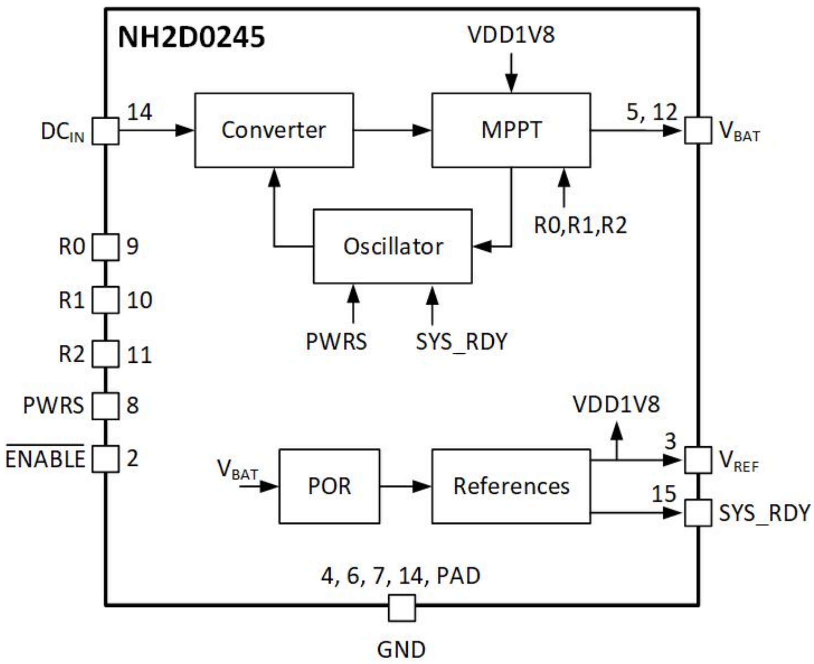

Figure 3: *NH2D0245 block diagram*

8. Absolute Maximum Ratings

Table 3: *Absolute Maximum Ratings*

	MIN	MAX	UNIT
DC_{IN}, V_{BAT}, $\overline{ENABLE}$, R0, R1, R2, PWRS	-0.3	5	V
DC_{IN} Input Voltage		V_{BAT} +0.3	V
DC_{IN} Input Current		100	mA
ESD voltage, Human Body Model (HBM)	1000		V
Operating junction temperature range	-50	125	°C
Storage temperature	-65	150	°C

Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

9. Recommended Operating Ratings

Table 4: *Recommended Operating Ratings*

	MIN	MAX	UNIT
V_{BAT}	2.5	4.5	V
Ambient temperature, T_A	-40	85	°C

10. Thermal Information

Table 5: *Thermal specifications*

	THERMAL METRIC	VALUE	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	30	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	49	°C/W

11. Electrical Characteristics

V_{BAT} = 3V, V_{OC} = 3V, T_A = 25°C unless otherwise specified.

Table 6: *Electrical Specifications*

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Supplies and Start-up						
V_{BAT}	Minimum battery voltage	To startup SYS_RDY becomes high		2.5		V
		After startup SYS_RDY is high		2.0		
V_{IN}	Harvester input voltage			1.65		V
I_{STBY}	Standby-current	$\overline{\text{ENABLE}}$ = HIGH	tbd	625	tbd	nA
V_{REF}	Internally generated supply			1.8		V
T_{START}	SYS_RDY high after applying V_{BAT}			50		ms
Power Converter						
A_V	Boost Factor	Unloaded power converter		2 or 2.3		
P_{IN_MIN}	Minimum input power	PWRS=R2=R1=R0=LOW, efficiency= 75%		15		µW
P_{IN_MAX}	Maximum input power	PWRS=R2=R1=HIGH, R0=LOW, efficiency= 80%		1000		µW
P_{MIN_DET}	Low-power detection level	PWRS=R2=R1=R0=LOW		10		µW
T_{MPPT}	MPPT Interval	Low Power		1		s
		High Power		0.7		
t_{MPPT_OPT}	Time for MPPT optimization			10		ms
f_{CONV_MIN}	Minimum power-converter frequency	PWRS=R2=R1=R0=LOW, Pin= 15µW		42		kHz
f_{CONV_MAX}	Maximum power-converter frequency	PWRS=R2=R1=HIGH, R0=LOW, Pin= 1000µW		2		MHz
Control						
V_{IL}	Logic low level for R2,R1,R0,PWRS				0.2 * V_{REF}	V
V_{IH}	Logic high level for R2,R1,R0,PWRS		0.8 * V_{REF}			V
$V_{IL\_\overline{ENABLE}}$	Logic low level for $\overline{\text{ENABLE}}$				0.1 * V_{BAT}	V
$V_{IH\_\overline{ENABLE}}$	Logic high level for $\overline{\text{ENABLE}}$		0.9 * V_{BAT}			V

12. Typical Performance Curves

V_{BAT} = 3V, V_{OC} = 3V, T_A = 25°C, unless otherwise specified

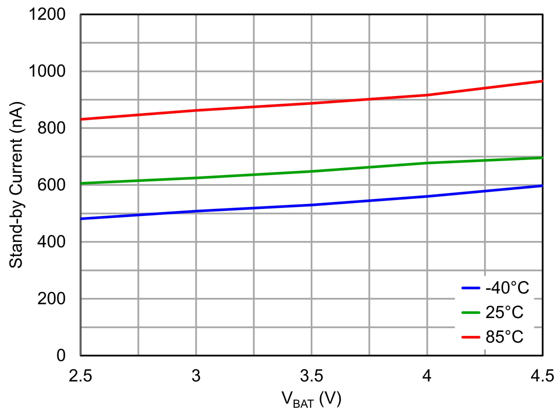

Figure 4: *Stand-by Current vs. V_{BAT} over Temperature*

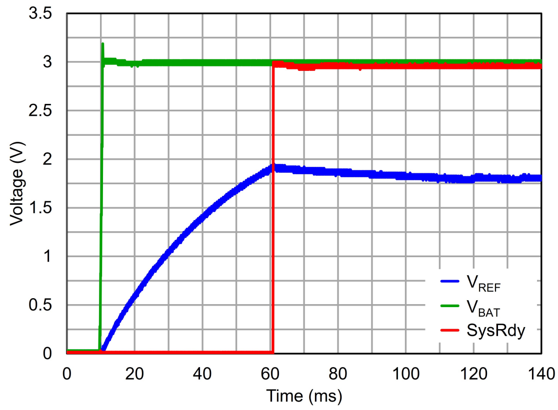

Figure 5: *Start-up sequence, $\overline{ENABLE}$= LOW*

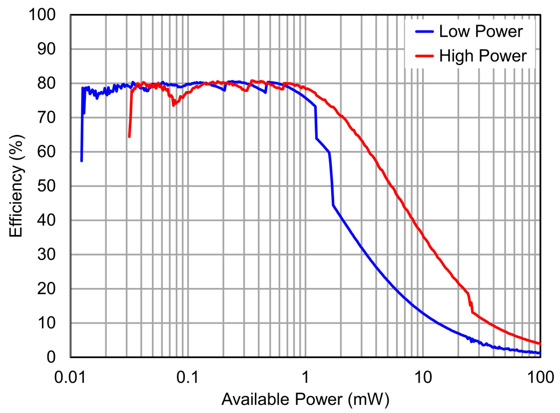

Figure 6: *Efficiency vs. Available Power Two power modes*

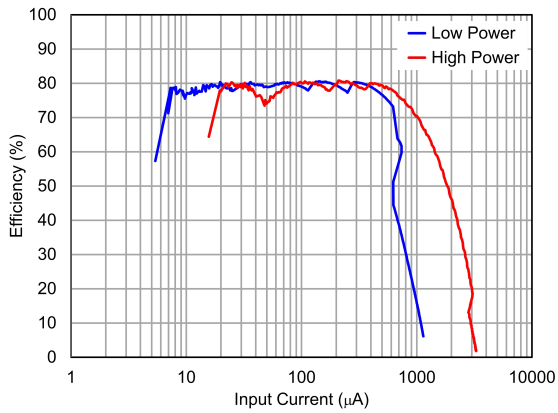

Figure 7: *Efficiency vs. Input Current Two power modes*

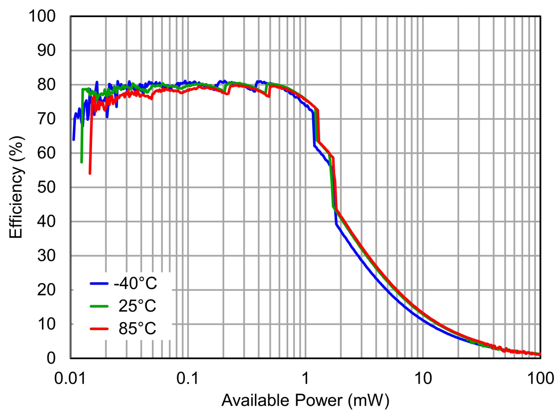

Figure 8: *Efficiency vs. Available Power Low Power Mode over Temperature*

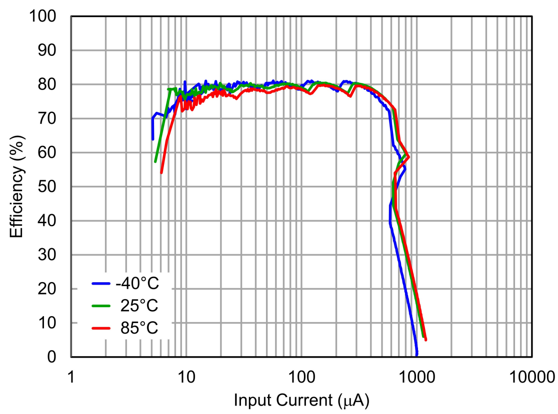

Figure 9: *Efficiency vs. Input Current Low Power Mode over Temperature*

12. Typical Performance Curves Continued

V_{BAT} = 3V, V_{OC} = 3V, T_A = 25°C, unless otherwise specified

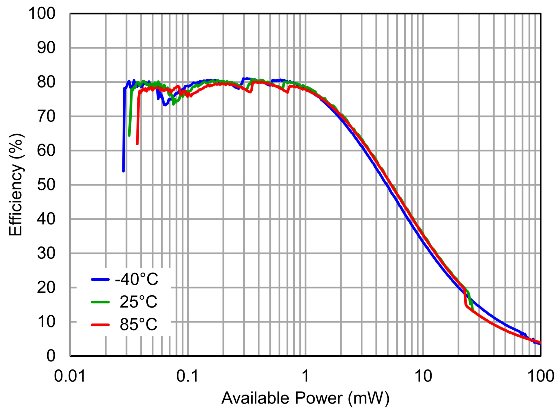

Figure 10: *Efficiency vs. Available Power High Power Mode over Temperature*

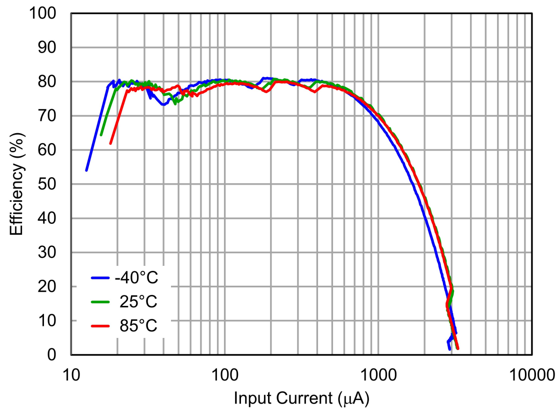

Figure 11: *Efficiency vs. Input Current High Power Mode over Temperature*

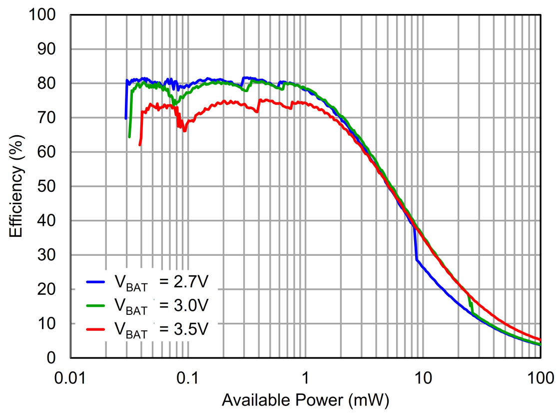

Figure 12: *Efficiency vs. Available Power High Power Mode over* V_{BAT}

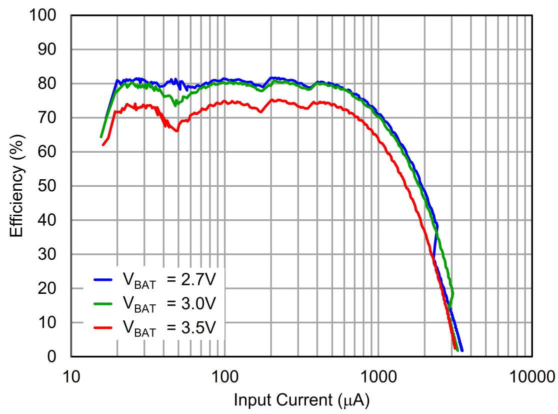

Figure 13: *Efficiency vs. Input Current High Power Mode over* V_{BAT}

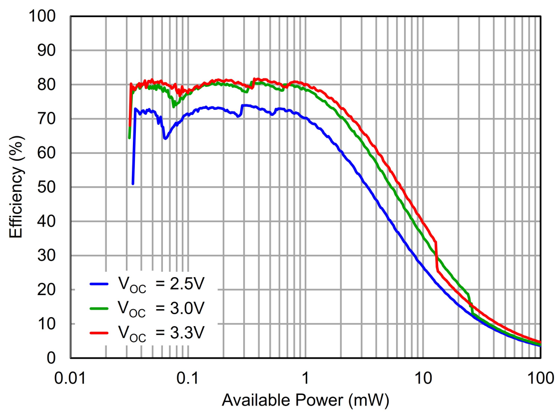

Figure 14: *Efficiency vs. Available Power High Power Mode over* V_{OC}

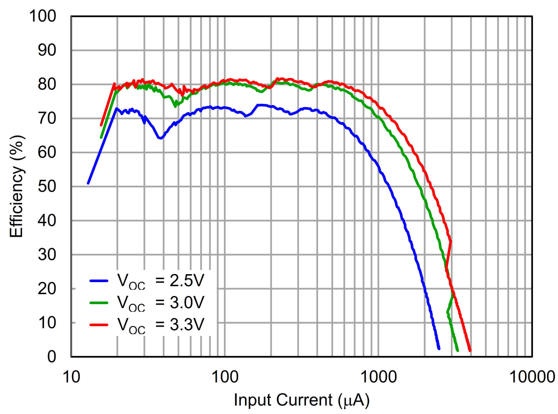

Figure 15: *Efficiency vs. Input Current High Power Mode over* V_{OC}

13. Application Information

13.1. Typical Application

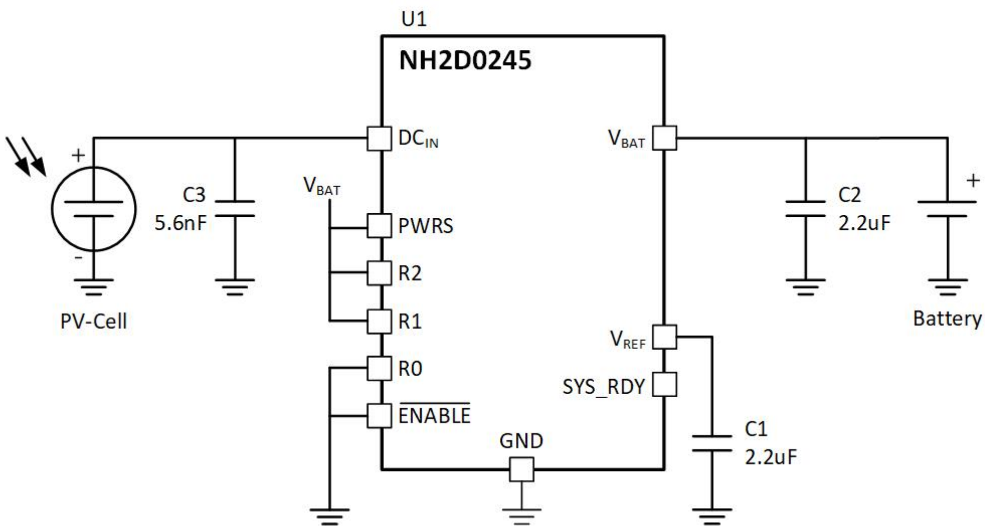

Figure 16: *Typical PV-Cell Application*

Table 7: *Bill of Materials*

REF DES	DESCRIPTION	TYPE	VALUE	QUANTITY
U1	NH2 PMIC	NH2D0245		1
C1, C2	Capacitor	X5R / 6.3V	2.2 uF	2
C3	Capacitor	X7R / 6.3V	5.6 nF	1

13.2. Efficiency Calculation

Efficiency numbers shown in this datasheet are calculated based on available power, rather than (only) input power. Available power is the power presented at the input of the harvested IC when PV-cell and harvester are optimally matched. Non-optimal matching results in a reduced overall efficiency.

$$\text{Efficiency}(\%) = \frac{P_{OUT}}{P_{AVAILABLE}} * 100$$

This equation implies that the matching of PV-cell and NH2D0245 is included in the efficiency number.

Figure 17 depicts a PV-cell connected to the NH2D0245, where the PV-cell is represented by voltage source (V_{OC}) and a series resistor R_{SOURCE}.

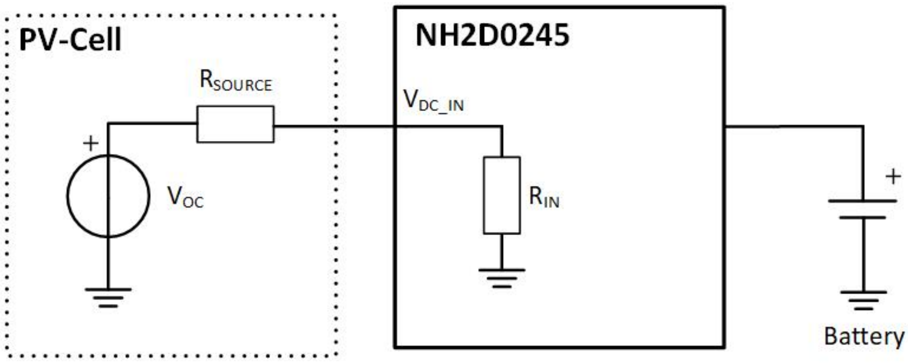

Figure 17: *PV-cell representation*

Optimal harvesting is achieved when the input impedance (R_{IN}) of the harvester IC is equal to the source impedance (R_{SOURCE}) of the PV-cell. In that case, the NH2D0245 input voltage (V_{DC_IN}) is 1/2 of the open circuit voltage (V_{OC}). The available power can be calculated accordingly:

$$P_{AVAILABLE} = \frac{(0.5 * V_{OC})^2}{R_{SOURCE}}$$

13.3. Selecting PV-cell

For best efficiency, the operating voltage of the PV-cell (V_{OPE}) needs to align with the input voltage of the NH2D0245 (V_{DC_IN}). The input voltage of the NH2D0245 relates to the battery voltage (V_{BAT}) via the loaded boost factor. For the NH2D0245, the loaded boost factor is about 1.8x. So:

$$V_{DC\_IN} = \frac{V_{BAT}}{1.8}$$

The PV-cell's optimal operating voltage depends on its characteristics and the level of light exposure. Typically, this is about

$$V_{OPE} = 0.7 * V_{OC}$$

It is not needed to do this very precise. As a result of the true MPPT feature of the NH2D0245, V_{DC_IN} will tune automatically to the optimal value within the supported power range.

14. Packaging information

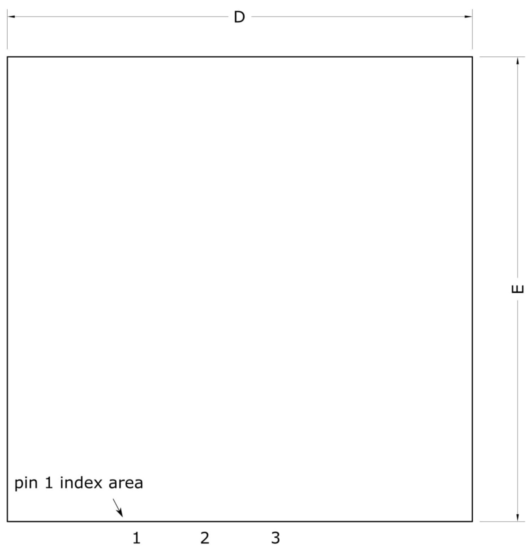

Figure 18: *Top view*

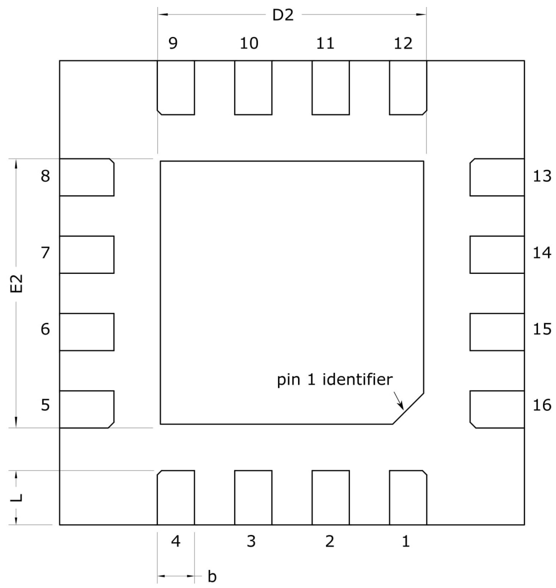

Figure 19: *Bottom view*

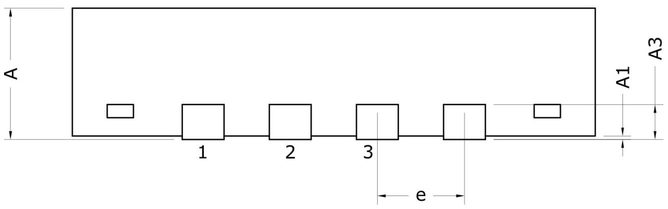

Figure 20: *Side view*

Table 8: *Dimensions in millimeters (mm)*

SYMBOL	MIN.	NOM.	MAX.
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A3		0.203	
b	0.18	0.24	0.30
D	2.90	3.00	3.10
E	2.90	3.00	3.10
D2	1.65	1.70	1.75
E2	1.65	1.70	1.75
e		0.50	
L	0.30	0.35	0.40

15. Disclaimer

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More product information (datasheets, silicon errata, application notes and reference designs) can be found on www.nowi-energy.com.