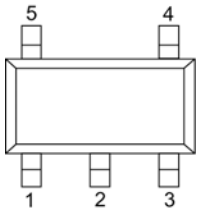
## ■PIN CONFIGURATION




SOT-25

## ■PIN ASSIGNMENT

| PIN NUMBER | PIN NAME | FUNCTION |
|---|---|---|
| 1 | GND | Ground |
| 2 | $V_{DD}$ | Power Supply |
| 3 | EXT/ | External Tr. Drive |
| 4 | $V_{OUT}$ | Output Voltage Monitor |
| 5 | CE | Chip Enable |

## ■PRODUCT CLASSIFICATION

●Ordering Information

XC9301①②③④⑤⑥-⑦ (*1): PWM control

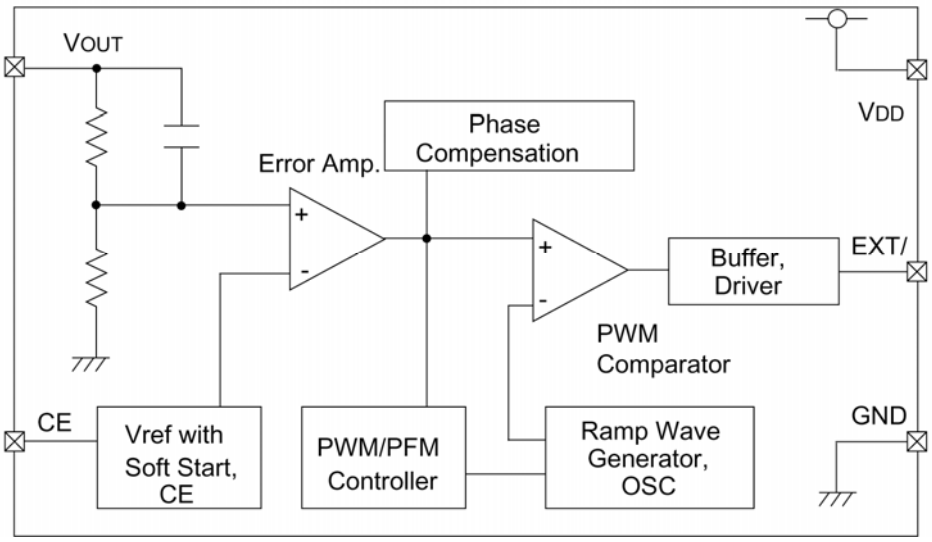
XC9302①②③④⑤⑥-⑦ (*1): PWM/PFM switching control

| DESIGNATOR | DESCRIPTION | SYMBOL | DESCRIPTION |
|---|---|---|---|
| ① | Standard | A | Fixed |
| ②③ | Output Voltage | 20~60 | e.g. $V_{OUT}$=3.0V→②=3, ③=0, $V_{OUT}$=5.3V→②=5, ③=3 |
| ④ | Oscillation Frequency | 2 | 180kHz |
| | | 3 | 300kHz |
| ⑤⑥-⑦ | Packages<br>Taping Type (*2) | MR-G | SOT-25 |

(*1) The "-G" suffix indicates that the products are Halogen and Antimony free as well as being fully RoHS compliant.

(*2) The device orientation is fixed in its embossed tape pocket. For reverse orientation, please contact your local Torex sales office or representative. (Standard orientation: ⑤R-⑦, Reverse orientation: ⑤L-⑦)

## ■BLOCK DIAGRAM



## ■ABSOLUTE MAXIMUM RATINGS

Ta = 25℃

| PARAMETER | SYMBOL | RATINGS | UNITS |
|---|---|---|---|
| $V_{DD}$ Pin Voltage | $V_{DD}$ | -0.3～12.0 | V |
| $V_{OUT}$ Pin Voltage | $V_{OUT}$ | -0.3～12.0 | V |
| CE Pin Voltage | $V_{CE}$ | -0.3～12.0 | V |
| EXT/ Pin Voltage | $V_{EXT/}$ | -0.3～$V_{DD}$+0.3 | V |
| EXT/ Pin Current | $I_{EXT/}$ | ±100 | mA |
| Power Dissipation | Pd | 150 | mW |
| Operating Temperature Range | Topr | -40～+85 | ℃ |
| Storage Temperature Range | Tstg | -40～+125 | ℃ |

## ■ELECTRICAL CHARACTERISTICS

XC9301x332MR, XC9302x332MR (VOUT=3.3V, FOSC=180kHz) Ta=25℃

| PARAMETER | SYMBOL | CONDITIONS | MIN. | TYP. | MAX. | UNITS |
|---|---|---|---|---|---|---|
| Output Voltage | VOUT | | 3.218 | 3.300 | 3.383 | V |
| Supply Voltage | VDD | | 2.0 | - | 10.0 | V |
| Supply Current 1 | IDD1 | VOUT=CE: Setting output voltage × 0.95 applied | - | 80 | 140 | μA |
| Supply Current 2 | IDD2 | VOUT=CE: Setting output voltage + 0.5 applied | - | 15 | 26 | μA |
| Stand-By Current | ISTB | VOUT: Setting output voltage × 0.95 applied, CE=0V | - | - | 0.5 | μA |
| Oscillation Frequency | FOSC | VDD=VOUT=CE: Setting output voltage × 0.95 applied | 153 | 180 | 207 | kHz |
| Maximum Duty Ratio | MAXDTY | VDD=VOUT=CE: Setting output voltage × 0.95 applied | 78 | 85 | 92 | % |
| PFM Duty Ratio (*1) | PFMDTY | No Load | 15 | 25 | 35 | % |
| Efficiency (*2) | EFFI | VDD=VIN=CE: Setting output voltage × 0.95 applied | - | 78 | - | % |
| Soft-Start Time | TSS | | 5.0 | 10.0 | 20.0 | ms |
| CE 'H' Voltage | VCEH | VOUT: Setting output voltage × 0.95 applied | 0.65 | - | - | V |
| CE 'L' Voltage | VCEL | VOUT: Setting output voltage × 0.95 applied | - | - | 0.20 | V |
| EXT/ 'H' ON Resistance | REXTBH | Same as IDD1, VEXT/ = VOUT - 0.4V | - | 29 | 43 | Ω |
| EXT/ 'L' ON Resistance | REXTBL | Same as IDD1, VEXT/ = 0.4V | - | 19 | 27 | Ω |

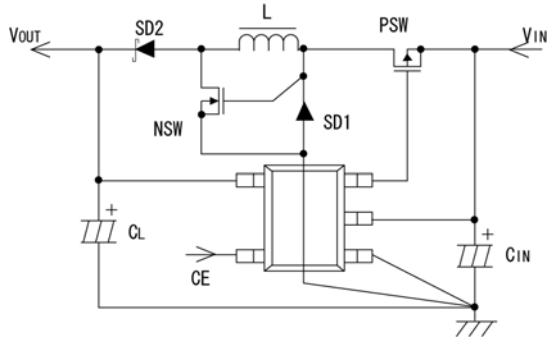
Test Conditions: Unless otherwise stated, VDD = 3.3V, IOUT = 130mA
NOTE: *1: XC9302 series only
*2: EFFI={[(output voltage) × (output current)] / [(input voltage) × (input current)]} × 100

XC9301x333MR, XC9302x333MR (VOUT=3.3V, FOSC=300kHz) Ta=25℃

| PARAMETER | SYMBOL | CONDITIONS | MIN. | TYP. | MAX. | UNITS |
|---|---|---|---|---|---|---|
| Output Voltage | VOUT | | 3.218 | 3.300 | 3.383 | V |
| Supply Voltage | VDD | | 2.0 | - | 10.0 | V |
| Supply Current 1 | IDD1 | VOUT=CE: Setting output voltage × 0.95 applied | - | 130 | 200 | μA |
| Supply Current 2 | IDD2 | VOUT=CE: Setting output voltage + 0.5 applied | - | 20 | 35 | μA |
| Stand-By Current | ISTB | VOUT: Setting output voltage × 0.95 applied, CE=0V | - | - | 0.5 | μA |
| Oscillation Frequency | FOSC | VDD=VOUT=CE: Setting output voltage × 0.95 applied | 255 | 300 | 345 | kHz |
| Max. Duty Ratio | MAXDTY | VDD=VOUT=CE: Setting output voltage × 0.95 applied | 78 | 85 | 92 | % |
| PFM Duty Ratio (*1) | PFMDTY | No Load | 15 | 25 | 35 | % |
| Efficiency (*2) | EFFI | VDD=VIN=CE: Setting output voltage × 0.95 applied | - | 78 | - | % |
| Soft-Start Time | TSS | | 5.0 | 10.0 | 20.0 | ms |
| CE 'H' Voltage | VCEH | VOUT: Setting output voltage × 0.95 applied | 0.65 | - | - | V |
| CE 'L' Voltage | VCEL | VOUT: Setting output voltage × 0.95 applied | - | - | 0.20 | V |
| EXT/ 'H' ON Resistance | REXTBH | Same as IDD1, VEXT/ = VOUT - 0.4V | - | 29 | 43 | Ω |
| EXT/ 'L' ON Resistance | REXTBL | Same as IDD1, VEXT/ = 0.4V | - | 19 | 27 | Ω |

Test Conditions: Unless otherwise stated, VDD = 3.3V, IOUT = 130mA
NOTE: *1: XC9302 series only
*2: EFFI={[(output voltage) × (output current)] / [(input voltage) × (input current)]} × 100

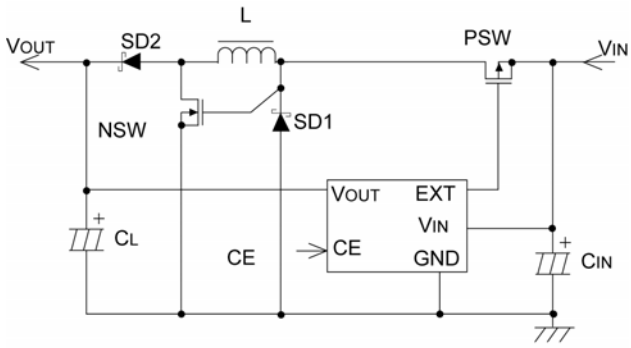
## ■TYPICAL APPLICATION CIRCUIT



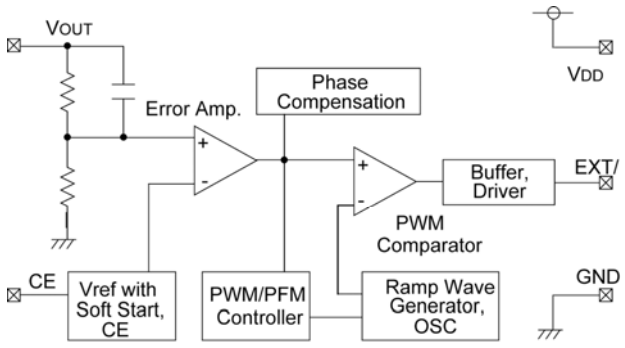

External Components
PSW: XP162A12 (SOT-89, TOREX)
NSW: XP161A12 (SOT-89, TOREX)
L : 22μH (CR54, SUMIDA)

SD : U2FWJ44N ( Schottky, TOSHIBA )
CL : 16V, 47μF×2 (Tantalum, MCE series, NICHICON )
CIN : 16V, 22μF (Tantalum, MCE series, NICHICON )
220μF (Electrolytic, NICHICON, PJ type)

# ■OPERATIONAL EXPLANATION




<Circuit Connection Example>




<Block Diagram>

The XC9301/9302 series are PWM (PWM/PFM switching) step-up/down DC/DC converter controller ICs. The XC9302 series switches to PFM operations during light loads and is very efficient over a wide range in relation to load. Further, the efficiency can be maintained over a wide input voltage range as both step-up & step-down operations are PWM controlled. Output voltage settings are laser trimmed.

<ON TIME>
P-ch MOSFET (PSW) = ON, N-ch MOSFET (NSW) = ON: Current flows from VIN via PSW, L, NSW, to GND: L is charged.

<OFF TIME>
P-ch MOSFET (PSW) = OFF, N-ch MOSFET (NSW) = OFF: Current flows from GND via SD1, L, SD2, to VOUT: VOUT rises due to the charge stored at L.
By comparing VOUT with the internal reference voltage, the ON TIME vs. OFF TIME ratio can be regulated & output stability can be protected.

<Error Amp.>
The error amplifier is used as an output voltage monitor. It compares the reference voltage with the feedback from the voltage divided by the internal resistor. Should a voltage higher than the reference voltage be fedback, the output of the error amp will increase.

<PWM Comparator>
The PWM comparator compares the output of the error amp with the ramp wave. When the voltage at the output of the error amp is low, the EXT/ pin will be low level (Switching ON time).

<Ramp Wave Generator>
The ramp wave generator generates the switching frequency's ramp wave.

<PWM / PFM Controller>
With the XC9302 series, control is automatically switched between PWM and PFM according to the size of the load.

<Vref with Soft Start, CE>
The start up of the Vref voltage at the error amp's input is gradual due to the internal capacitor and low current circuit. Because of this soft-start function, the operations of the error amp's 2 inputs are balanced and the EXT/ pin's ON TIME can be manipulated to produce longer ON times. Further, with the U.V.L.O. function, the signal will be such so as not to turn the MOSFET switch ON until any instability in the internal circuit stabilizes during soft-start time. Even in cases where input voltage is so low as to produce instability in the IC, the U.V.L.O. function will operate and the MOSFET switch will be turned OFF.

## ■OPERATIONAL EXPLANATION (Continued)

●Product Selection (Notes)

XC9301/02 series is a group of PFM controlled (XC9302 series switches from PWM to PFM control during light loads) step-up and down DC/DC converters. The series is highly efficient with a wide range of input voltage since its stepping-up and down operation is controlled by PWM movements. In general, there are several methods available for obtaining a stable output voltage at such times when input voltage is changing from being higher than the established output voltage to being lower than the established output voltage. Each method has its merits and demerits but is essential that a method, which provides the best results in terms of input and output under actual operating conditions. Below, two methods are highlighted and their respective performances in terms of efficiency are compared. This is an efficiency comparison of two ways, step-up DC/DC converter + VR and step-up & down DC/DC converter.

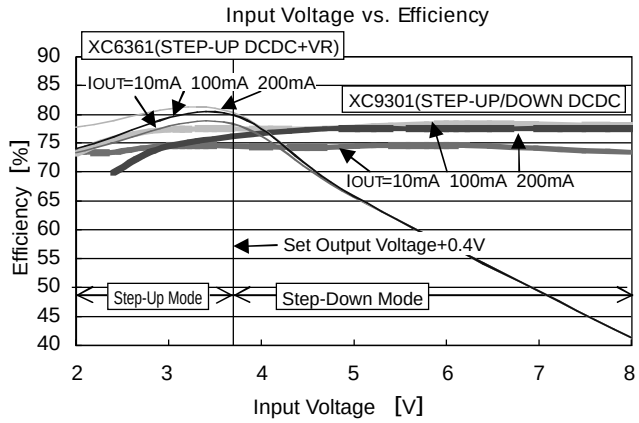
[Step-Up DC/DC Converter + VR] (XC6361/62)

◆Step-up mode (Input voltage < setting output voltage + 0.4V)
After input voltage has been stepped-up to setting output voltage + 0.4V by the step-up DC/DC converter, the output voltage will be regulated to the set value by the VR. (0.4V loss via the VR)

◆Step-down mode (Input voltage ≧ setting output voltage + 0.4V)
After input voltage has been stepped-up to setting output voltage + 0.4V by the step-up DC/DC converter, the output voltage will be regulated to the set value by the VR. (Dropout voltage loss via the VR)

[Step-Up & Down DC/DC Converter] (XC9301/02)

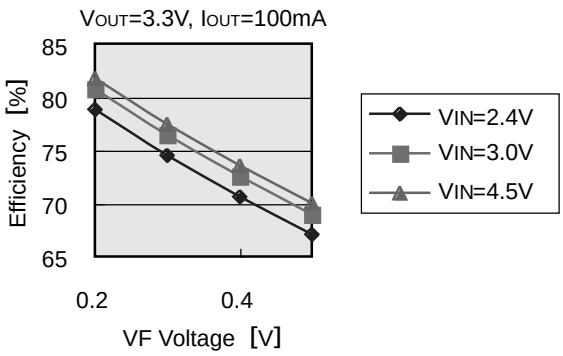
◆Setting output voltage obtained as a result of the automatic switching operations of the IC regardless of the difference between input voltage and set output voltage.




The above graph shows that over a wide input voltage range, the efficiency of the XC9301/02 is more or less constant. On the other hand, the efficiency of the XC6361/62 is clearly shown to decrease as input voltage increases. In step-down mode in particular, the efficiency of the XC9301/02 is much better than the XC6361/62. In applications that use either a standard dry 3 cell battery or a 2 cell lithium Ion battery to obtain an output of 3.3V, for example, the efficiency of the XC9301/02 series is again much better. Because the XC9301/02 series does not have a series regulator output, we recommend a test with samples for use in applications where ripple voltage is a problem.

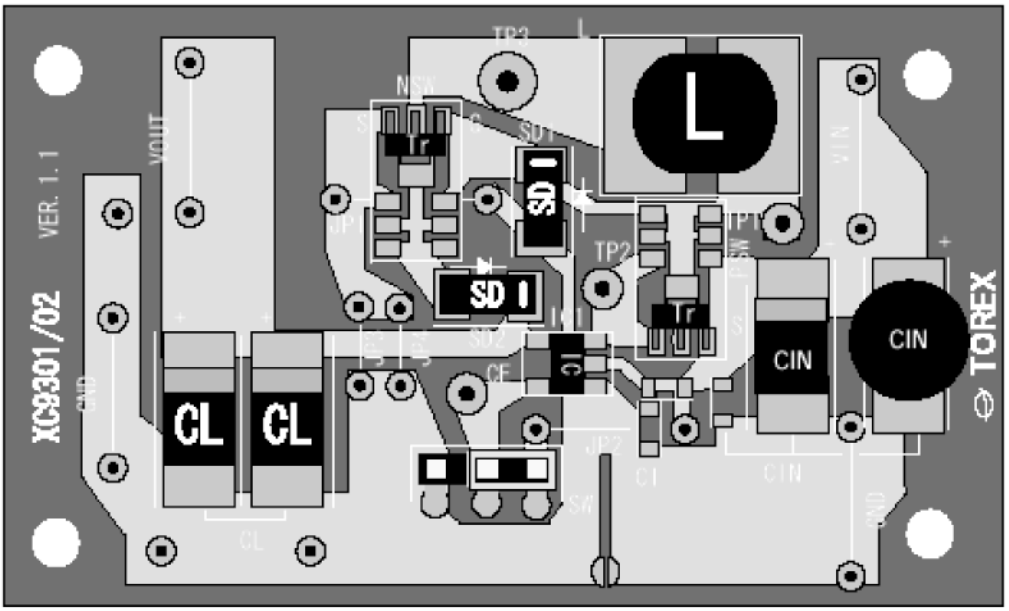
●External Components Selection (Notes)

- The performance of the DC/DC converter IC circuit is heavily reliant upon the performance of the surrounding circuitry and components. In particular, since the $V_F$ voltage of the Schottky Diode used will have a direct effect upon efficiency, the smaller the diode, the better the efficiency obtainable. (Refer to the graph below)
- It is also recommended that a switching MOSFET with a small ON resistance be used. With the XC9301/02, an ON resistance of 500mΩ or less is recommended.



# ■OPERATIONAL EXPLANATION (Continued)

●Demo Board Version 1.1




External Components

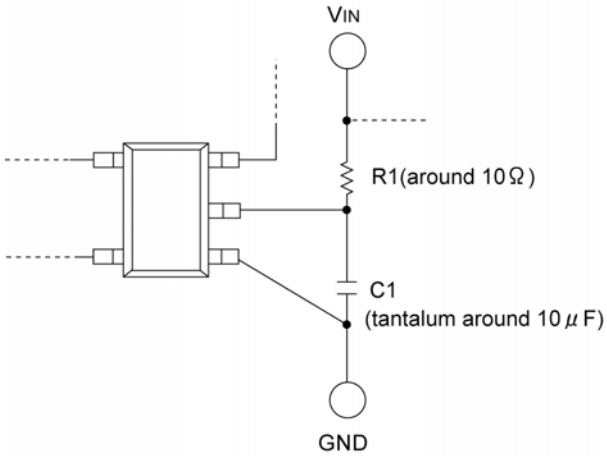
| | | |
|---|---|---|
| PSW | : | XP162A12 (SOT-89) |
| NSW | : | XP161A12 (SOT-89) |
| L | : | 22μH (CR54, SUMIDA) |
| SD | : | U2FWJ44N (Schottky, TOSHIBA) |
| CL | : | 16V, 47μF×2 (Tantalum, MCE series, NICHICON) |
| CIN | : | 16V, 22μF (Tantalum, MCE series, NICHICON)<br>16V, 220μF (Electrolytic, NICHICON, PJ type) |

Demo Board Connection Layout

→suitable for SOT-23, SOT-89, CPH-6
→suitable for CR43～CR105
→suitable for MA720, MA735, U2FWJ44N
→suitable for 1005 type～D2 Package

<Jumper Settings>
JP3: Must be connected
JP2: To be connected if using SW (CE pin fixed to VIN)
* Use tinned copper wire for the VIN pin, VOUT pin, GND pin, JP2, and JP3.
* Connect test pins for the TP1, TP2, TP3, and CE.

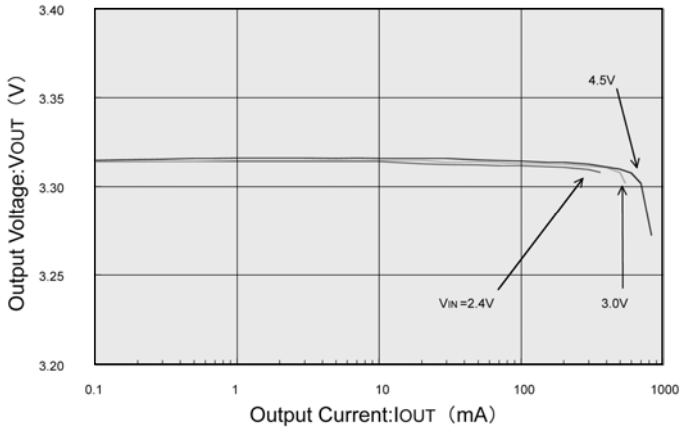
Note:
Oscillation may occur as a result of input voltage instability when the output current is large. At such times, we recommend that in place of the 220μF, PJ type capacitor, you connect R1 & C1 as shown in the diagram on the right hand side. (In case of demo boards version 1.1, cut the pattern wire of R1 connecting point, then connect R1.)



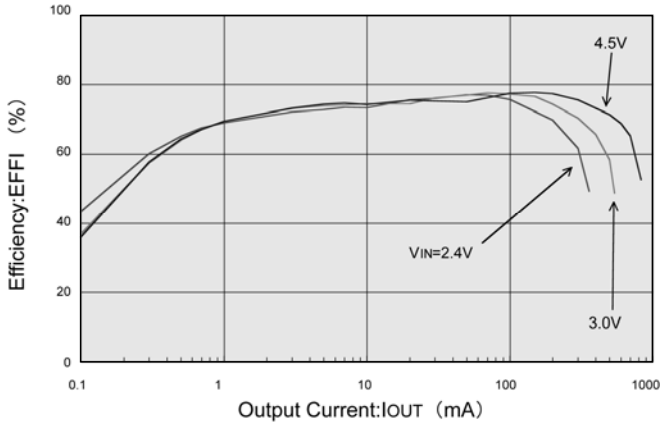
## ■TYPICAL PERFORMANCE CHARACTERISTICS

XC9302A332 (PWM/PFM switching control, 180kHz, VOUT=3.3V)

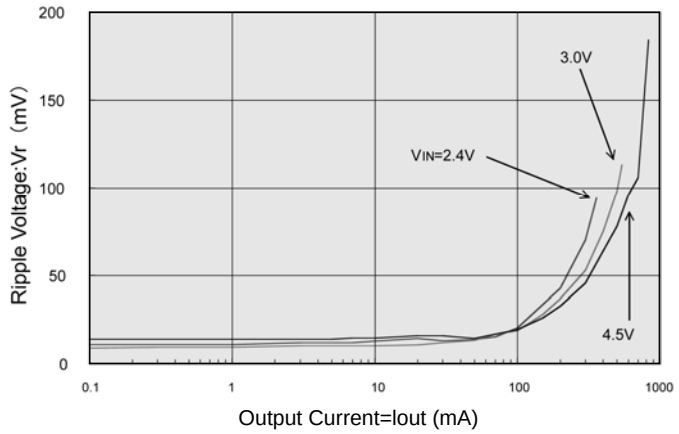
(1) Output Voltage vs. Output Current (Topr=25℃)




(2) Efficiency vs. Output Current (Topr=25℃)




(3) Ripple Voltage vs. Output Current (Topr=25℃)



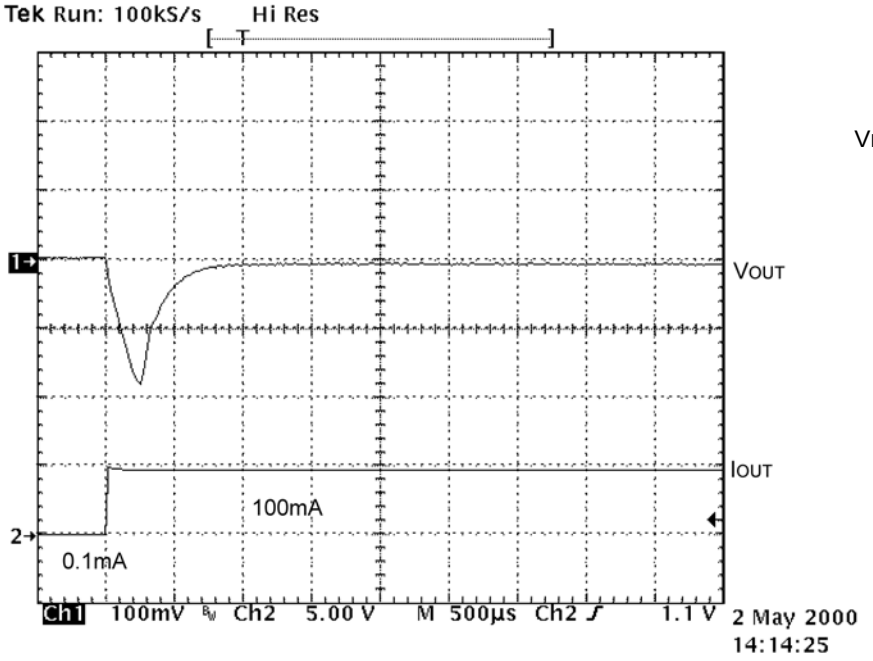

External Components

| | | | |
|---|---|---|---|
| PSW | : XP162A12A6PR | CL | : 47μF (MCE series, Tantalum) × 2 |
| NSW | : XP161A1265PR | CIN | : 220μF (Electrolytic, PJ type) |
| SD | : U2FWJ44N | RDD | : 10Ω |
| L | : 22μH (CR54) | CDD | : 47μF (MCE series, Tantalum) |
| | | VCE=VIN | |

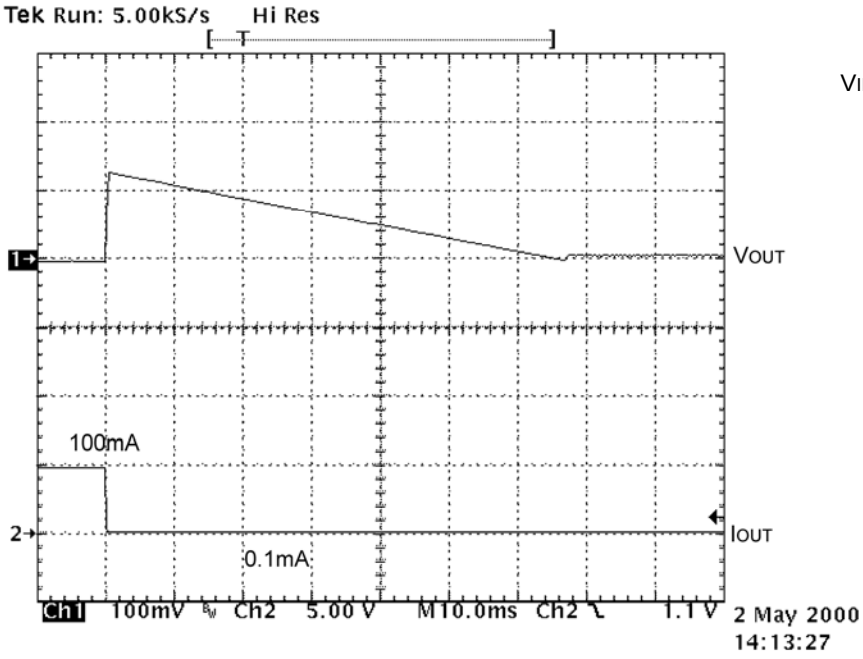
# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

XC9302A332 (PWM/PFM switching control, 180kHz, VOUT=3.3V) (Continued)

(4) Load Transient Response (Topr=25℃)




VIN=3.0V




VIN=3.0V

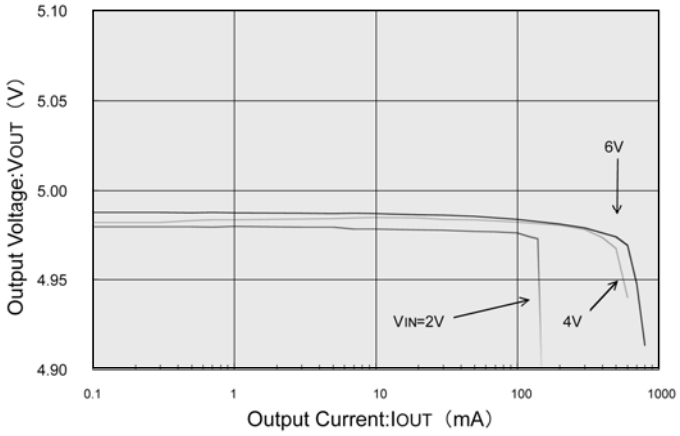
External Components

| | | | |
|---|---|---|---|
| PSW | : XP162A12A6PR | CL | : 47µF (MCE series, Tantalum) × 2 |
| NSW | : XP161A1265PR | CIN | : 220µF (Electrolytic, PJ type) |
| SD | : U2FWJ44N | RDD | : 10Ω |
| L | : 22µH (CR54) | CDD | : 47µF (MCE series, Tantalum) |
| | | VCE=VIN | |

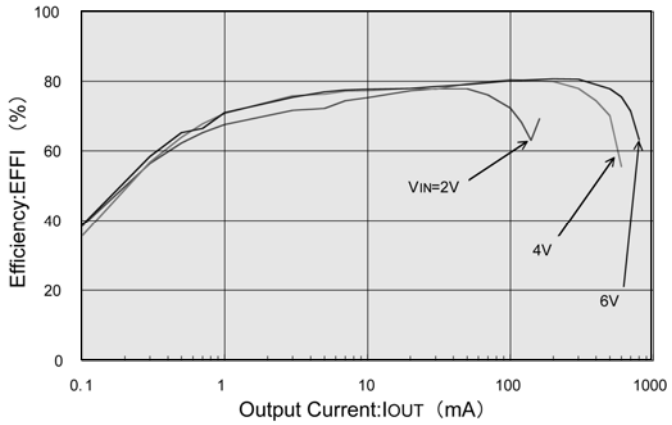
## ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

XC9302A502 (PWM/PFM switching control, 180kHz, VOUT=5.0V)

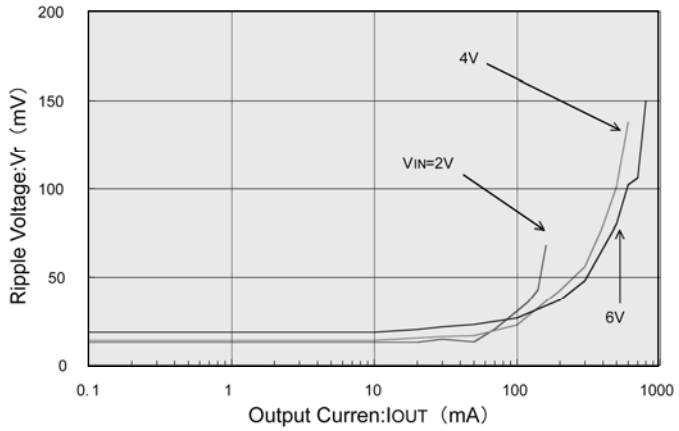
(1) Output Voltage vs. Output Current (Topr=25℃)




(2) Efficiency vs. Output Current (Topr=25℃)




(3) Ripple Voltage vs. Output Current (Topr=25℃)



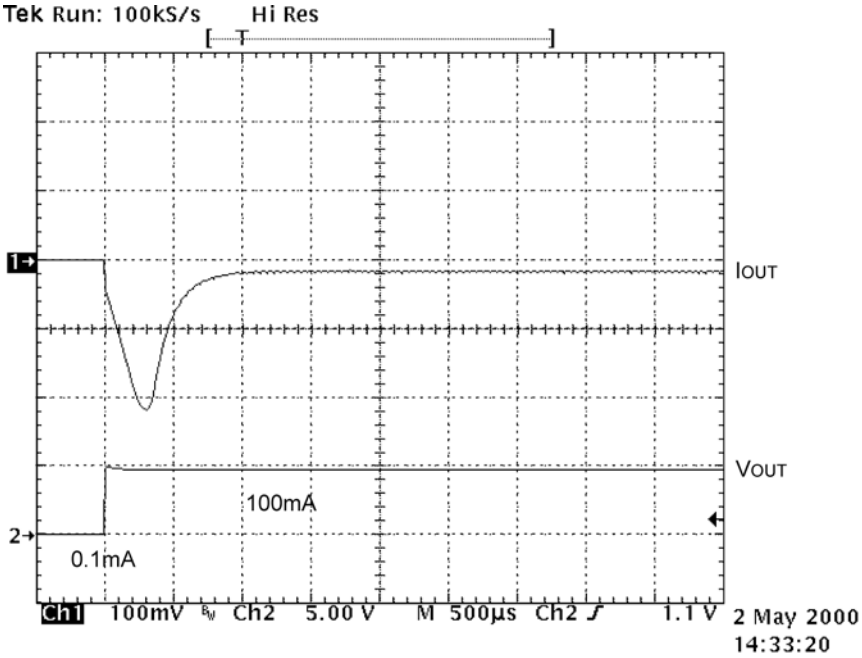

External Components

| | | | |
|---|---|---|---|
| PSW | : XP162A12A6PR | CL | : 47μF (MCE series, Tantalum) × 2 |
| NSW | : XP161A1265PR | CIN | : 220μF (Electrolytic, PJ type) |
| SD | : U2FWJ44N | RDD | : 10Ω |
| L | : 22μH (CR54) | CDD | : 47μF (MCE series, Tantalum) |
| | | VCE=VIN | |

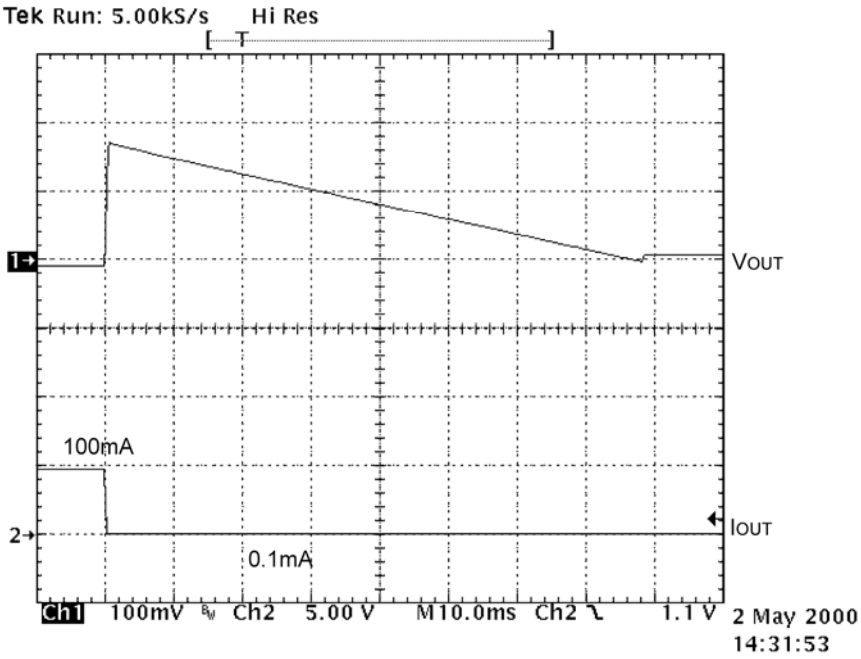
# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

XC9302A502 (PWM/PFM switching control, 180kHz, VOUT=5.0V) (Continued)

(4) Load Transient Response (Topr=25℃)




VIN=4.0V



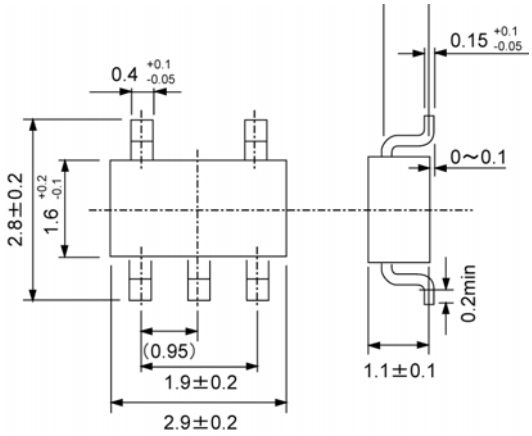

VIN=4.0V

External Components

| | | | |
|---|---|---|---|
| PSW | : XP162A12A6PR | CL | : 47µF (MCE series Tantalum) ×2 |
| NSW | : XP161A1265PR | CIN | : 220µF (Electrolytic, PJ type) |
| SD | : U2FWJ44N | RDD | : 10Ω |
| L | : 22µH (CR54) | CDD | : 47µF (MCE series Tantalum) |
| | | VCE=VIN | |

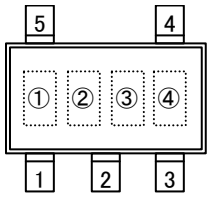
## ■PACKAGING INFORMATION

●SOT-25




## ■MARKING RULE

●SOT-25




SOT-25
(TOP VIEW)

①represents the product series

| MARK | PRODUCT SERIES |
|---|---|
| A | XC9301AxxxMx |
| K | XC9302AxxxMx |

②represents the integer of the output voltage and oscillation frequency

| OUTPUT VOLTAGE (V) | MARK | |
|---|---|---|
| | FREQUENCY=180kHz (XC9301/XC9302Axx2Mx) | FREQUENCY=300kHz (XC9301/XC9302Axx3Mx) |
| 2.x | 2 | 2 |
| 3.x | 3 | 3 |
| 4.x | 4 | 4 |
| 5.x | 5 | 5 |
| 6.x | 6 | 6 |

③represents decimal number of output voltage and oscillation frequency

| OUTPUT VOLTAGE (V) | MARK | |
|---|---|---|
| | FREQUENCY=180kHz (XC9301/XC9302Axx2Mx) | FREQUENCY=300kHz (XC9301/XC9302Axx3Mx) |
| 0.x | 0 | A |
| 1.x | 1 | B |
| 2.x | 2 | C |
| 3.x | 3 | D |
| 4.x | 4 | E |
| 5.x | 5 | F |
| 6.x | 6 | H |
| 7.x | 7 | K |
| 8.x | 8 | L |
| 9.x | 9 | M |

④represents production lot number
0 to 9, A to Z reverse character 0 to 9, A to Z repeated
(G, I, J, O, Q, W excluded)

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