# Ultra-low Power Consumption 300 mA Buck DC/DC Converter with Battery Monitor

No.EA-505-190328

## OVERVIEW

The RP515x is a buck DC/DC converter with a Battery Monitor (BM) featuring ultra-low current and low-voltage resistance. The battery monitor divides the input voltage ($V_{IN}$) into 1/3 or 1/4, and directly provides the MCU's built-in low voltage AD converter with buffered voltage without external circuits.

## KEY BENEFITS

- Ultra-low consumption current ($I_Q$:0.3 μA ) with the VFM control for DC/DC (switching frequency: 1 MHz max.)
- High efficiency under light load conditions
- Reducing components and space by combining DC/DC and BM into a single chip
- Suitable for coin batteries and USB ports due to its wide input voltage range from 1.8 V to 5.5 V

## KEY SPECIFICATIONS

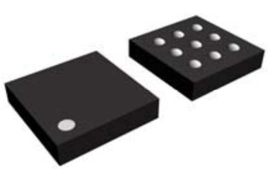
**DC/DC Section**

- Supply Current: Typ. 0.3 μA
- Output Current: 300 mA
- Input Voltage Range: 1.8 V to 5.5 V
- Output Voltage Range : 1.0 V to 4.0 V
- Output Voltage Accuracy: ±1.5%

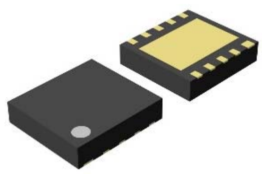
**Battery Monitor Section**

- Output Voltage: $V_{IN}$ /3 (RP515xxx3x)
  $V_{IN}$ /4 (RP515xxx4x)
- Supply Current: Typ. 0.1 μA

## PACKAGES

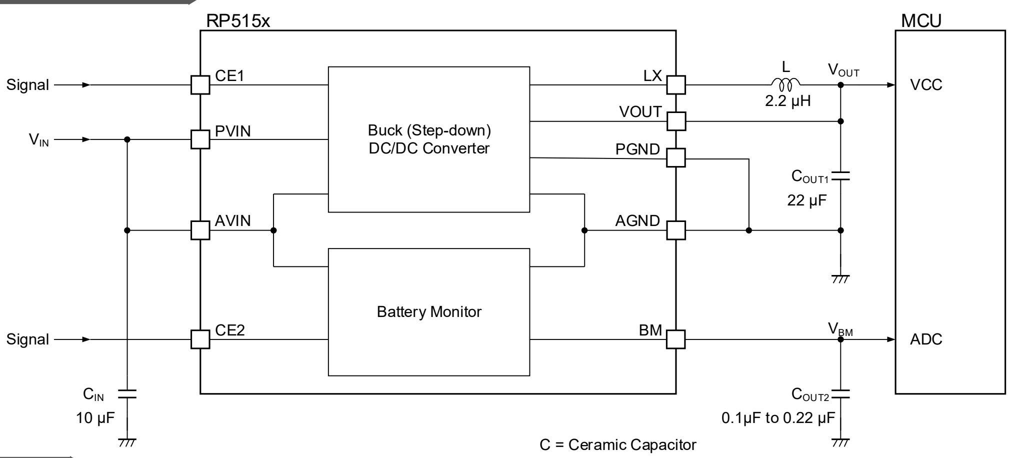


WLCSP-9-P2
1.45 x 1.48 x 0.36 (mm)



DFN(PLP)2527-10
2.7 x 2.5 x 0.6 (mm)

## TYPICAL APPLICATIONS




## APPLICATIONS

- Coin cell-used equipment and Li-ion battery-used equipment
- Wearable devices such as SmartWatch, SmartBand and Health monitoring
- Low Power RF Modules such as *Bluetooth*® LE, Zigbee, WiSun and ANT
- Low Power CPU, Memory, Sensor device and Energy Harvester

# SELECTION GUIDE

The set output voltage for DC/DC, the division ratio of BM output voltage, the auto-discharge function [1] for DC/DC and the packages are user-selectable options.

**Selection Guide**

| Product Name | Package | Quantity per Reel | Pb Free | Halogen Free |
|---|---|---|---|---|
| RP515Zxx#$-TR-F | WLCSP-9-P2 | 5,000 pcs | Yes | Yes |
| RP515Kxx#$-TR | DFN(PLP)2527-10 | 5,000 pcs | Yes | Yes |

xx: Specify the set output voltage for DC/DC ($V_{SET}$).within the range from 1.0 V (10) to 4.0 V (40)

The voltage in 0.05 V step is shown as follows:
Ex. 1.25 V: RP515x12xx5

Refer to the *Product-specific Electrical Characteristics* for detailed information.

* Contact our sales representatives for other voltages.

#: Select the division ratio of BM output voltage

3: $V_{IN}$ /3

4: $V_{IN}$ /4

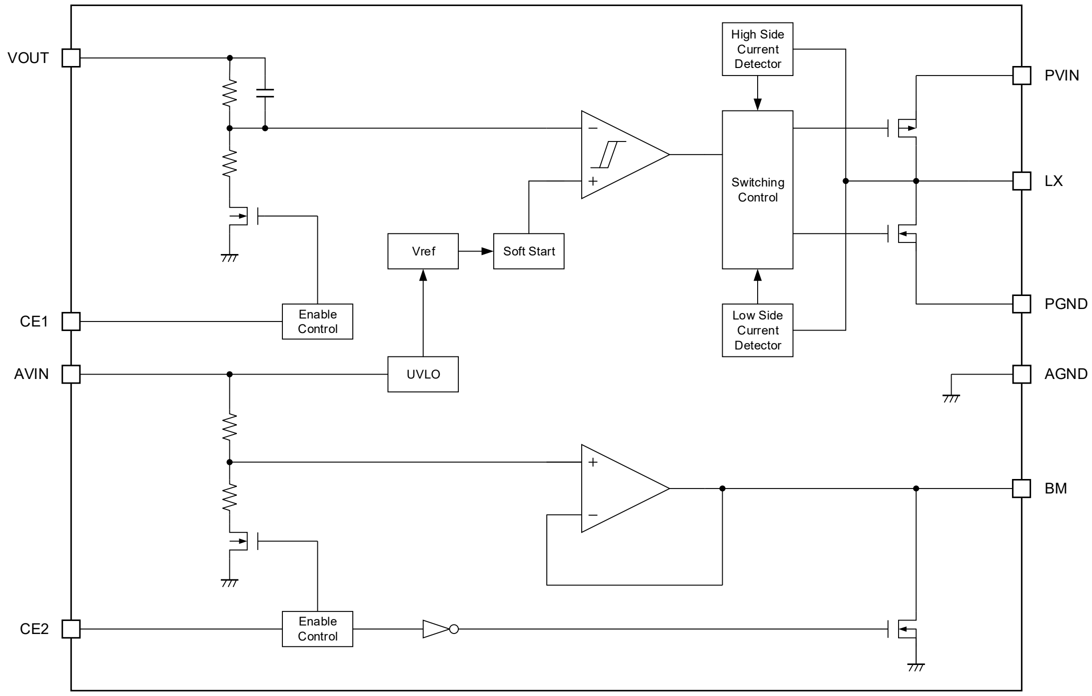
$: Select the auto-discharge option for DC/DC.

C: DC/DC auto-discharge is not included

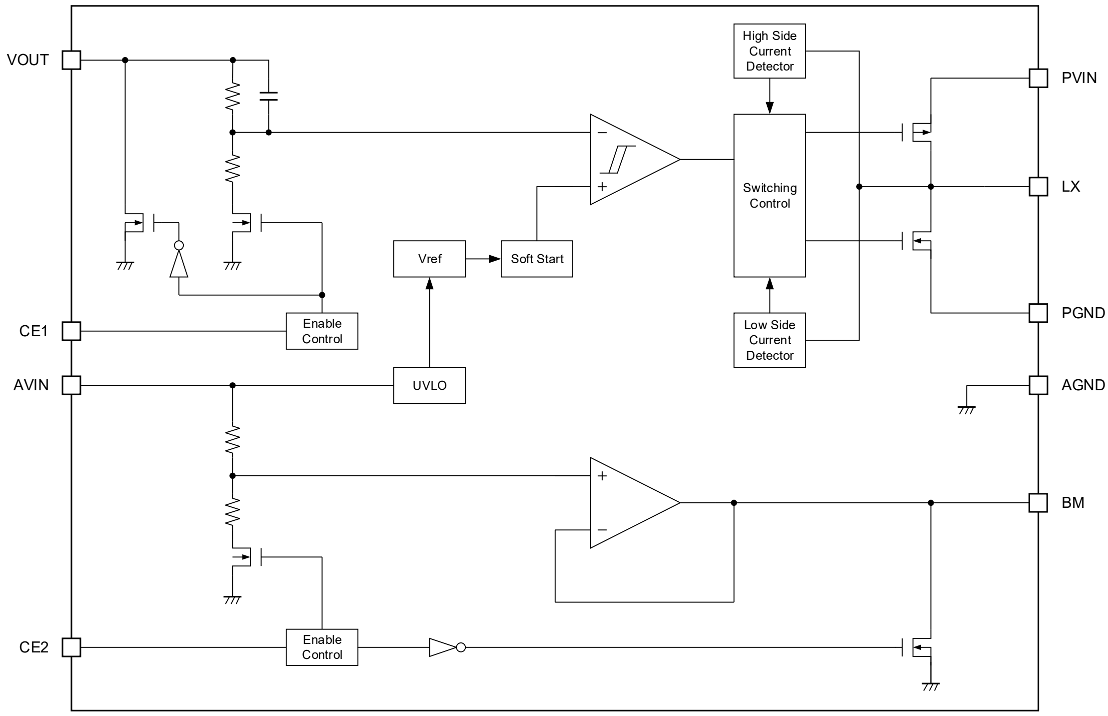
D: DC/DC auto-discharge is included

[1] Auto-discharge function quickly lowers the output voltage to 0 V by releasing the electrical charge accumulated in the external capacitor, when the chip enable signal is switched from the active mode to the standby mode.

# BLOCK DIAGRAMS

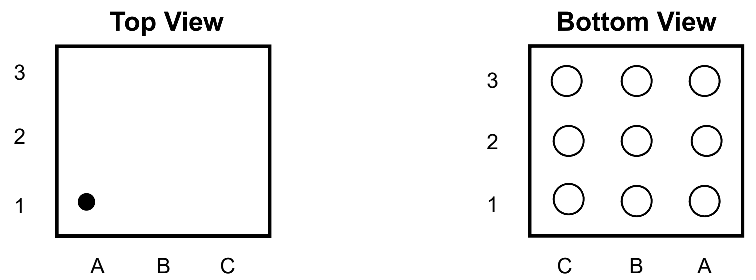



RP515xxxxC Block Diagram: Without DC/DC auto-discharge function




RP515xxxxD Block Diagram: With DC/DC auto-discharge function

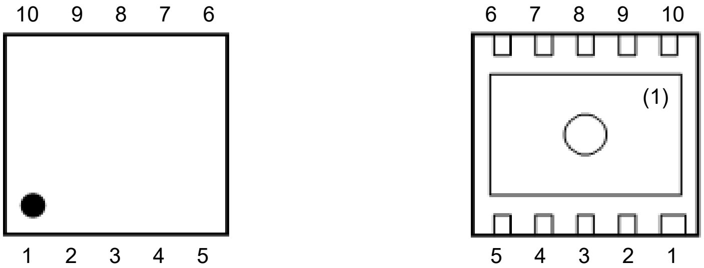
## PIN DESCRIPTIONS




**RP515Z (WLCSP-9-P2) Pin Configuration**

**RP515Z Pin Description**

| Pin No. | Symbol | Description |
|---|---|---|
| A1 | AVIN | Input Pin for Analog Power Supply (also for Battery Monitor) |
| B1 | PVIN | Input Pin for Power Supply |
| C1 | LX | Switching Pin |
| A2 | CE1 | DC/DC Enable Pin (Active-high) |
| B2 | CE2 | Battery Monitor Enable Pin (Active-high) |
| C2 | PGND | Power Ground Pin |
| A3 | BM | Battery Monitor Output Pin |
| B3 | VOUT | DC/DC Output Pin |
| C3 | AGND | Analog Ground Pin |




**RP515K [DFN(PLP)2570-10] Pin Configuration**

**RP515K Pin Description**

| Pin No. | Symbol | Description |
|---|---|---|
| 1 | VOUT | DC/DC Output Pin |
| 2 | AGND | Analog Ground Pin |
| 3 | PGND | Power Ground Pin |
| 4 | LX | Switching Pin |
| 5 | LX | Switching Pin |
| 6 | PVIN | Input Pin for Power Supply |
| 7 | AVIN | Input Pin for Analog Power Supply (also for Battery Monitor) |
| 8 | CE1 | DC/DC Enable Pin (Active-high) |
| 9 | CE2 | Battery Monitor Enable Pin (Active-high) |
| 10 | BM | Battery Monitor Output Pin |

(1) The tab on the bottom of the package is substrate level (GND). It is recommended that the tab be connected to the ground plane on the board, but it is possible to leave the tab floating.

# ABSOLUTE MAXIMUM RATINGS

**Absolute Maximum Ratings**

| Symbol | Parameter | | Rating | Unit |
|---|---|---|---|---|
| $V_{IN}$ | Input Voltage for AVIN and PVIN Pins | | −0.3 to 6.5 | V |
| $V_{CE1}$ | CE1 Pin Voltage | | −0.3 to 6.5 | V |
| $V_{CE2}$ | CE2 Pin Voltage | | −0.3 to 6.5 | V |
| $V_{OUT}$ | Output Pin Voltage | | −0.3 to $V_{IN}$ + 0.3 | V |
| $V_{BM}$ | BM Pin Voltage | | −0.3 to $V_{IN}$ + 0.3 | V |
| $I_{LX}$ | LX Pin Output Current | | 650 | mA |
| $P_D$ | Power Dissipation [1] (JEDEC STD. 51) | WLCSP-9-P2 | 1090 | mW |
| | | DFN(PLP)2527-10 | 2500 | |
| Tj | Junction Temperature Range | | −40 to 125 | °C |
| Tstg | Storage Temperature Range | | −55 to 125 | °C |

| ABSOLUTE MAXIMUM RATINGS |
|---|
| Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause permanent damage and may degrade the life time and safety for both device and system using the device in the field. The functional operation at or over these absolute maximum ratings is not assured. |

# RECOMMENDED OPERATING CONDITIONS

**Recommended Operating Conditions**

| Symbol | Parameter | | Rating | Unit |
|---|---|---|---|---|
| $V_{IN}$ | Input Voltage | RP515xxx3x | 1.8 to 5.5 | V |
| | | RP515xxx4x | 2.4 to 5.5 | |
| Ta | Operating Temperature | | −40 to 85 | °C |

| RECOMMENDED OPERATING CONDITIONS |
|---|
| All of electronic equipment should be designed that the mounted semiconductor devices operate within the recommended operating conditions. The semiconductor devices cannot operate normally over the recommended operating conditions, even if they are used over such conditions by momentary electronic noise or surge. And the semiconductor devices may receive serious damage when they continue to operate over the recommended operating conditions. |

[1] Refer to *POWEWR DISSIPATION* for detailed information.

## ELECTRICAL CHARACTERISTICS

The specifications surrounded by $\boxed{\quad\quad}$ are guaranteed by design engineering at −40°C ≤ Ta ≤ 85°C.

**RP515x Electrical Characteristics: DC/DC Section** (Ta = 25°C)

| Symbol | Parameter | Condition | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| $V_{OUT}$ | Output voltage | $V_{IN}$ = $V_{CE1}$ = 3.6 V ($V_{SET}$ ≤ 2.6 V), $V_{IN}$ = $V_{CE1}$ = $V_{SET}$ +1 V ($V_{SET}$ > 2.6 V) | $V_{SET}$ ≥ 1.2 V | x 0.985 | | x 1.015 | V |
| | | | $V_{SET}$ < 1.2 V | −0.018 | | +0.018 | |
| $I_Q$ | Operating quiescent current | $V_{IN}$ = $V_{CE1}$ = $V_{OUT}$ = 5.5 V, $V_{SET}$ = 1.8 V at rest | | | 0.3 | | µA |
| $I_{STANDBY}$ | Standby current | $V_{IN}$ = 5.5 V, $V_{CE1}$ = 0 V | | | 0.01 | $\boxed{1}$ | µA |
| $I_{CE1H}$ | CE1 pin input current, high | $V_{IN}$ = $V_{CE1}$ = 5.5 V | | $\boxed{-0.025}$ | 0 | $\boxed{0.025}$ | µA |
| $I_{CE1L}$ | CE1 pin input current, low | $V_{IN}$ = 5.5 V, $V_{CE1}$ = 0 V | | $\boxed{-0.025}$ | 0 | $\boxed{0.025}$ | µA |
| $I_{VOUTH}$ | $V_{OUT}$ pin input current, high(1) | $V_{IN}$ = $V_{OUT}$ = 5.5 V, $V_{CE1}$ = 0 V | | $\boxed{-0.025}$ | 0 | $\boxed{0.025}$ | µA |
| $I_{VOUTL}$ | $V_{OUT}$ pin input current, low | $V_{IN}$ = 5.5 V, $V_{CE1}$ = $V_{OUT}$ = 0 V | | $\boxed{-0.025}$ | 0 | $\boxed{0.025}$ | µA |
| $R_{DISN}$ | Auto-discharge NMOS on-resistance (2) | $V_{IN}$ = 3.6 V, $V_{CE1}$ = 0 V | | | 60 | | Ω |
| $V_{CE1H}$ | CE1 pin input voltage, high | 1.8 V ≤ $V_{IN}$ ≤ 5.5 V | | $\boxed{1.0}$ | | | V |
| $V_{CE1L}$ | CE1 pin input voltage, low | 1.8 V ≤ $V_{IN}$ ≤ 5.5 V | | | | $\boxed{0.4}$ | V |
| $R_{ONP}$ | PMOS on-resistance RP515Z | $V_{IN}$ = 3.6 V, $I_{LX}$ = −100 mA | | | 0.15 | | Ω |
| | PMOS on-resistance RP515K | | | | 0.19 | | |
| $R_{ONN}$ | NMOS on-resistance RP515Z | $V_{IN}$ = 3.6 V, $I_{LX}$ = −100 mA | | | 0.15 | | Ω |
| | NMOS on-resistance RP515K | | | | 0.19 | | |
| $t_{START}$ | Soft-start time | $V_{IN}$ = $V_{CE1}$ = 3.6 V ($V_{SET}$ ≤ 2.6 V), $V_{IN}$ = $V_{CE1}$ = $V_{SET}$ + 1 V ($V_{SET}$ > 2.6 V) | | | 10 | | ms |
| $I_{LXLIM}$ | LX current limit | $V_{IN}$ = $V_{CE1}$ = 3.6 V ($V_{SET}$ ≤ 2.6 V), $V_{IN}$ = $V_{CE1}$ = $V_{SET}$ + 1 V ($V_{SET}$ > 2.6 V) | | $\boxed{300}$ | 580 | | mA |
| $V_{UVLOF}$ | Undervoltage lockout (UVLO) threshold voltage | $V_{IN}$ = $V_{CE1}$, falling | | $\boxed{1.40}$ | 1.50 | $\boxed{1.65}$ | V |
| $V_{UVLOR}$ | | $V_{IN}$ = $V_{CE1}$, rising | | $\boxed{1.55}$ | 1.65 | $\boxed{1.80}$ | V |

All test items listed under Electrical Characteristics are done under the pulse load condition (Tj ≈ Ta = 25°C).

(1) RP515xxxxC only
(2) RP515xxxxD only

# ELECTRICAL CHARACTERISTICS (Continued)

The specifications surrounded by $\boxed{\phantom{xx}}$ are guaranteed by design engineering at −40°C ≤ Ta ≤ 85°C.

**RP515x Electrical Characteristics: Battery Monitor Section** (Ta = 25°C)

| Symbol | Parameter | | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| $V_{BM}$ | Output voltage | RP515xxx3x | $V_{IN}$ = 5.5 V, −10 μA ≤ $I_{BM}$ ≤ 10 μA | $V_{IN}$/3-30 | $V_{IN}$/3 | $V_{IN}$/3+30 | mV |
| | | RP515xxx4x | | $V_{IN}$/4-30 | $V_{IN}$/4 | $V_{IN}$/4+30 | |
| $I_{BM}$ | Output current | | $V_{IN}$ = 5.5 V | −10 | | 10 | μA |
| $I_{SSBM}$ | Supply current | | $V_{IN}$ = $V_{CE2}$ =5.5 V, $I_{BM}$ = 0 μA | | 0.1 | | μA |
| $V_{CE2H}$ | CE2 pin input voltage, high | | 1.8 V ≤ $V_{IN}$ ≤ 5.5 V | $\boxed{1.0}$ | | | V |
| $V_{CE2L}$ | CE2 pin input voltage, low | | 1.8 V ≤ $V_{IN}$ ≤ 5.5 V | | | $\boxed{0.4}$ | V |
| $R_{DISNBM}$ | Auto-discharge NMOS on-resistance | | $V_{IN}$ = 4.0 V, $V_{CE2}$ = 0 V | | 50 | | Ω |

All test items listed under Electrical Characteristics are done under the pulse load condition (Tj ≈ Ta = 25°C).

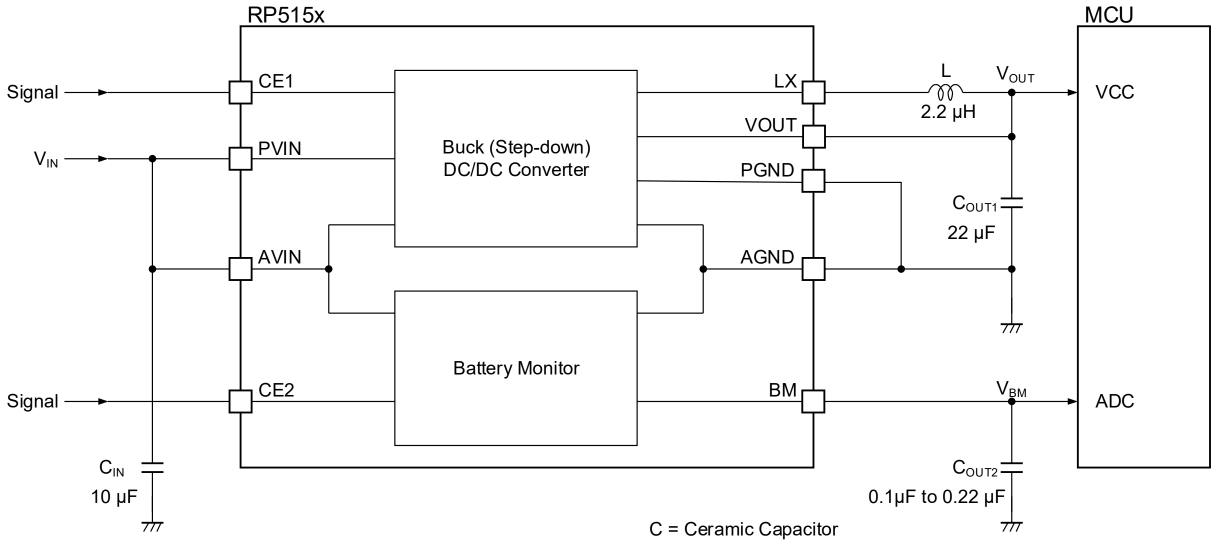
# ELECTRICAL CHARACTERISTICS (Continued)

**Product-specific Electrical Characteristics**

**RP515xxxxx** (Ta = 25°C)

| Product name | $V_{OUT}$ [V] | | |
|---|---|---|---|
| | Min. | Typ. | Max. |
| RP515x10xx | 0.9820 | 1.00 | 1.0180 |
| RP515x12xx | 1.1820 | 1.20 | 1.2180 |
| RP515x15xx | 1.4775 | 1.50 | 1.5225 |
| RP515x18xx | 1.7730 | 1.80 | 1.8270 |
| RP515x24xx | 2.3640 | 2.40 | 2.4360 |
| RP515x25xx | 2.4625 | 2.50 | 2.5375 |
| RP515x28xx | 2.7580 | 2.80 | 2.8420 |
| RP515x30xx | 2.9550 | 3.00 | 3.0450 |
| RP515x31xx | 3.0535 | 3.10 | 3.1465 |
| RP515x33xx | 3.2505 | 3.30 | 3.3495 |
| RP515x36xx | 3.5460 | 3.60 | 3.6540 |
| RP515x40xx | 3.9400 | 4.00 | 4.0600 |

# TYPICAL APPLICATION CIRCUIT




**RP515x Typical Application Circuit**

# TECHNICAL NOTES

The performance of a power source circuit using this device is highly dependent on the peripheral circuit. A peripheral component or the device mounted on PCB should not exceed a rated voltage, a rated current or a rated power. When designing a peripheral circuit, please be fully aware of the following points.

- When an intermediate voltage other than $V_{IN}$ and GND is input to the CE1 pin or/and CE2 pin, a supply current may be increased with a through current of a logic circuit in the IC. The CE pin is neither pulled up nor pulled down, therefore the operation is not stable at open.

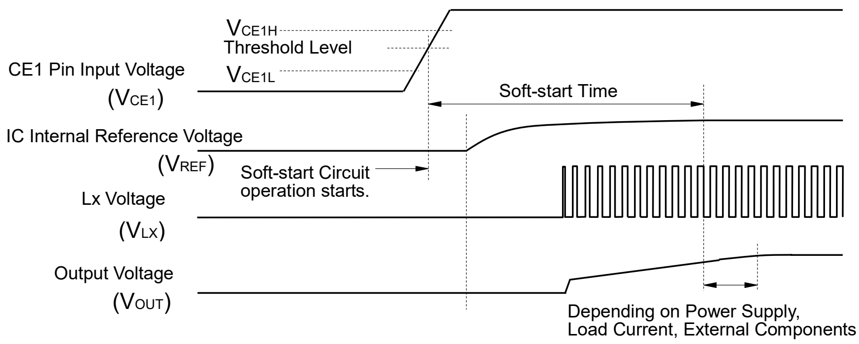
# THEORY OF OPERATION

## DC/DC Section

## Soft-start Time

**Starting-up with CE1 Pin**

The IC starts to operate when the CE1 pin voltage ($V_{CE1}$) exceeds the threshold voltage. The threshold voltage is preset between CE1 "High" input voltage ($V_{CE1H}$) and CE1 "Low" input voltage ($V_{CE1L}$). After the start-up of the IC, soft-start circuit starts to operate. Then, after a certain period of time, the reference voltage ($V_{REF}$) in the IC gradually increases up to the specified value. Switching starts when $V_{REF}$ reaches the preset voltage, and after that the output voltage rises as $V_{REF}$ increases. Soft-start time ($t_{START}$) indicates the period from the time soft-start circuit gets activated to the time $V_{REF}$ reaches the specified voltage. $t_{START}$ is not always equal to the turn-on speed of the DC/DC converter. Note that the turn-on speed could be affected by the power supply capacity, the output current ($I_{OUT}$), the inductance and the output capacitor value ($C_{OUT1}$).

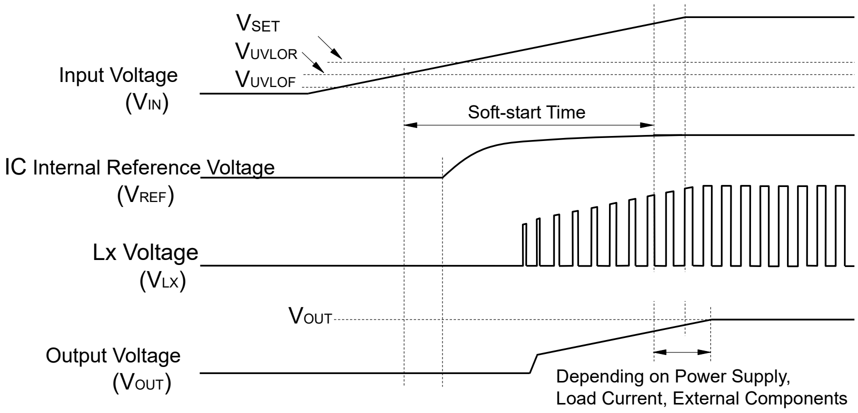



**Timing Chart: Starting-up with CE1 Pin**

**Starting-up with Power Supply**

After the power-on, when $V_{IN}$ exceeds the UVLO release voltage ($V_{UVLOR}$), the IC starts to operate. Then, soft-start circuit starts to operate and after a certain period of time, $V_{REF}$ gradually increases up to the specified value. Switching starts when $V_{REF}$ reaches the preset voltage, and after that the output voltage rises as $V_{REF}$ increases. The turn-on speed of $V_{OUT}$ could be affected by following conditions:

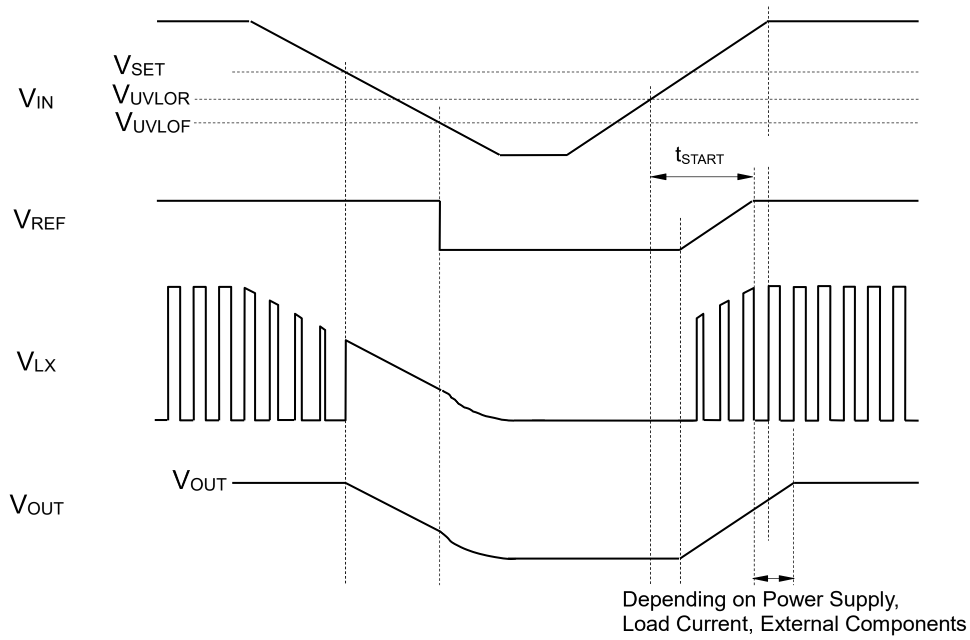
1. The $V_{IN}$ turn-on speed determined by the power supply to the IC and the $C_{IN}$
2. The output capacitor value ($C_{OUT1}$) and the output current ($I_{OUT}$)




**Timing Chart: Starting-up with Power Supply**

## Undervoltage Lockout (UVLO) Circuit

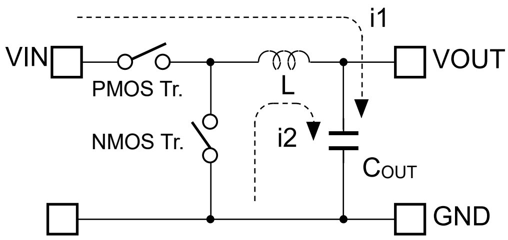
When $V_{IN}$ becomes lower than $V_{SET}$, the buck DC/DC converter stops its switching operation and ON duty becomes 100%, then $V_{OUT}$ gradually falls according to $V_{IN}$. When the $V_{IN}$ drops below the UVLO detector threshold ($V_{UVLOF}$), the UVLO operates, $V_{REF}$ stops, and PMOS and NMOS built-in switch transistors turn "OFF". As a result, $V_{OUT}$ drops according to the $C_{OUT1}$ capacitance value and $I_{OUT}$. As for RP515xxx1D, the discharge transistor for $C_{OUT1}$ discharges after it turns on.
To restart the operation, $V_{IN}$ needs to exceed $V_{UVLOR}$. The timing chart below shows the voltage shifts of $V_{REF}$, $V_{LX}$ and $V_{OUT}$ when $V_{IN}$ value is varied.
Note: Falling edge (operating) and rising edge (releasing) waveforms of $V_{OUT}$ could be affected by the initial voltage of $C_{OUT1}$ and the output current of $V_{OUT}$.



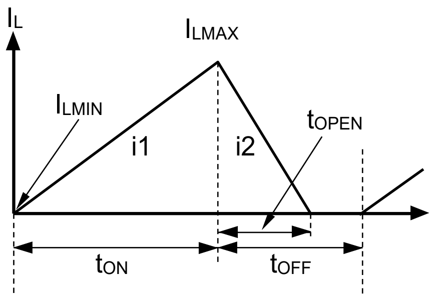

**Timing Chart with Variations in Input Voltage ($V_{IN}$)**

### Operation of Buck DC/DC Converter and Output Current

The buck DC/DC converter charges energy in the inductor while LX transistor turns “ON”, and discharges the energy from the inductor when LX transistor turns “OFF”. This inductor reduces the energy loss to provide the lower output voltage ($V_{OUT}$) than the input voltage ($V_{IN}$). The operation of the buck DC/DC converter is shown in the following figures.




**Basic Circuit**




**Inductor Current (IL) flowing through Inductor (L)**

**Step1.** When the PMOS transistor turns “ON”, $I_L$ (i1) flows through the L to charge $C_{OUT}$ and provide $I_{OUT}$. At this moment, i1 increases from the minimum inductor current ($I_{LMIN}$) of 0 A to reach the maximum inductor current ($I_{LMAX}$) in proportion to the on-time period ($t_{ON}$) of PMOS transistor.

**Step2.** When PMOS transistor turns “OFF”, L turns NMOS transistor “ON” to maintain $I_L$ at $I_{LMAX}$ and $I_L$ (i2) flows into L.

**Step3.** $I_L$ = i2 decreases gradually and reaches $I_{LMIN}$ after the open-time period ($t_{OPEN}$) of NMOS transistor and NMOS transistor turns “OFF”. This is called discontinuous current mode.
As to the continuous current mode, the output current ($I_{OUT}$) increases and the off-time period ($t_{OFF}$) of PMOS transistor ends before $I_L$ reaches $I_{LMIN}$. In the next cycle, PMOS transistor turns “ON” and NMOS transistor turns “OFF”, then $I_L$ increases from $I_L = I_{LMIN} > 0$.

When the buck DC/DC operation is constant, $I_{LMIN}$ and $I_{LMAX}$ during ton of PMOS transistor would be same as during $t_{OFF}$ of PMOS transistor. The difference of the current between $I_{LMAX}$ and $I_{LMIN}$ represents $\Delta I$ as shown in the following equation 1.

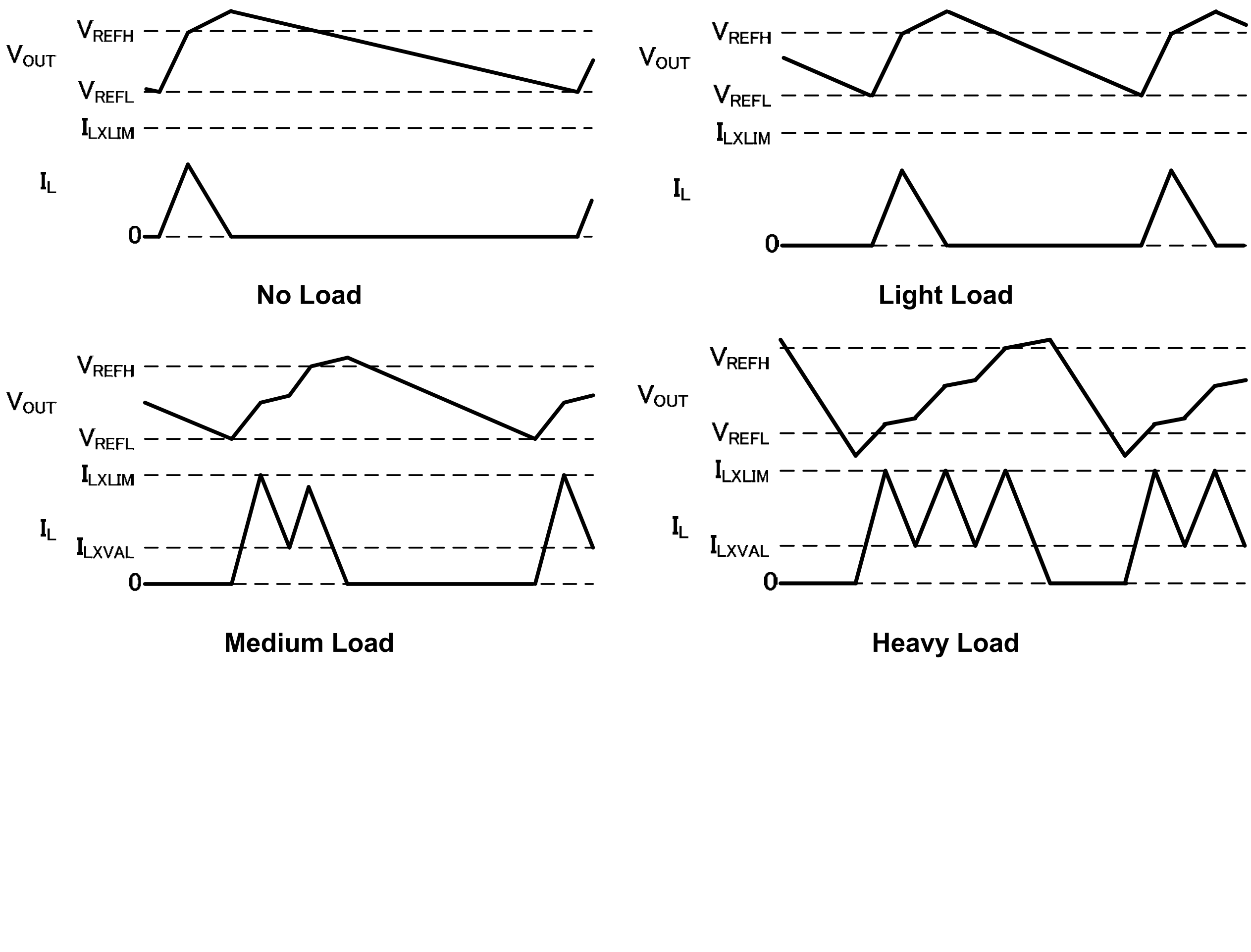
$\Delta I = I_{LMAX} - I_{LMIN} = V_{OUT} \times t_{OPEN} / L = (V_{IN} - V_{OUT}) \times t_{ON} / L$ .......................................................................... (1)

### VFM Mode

The VFM (Variable Frequency Modulation) mode is adopted as a switching method to achieve a high efficiency under light load conditions. A switching frequency varies depending on values of input voltage ($V_{IN}$), output voltage ($V_{OUT}$), and output current ($I_{OUT}$). Check the actual characteristics to avoid the switching noise.

A switching starts when $V_{OUT}$ drops below the lower-limit reference voltage ($V_{REFL}$). When $V_{OUT}$ exceeds the upper-limit reference voltage ($V_{REFH}$), a constant voltage is output by a hysteresis control which stops the switching.

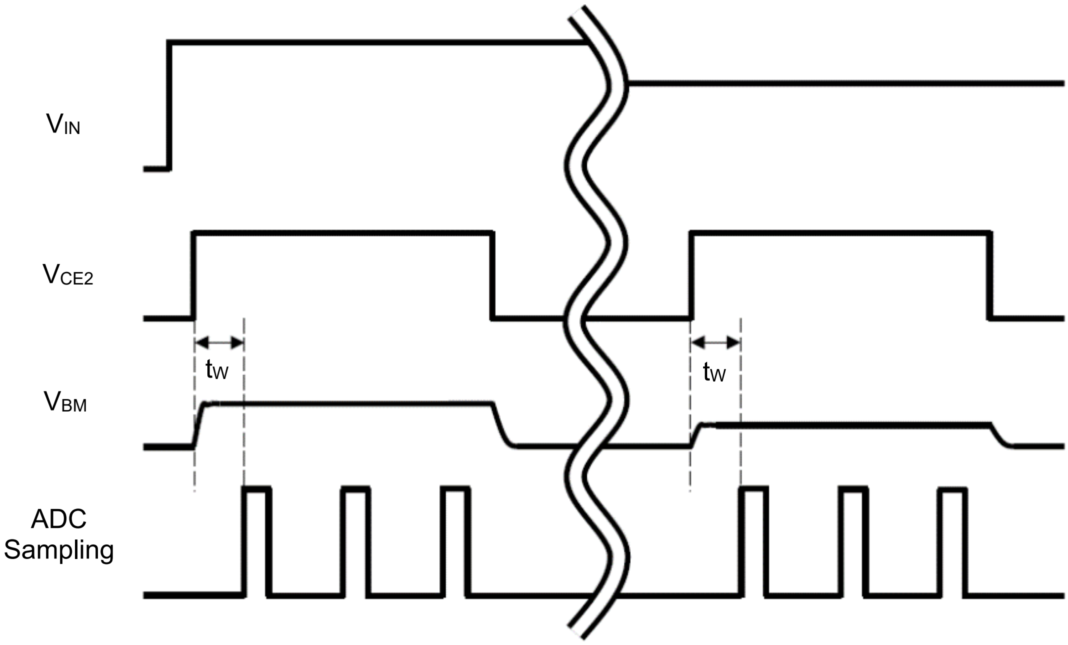
In order to operate within the rated characteristic of inductor and avoid the deteriorated band frequency of DC superimposed characteristics, when the inductor current ($I_L$) exceeds LX current limit ($I_{LXLIM}$), the operation shifts to off-cycle. And when $I_L$ drops below the valley current limit ($I_{LXVAL}$), the operation shift to on-cycle.




No Load / Light Load / Medium Load / Heavy Load

### Battery Monitor Section

### Timing Chart of Typical Application Circuit




RP515x Timing Chart of Typical Application Circuit

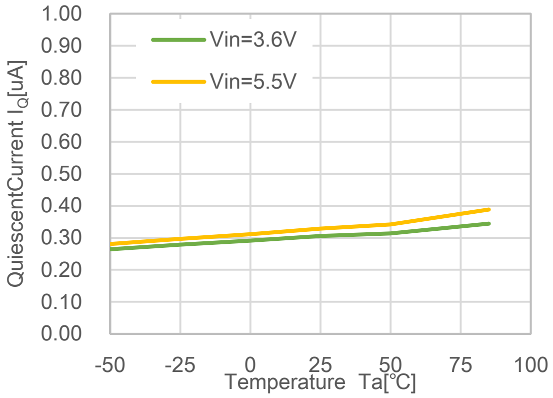
The RP515x can monitor the battery voltage by connecting BM pin with ADC input pin in MCU. The RP515x allows the CE2 pin to control the battery monitor's start and stop according to the sampling cycle from the ADC, reducing the power consumption of the entire system.

During the battery voltage monitoring, waiting time is needed, preferable tw>=10ms, for the CE2 pin to gain stable $V_{BM}$.

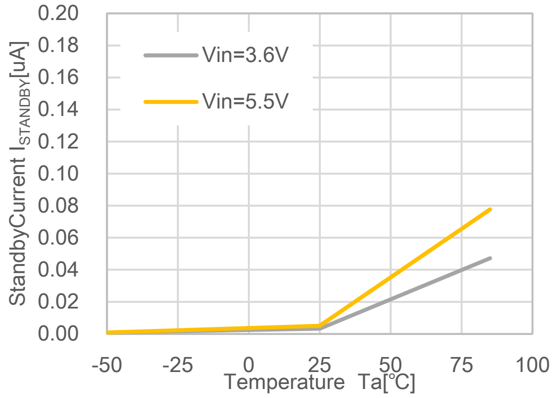
# TYPICAL CHARACTERISTICS

Note: Typical Characteristics are intended to be used as reference data; they are not guaranteed.

**1) Quiescent Current vs Temperature**

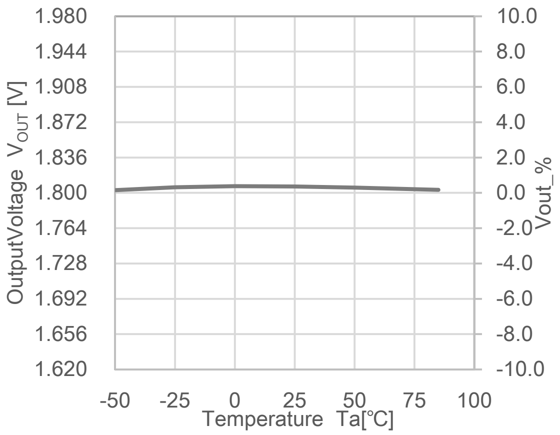



**2) Standby Current vs Temperature**



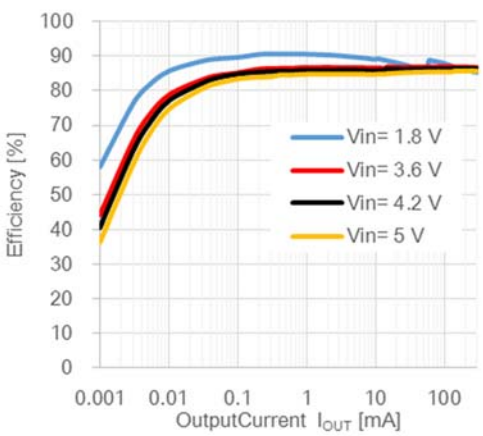

**3) Output Voltage vs Temperature**

RP515x181x, $V_{IN}$=3.6V

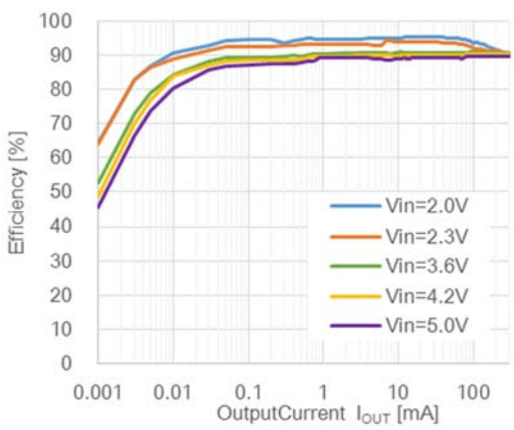



**4) Efficiency vs Output Current**

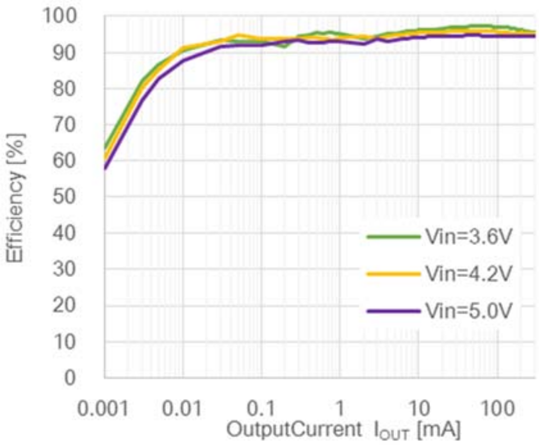
RP515x121x, Ta=25°C




RP515x181x, Ta=25°C

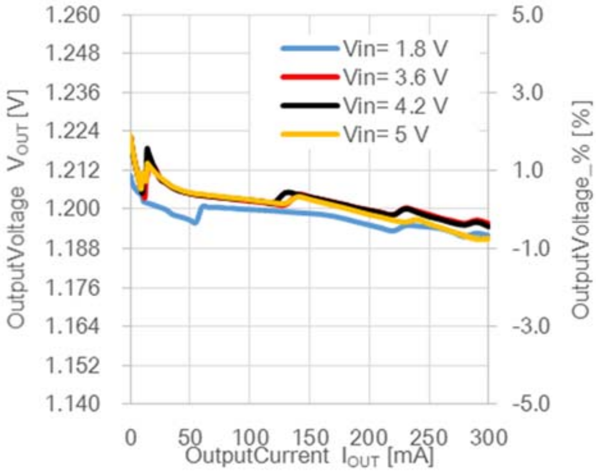


RP515x331x, Ta=25°C

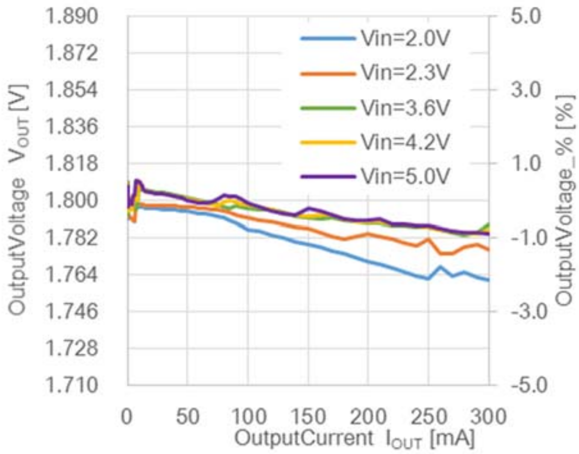



**5) Output Voltage vs Output Current**

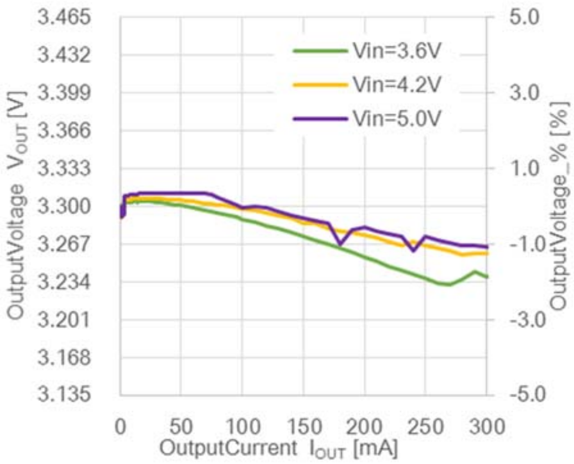
RP515x121x, Ta=25°C




RP515x181x, Ta=25°C

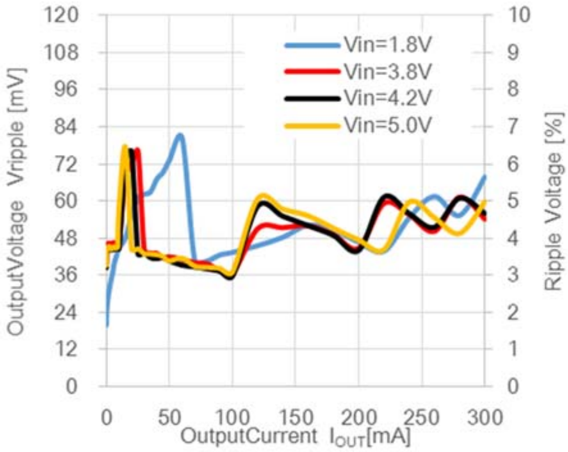



RP515x331x, Ta=25°C

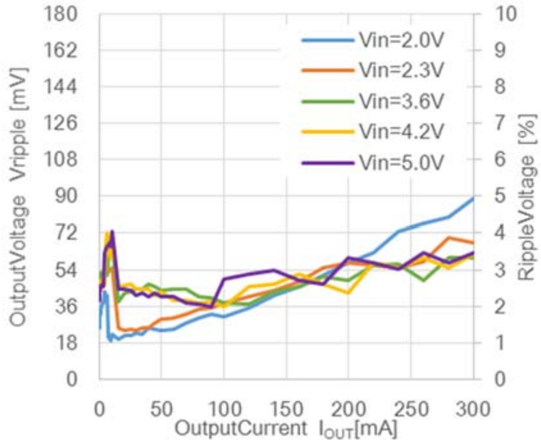


**6) Ripple Voltage vs Output Current**

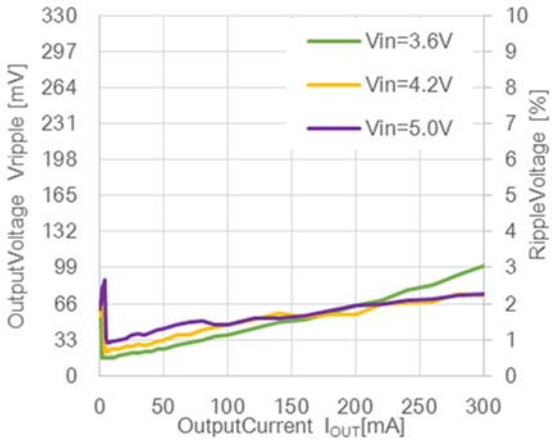
RP515x121x, Ta=25°C




RP515x181x, Ta=25°C

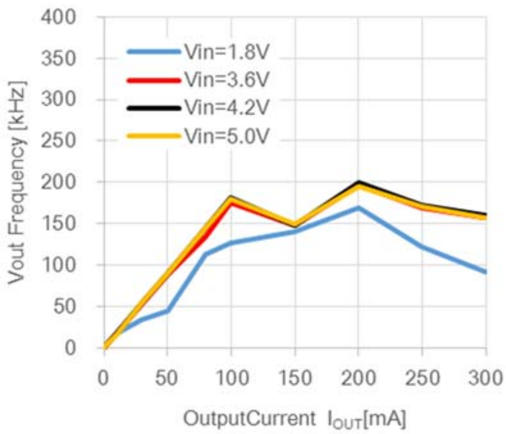



RP515x331x, Ta=25°C

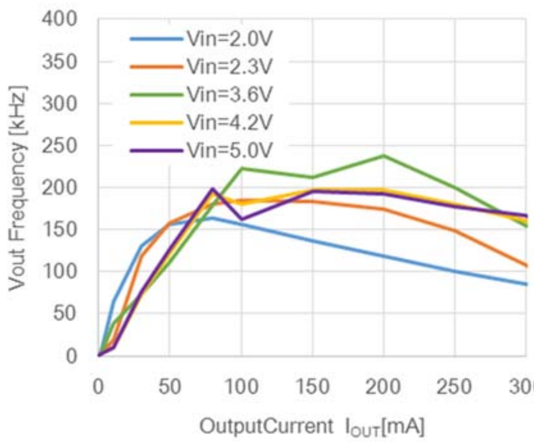



**7) Switching Frequency vs Output Current**

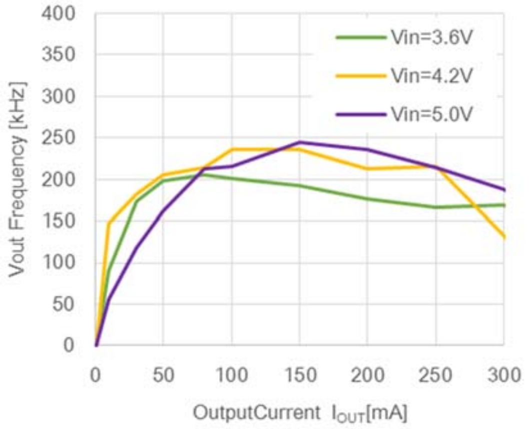
RP515x121x, Ta=25°C




RP515x181x, Ta=25°C



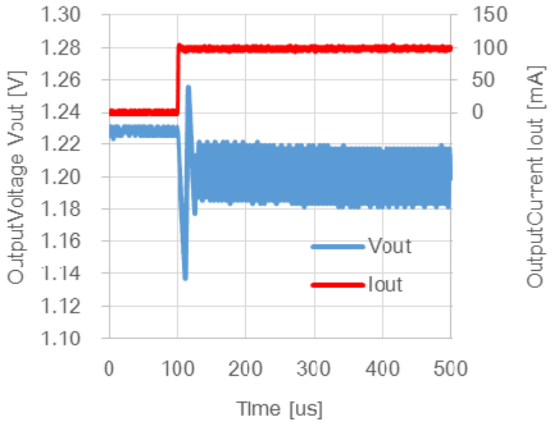
RP515x331x, Ta=25°C



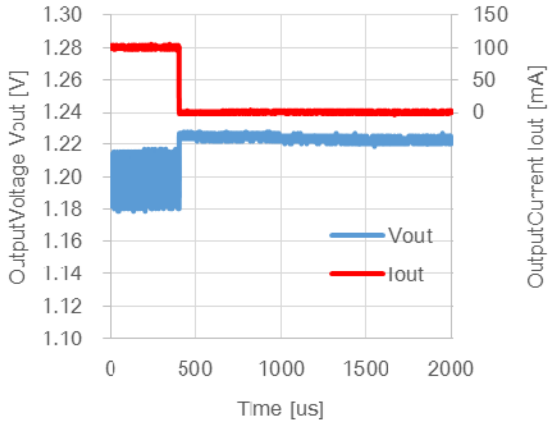

**8) Load Transient Response**

RP515x181x, $V_{IN}$=3.6V, Ta=25°C

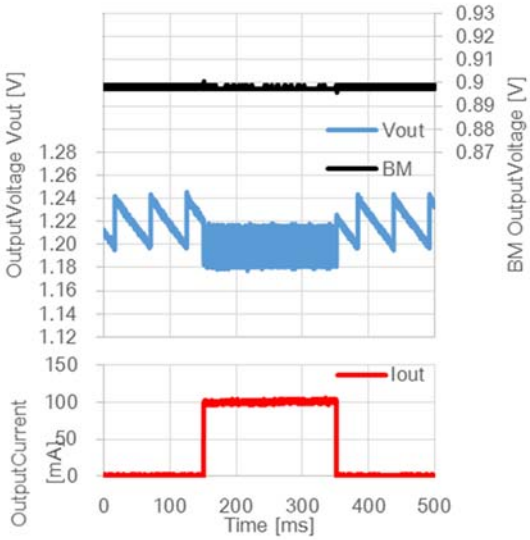
$I_{OUT}$=10uA->100mA




$I_{OUT}$=100mA->10uA



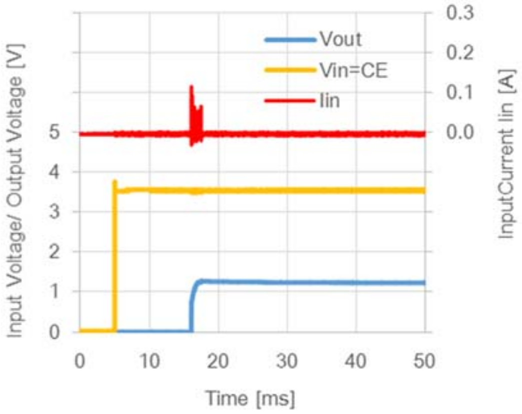

$I_{OUT}$=10uA->100mA->10uA



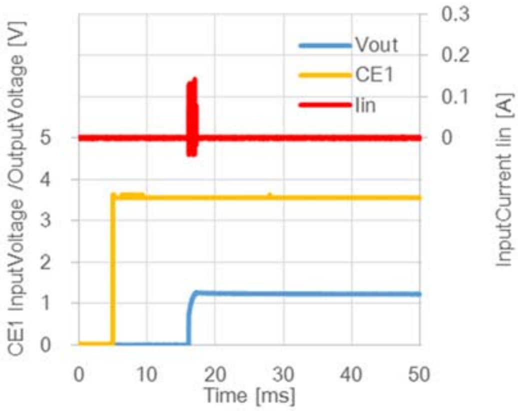
### 9) Soft Start Time

RP515x181x, Ta=25°C

$V_{IN}=V_{CE1}$=0V->3.6V, ⊿t=10 μ s

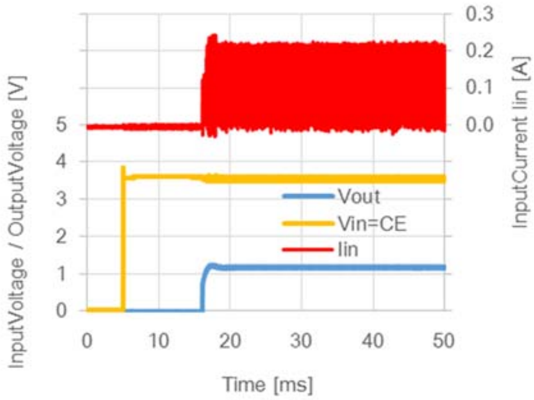



$V_{IN}$=3.6V, $V_{CE1}$=0V->3.6V, ⊿t=10 μ s

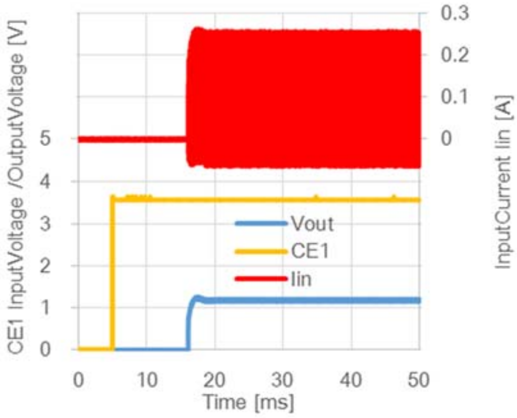



$I_{OUT}$=300mA

$V_{IN}=V_{CE1}$=0V->3.6V, ⊿t=10 μ s

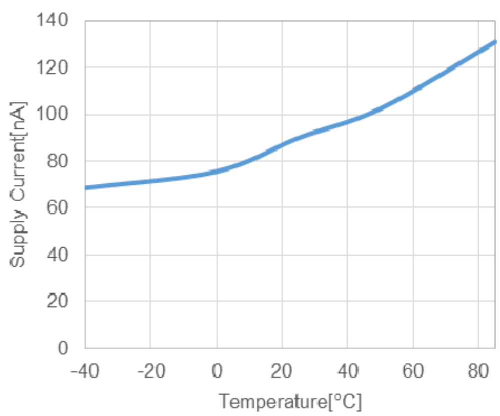



$V_{IN}$=3.6V, $V_{CE1}$=0V->3.6V, ⊿t=10 μ s

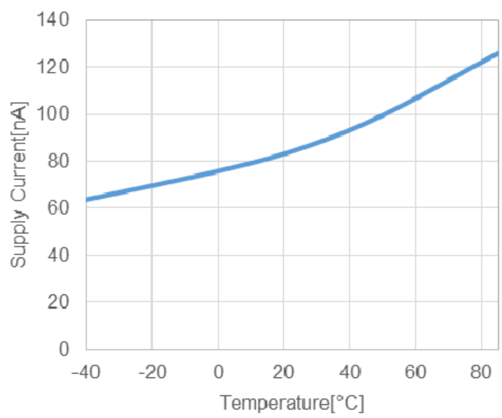



### 10) BM Supply Current vs Temperature ($C_{OUT2}$ = Ceramic 0.1μF, $V_{IN}$=3.6V)

RP515xxx3x

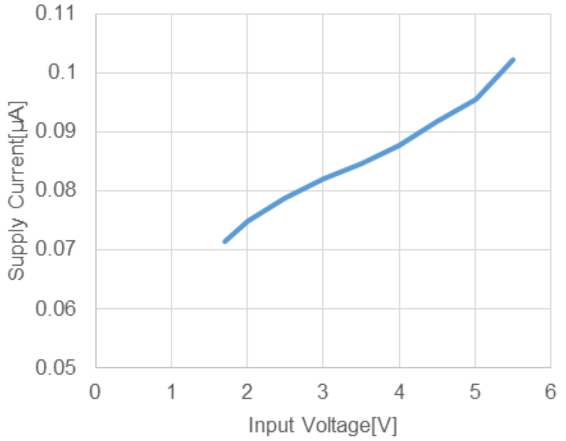



RP515xxx4x

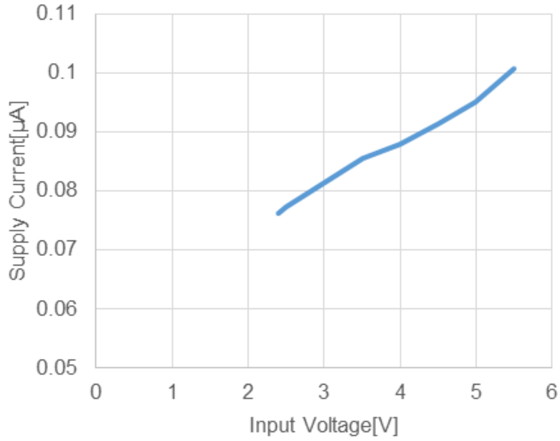


**11) BM Supply Current vs Input Voltage** ($C_{OUT2}$ = Ceramic 0.1μF, Ta = 25°C)

RP515xxx3x

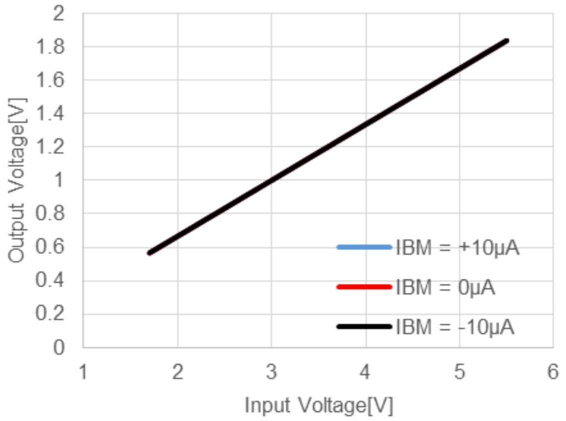



RP515xxx4x

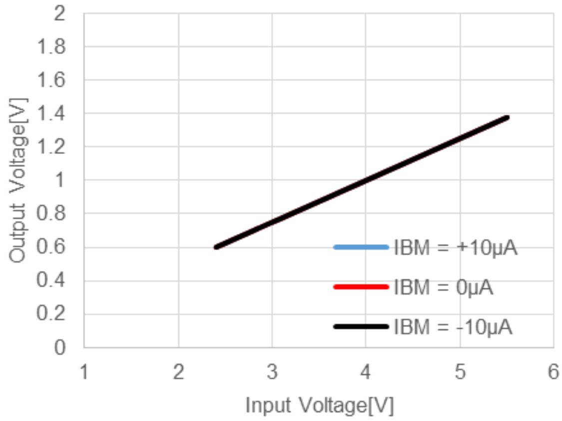



**12) BM Output Voltage vs Input Voltage** ($C_{OUT2}$ = Ceramic 0.1μF, $V_{IN}$=3.6V)

RP515xxx3x

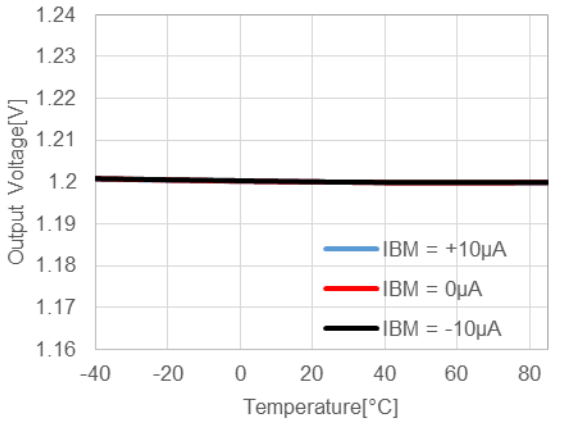



RP515xxx4x

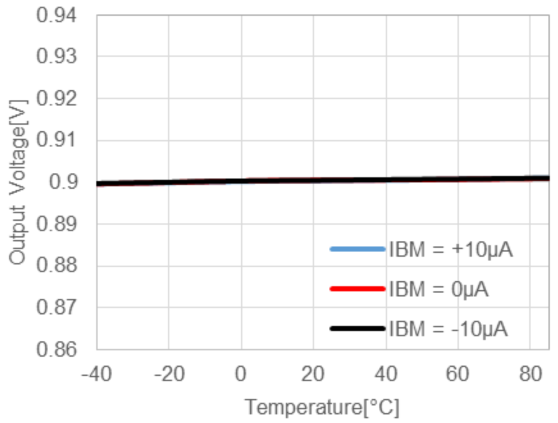



**13) BM Output Voltage vs Temperature** ($C_{OUT2}$ = Ceramic 0.1μF, Ta = 25°C)

RP515xxx3x

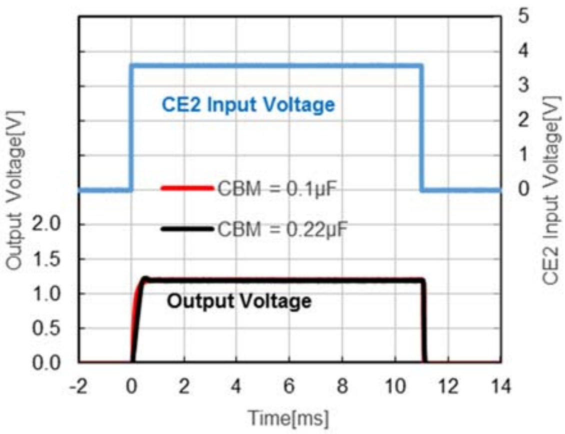



RP515xxx4x

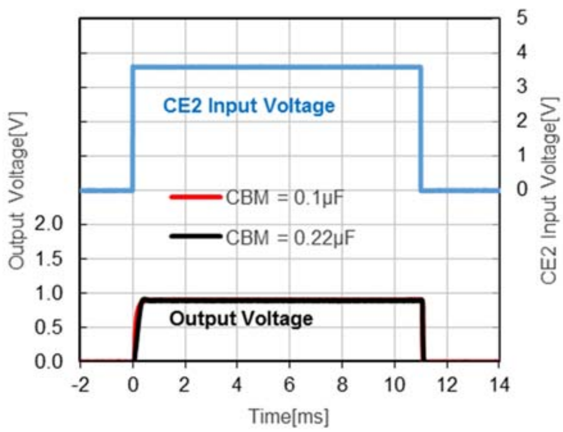


**14) BM CE2 Rising / Falling** ( $C_{OUT2}$ = Ceramic 0.1µF, 0.22µF, Ta = 25°C)

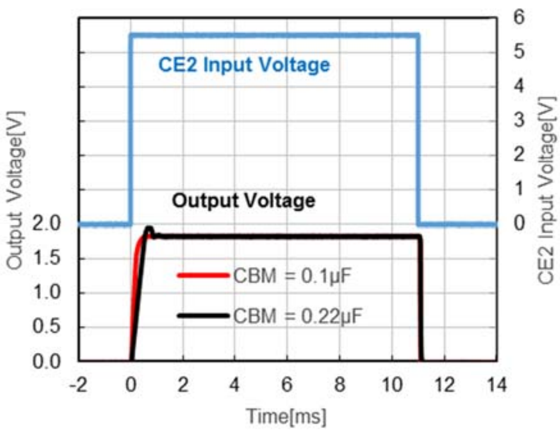
RP515xxx3x, $V_{IN}$=3.6V, $V_{CE2}$ = 0V <=> 3.6V



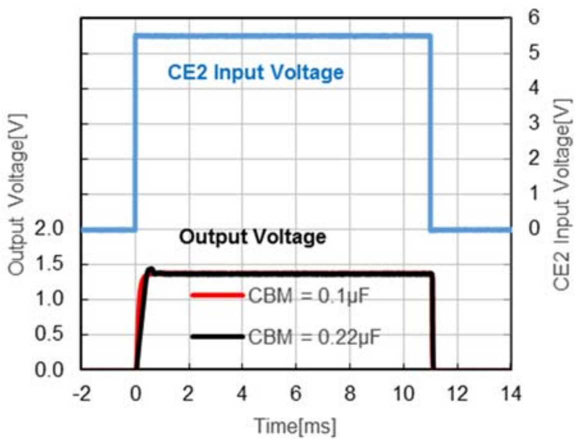

RP515xxx4x, $V_{IN}$=3.6V, $V_{CE2}$ = 0V <=> 3.6V



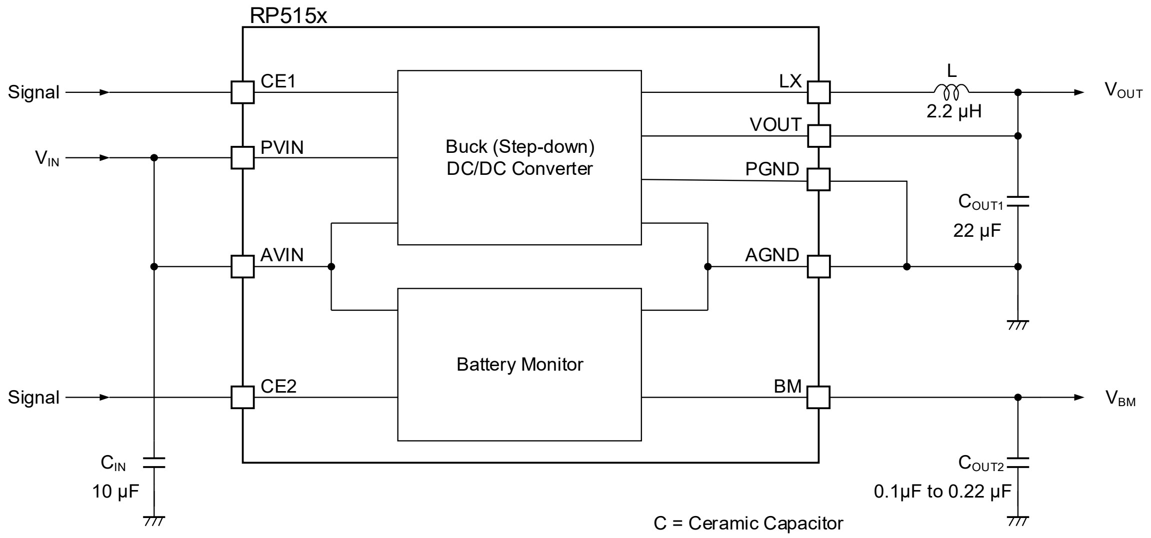

RP515xxx3x, $V_{IN}$=5.5V, $V_{CE2}$ = 0V <=> 5.5V




RP515xxx4x, $V_{IN}$=5.5V, $V_{CE2}$ = 0V <=> 5.5V



## Test Circuit




**Test Circuit of Typical Characteristics**

### Measurement Components of Typical Characteristics

| Symbol | Capacitance | Manufacture | Parts number |
|---|---|---|---|
| $C_{IN}$ | 10μF | Murata | GRM155R60J106ME44 |
| $C_{OUT1}$ | 22μF | TAIYO YUDEN | JMK107BBJ226MA-T |
| $C_{OUT2}$ | 0.1μF | Murata | GRM155R61A104KA01D |
| L | 2.2μH | TOKO | DFE201610P-2R2M |

The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following measurement conditions are based on JEDEC STD. 51-9.

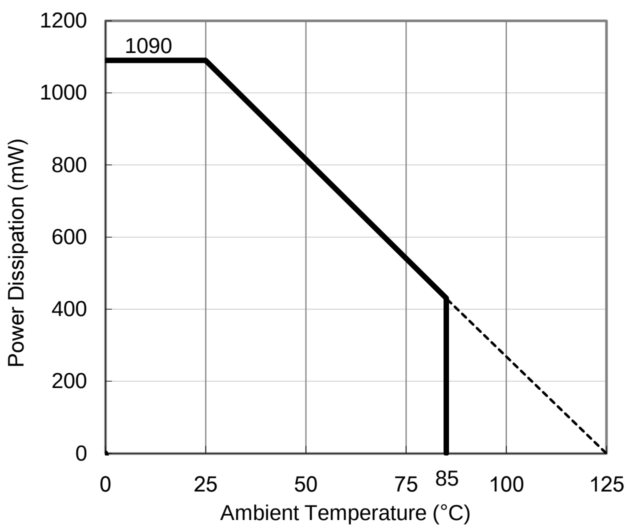
**Measurement Conditions**

| Item | Measurement Conditions |
|---|---|
| Environment | Mounting on Board (Wind Velocity = 0 m/s) |
| Board Material | Glass Cloth Epoxy Plastic (Four-Layer Board) |
| Board Dimensions | 101.5 mm x 114.5 mm x 1.6 mm |
| Copper Ratio | Outer Layer (First Layer): 60%<br>Inner Layers (Second and Third Layers): 100%<br>Outer Layer (Fourth Layer): 60% |

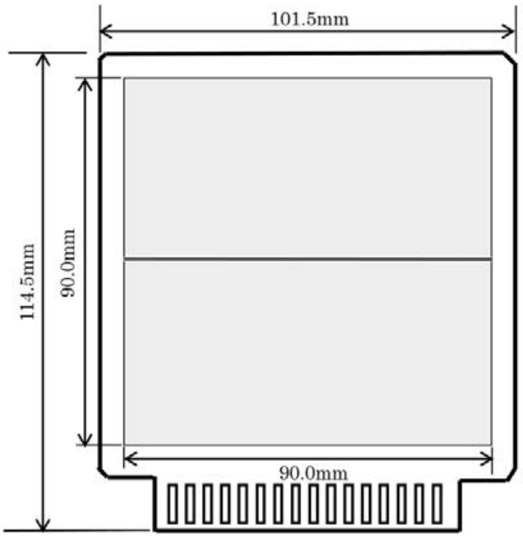
**Measurement Result** (Ta = 25°C, Tjmax = 125°C)

| Item | Measurement Result |
|---|---|
| Power Dissipation | 1090 mW |
| Thermal Resistance (θja) | θja = 91°C/W |

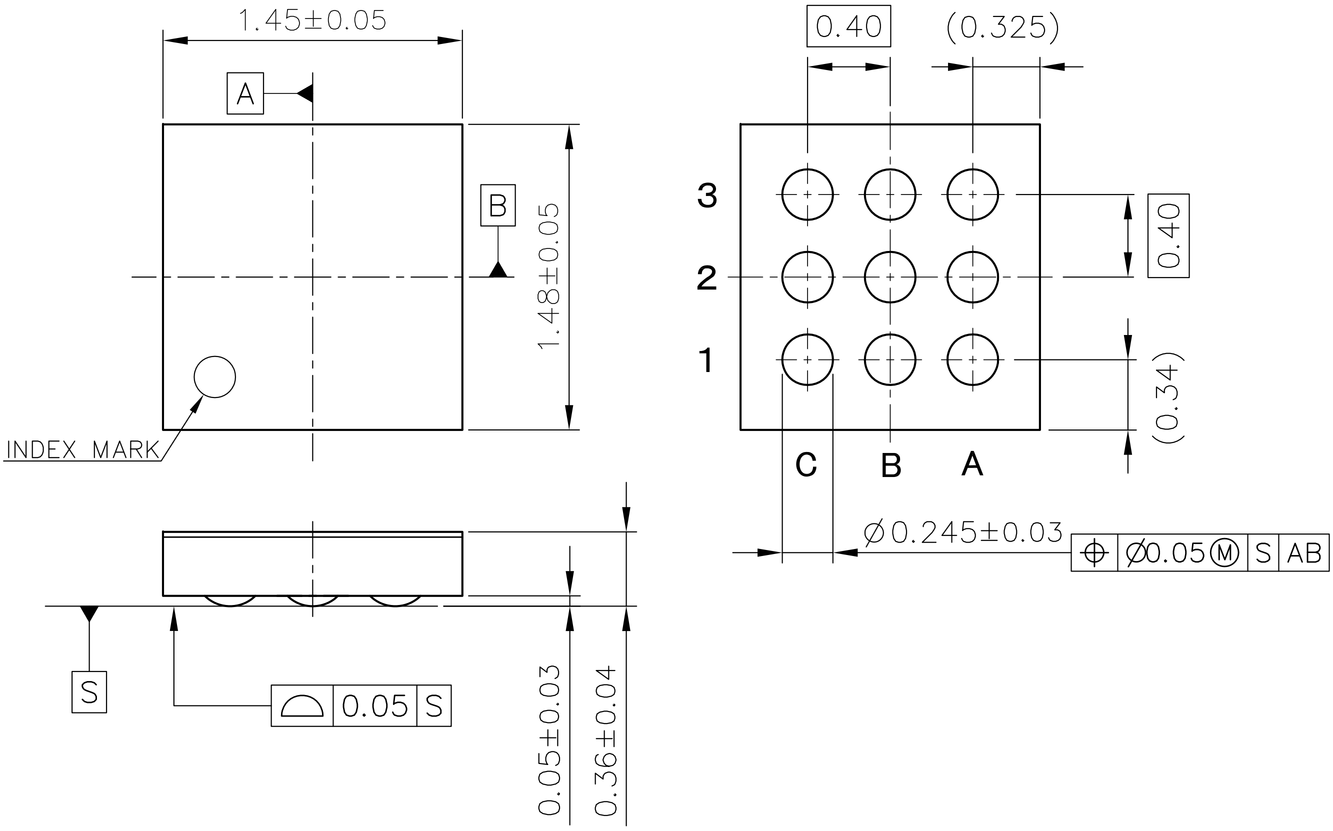
θja: Junction-to-Ambient Thermal Resistance




**Power Dissipation vs. Ambient Temperature**

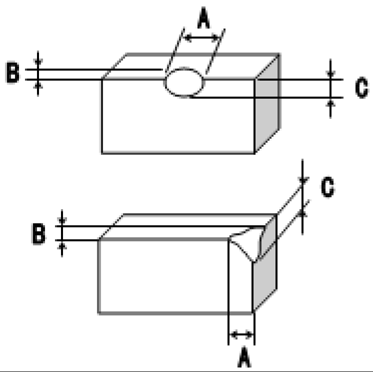



**Measurement Board Pattern**




**WLCSP-9-P2 Package Dimensions (Unit: mm)**

VI-160823

| No. | Inspection Items | Inspection Criteria | Figure |
|---|---|---|---|
| 1 | Package chipping | A≥0.2mm is rejected<br>B≥0.2mm is rejected<br>C≥0.2mm is rejected<br>And, Package chipping to Si surface and to bump is rejected. |   |
| 2 | Si surface chipping | A≥0.2mm is rejected<br>B≥0.2mm is rejected<br>C≥0.2mm is rejected<br>But, even if A≥0.2mm, B≤0.1mm is acceptable. | |
| 3 | No bump | No bump is rejected. | |
| 4 | Marking miss | To reject incorrect marking, such as another product name marking or another lot No. marking. | |
| 5 | No marking | To reject no marking on the package. | |
| 6 | Reverse direction of marking | To reject reverse direction of marking character. | |
| 7 | Defective marking | To reject unreadable marking.<br>(Microscope: X15/ White LED/ Viewed from vertical direction) | |
| 8 | Scratch | To reject unreadable marking character by scratch.<br>(Microscope: X15/ White LED/ Viewed from vertical direction) | |
| 9 | Stain and Foreign material | To reject unreadable marking character by stain and foreign material.<br>(Microscope: X15/ White LED/ Viewed from vertical direction) | |

The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following measurement conditions are based on JEDEC STD. 51-7.

**Measurement Conditions**

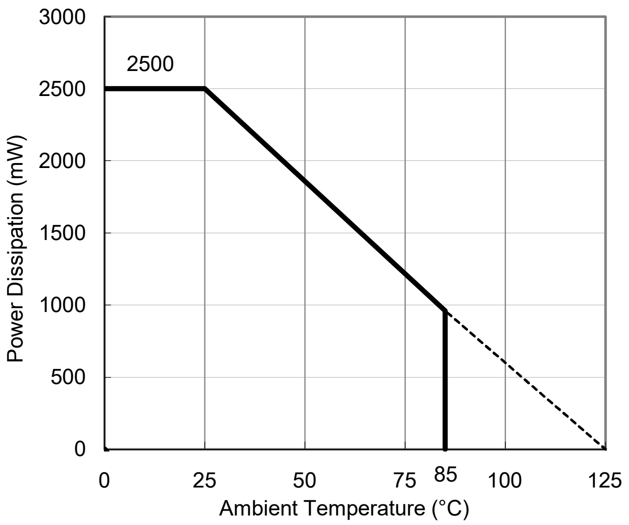
| Item | Measurement Conditions |
|---|---|
| Environment | Mounting on Board (Wind Velocity = 0 m/s) |
| Board Material | Glass Cloth Epoxy Plastic (Four-Layer Board) |
| Board Dimensions | 76.2 mm × 114.3 mm × 0.8 mm |
| Copper Ratio | Outer Layer (First Layer): Less than 95% of 50 mm Square<br>Inner Layers (Second and Third Layers): Approx. 100% of 50 mm Square<br>Outer Layer (Fourth Layer): Approx. 100% of 50 mm Square |
| Through-holes | ϕ 0.3 mm × 30 pcs |

**Measurement Result** (Ta = 25°C, Tjmax = 125°C)

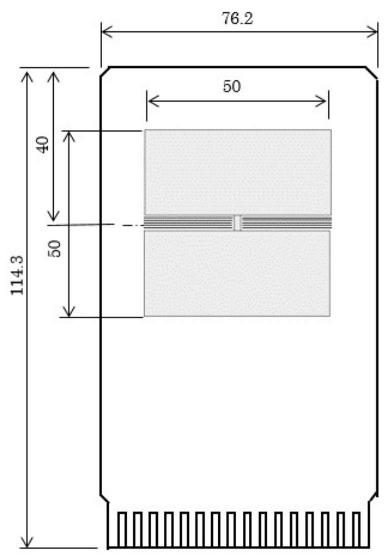
| Item | Measurement Result |
|---|---|
| Power Dissipation | 2500 mW |
| Thermal Resistance (θja) | θja = 39°C/W |
| Thermal Characterization Parameter (ψjt) | ψjt = 11°C/W |

θja: Junction-to-Ambient Thermal Resistance

ψjt: Junction-to-Top Thermal Characterization Parameter

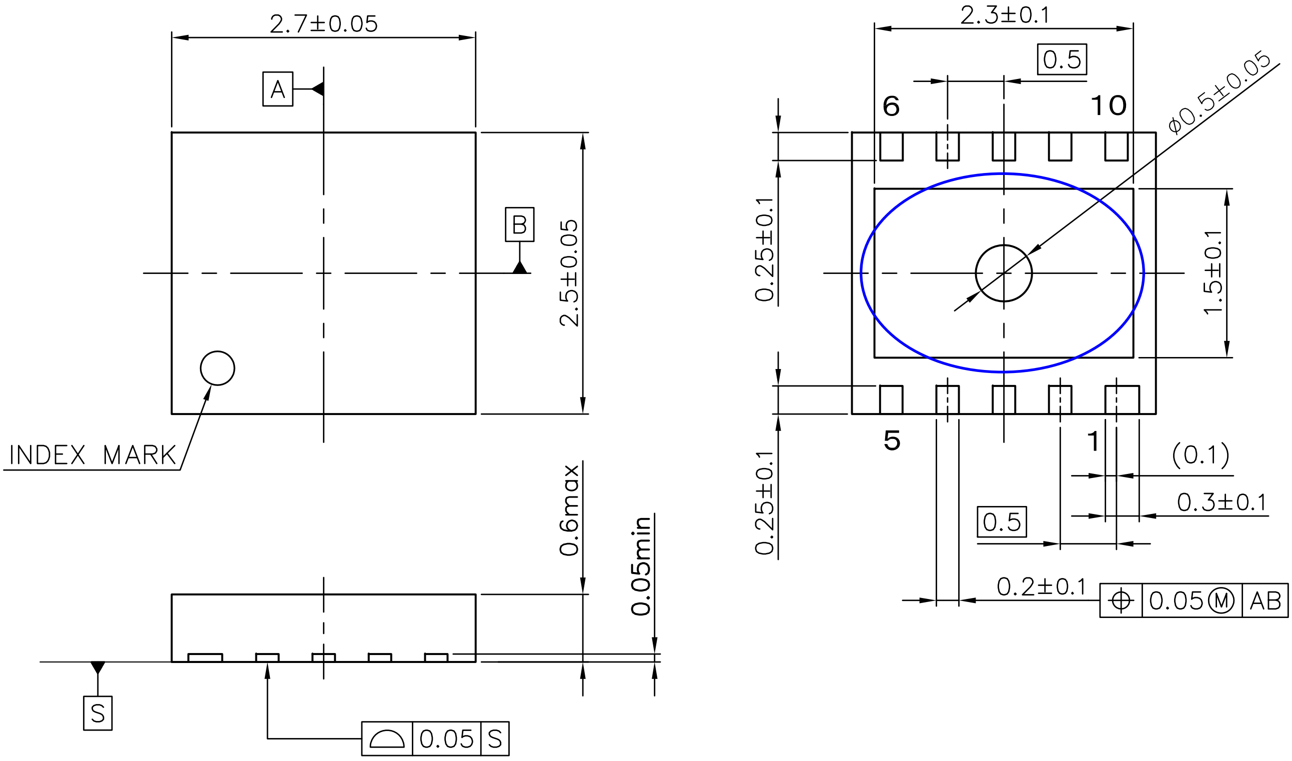



**Power Dissipation vs. Ambient Temperature**




**Measurement Board Pattern**

Ver. B




**DFN(PLP)2527-10 Package Dimensions (mm)**

* The tab on the bottom of the package shown by blue circle is a substrate potential (GND). It is recommended that this tab be connected to the ground plane on the board but it is possible to leave the tab floating.

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