XC9301/XC9302 Series

PWM,PWM/PFM Switching Step-Up & Down DC/DC Converter Controller ICs

☆GO-Compatible

■GENERAL DESCRIPTION

The XC9301/02 series are step-up/down DC/DC converter controller ICs with fast, low ON resistance drivers built-in. A versatile, large output current, step-up/down DC/DC converter can be realized using only 4 basic external components - transistors, coils, diodes and capacitors.
Output voltage is selectable in 100mV increments within a 2.4V ~ 6.0V (±2.5% accuracy) range and switching frequency is set at 180kHz or 300kHz.
The XC9302 series switches from PWM to PFM control during light loads and the series offers high efficiencies from light loads through to large output currents.
Soft-start time is internally set to 10msec which offers protection against rush currents when the power is switched on and also against voltage overshoot.
During shutdown (CE pin = L), consumption current can be reduced to as little as 0.5μA or less.

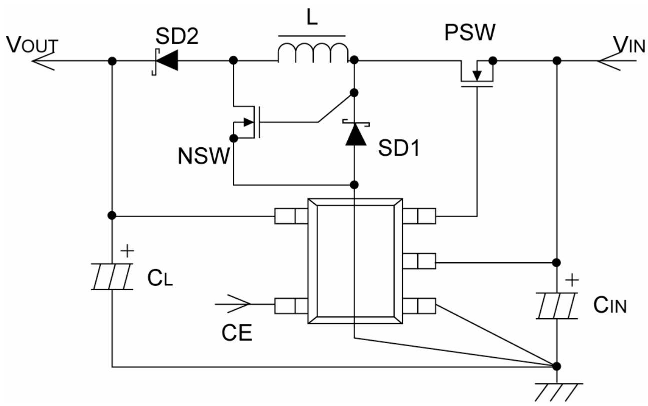
■APPLICATIONS

●Mobile phones
●PDAs
●Palmtop computers
●Portable audio equipment
●Various power supplies

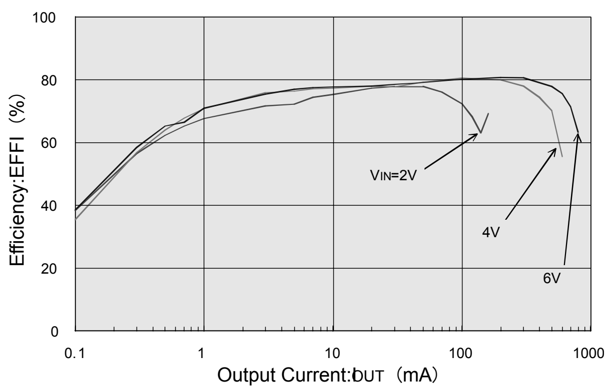
■FEATURES

Input Voltage Range : 2.0V ~ 10V
Output Voltage Range : 2.4V ~ 6.0V (±2.5% accuracy) (selectable in 100mV increments)
Oscillation Frequency : 180KHz, 300KHz (±15% accuracy)
Output Current : more than 250mA (V_{IN}=2.4V, V_{OUT}=3.3V)
Efficiency : 81%(TYP.) @ V_{OUT}=5.0V, 78%(TYP.) @ V_{OUT}=3.3V
Stand-By : I_{STB} = 0.5μA (MAX.)
Maximum Duty Ratio : 85%(TYP.)
PWM/PFM Switching Step-Up & Down Control (XC9302)
Package : SOT-25
Output Voltage Internal Set-Up

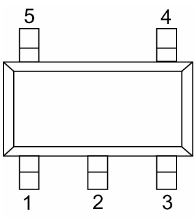
■TYPICAL APPLICATION CIRCUIT



■TYPICAL PERFORMANCE CHARACTERISTICS



■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

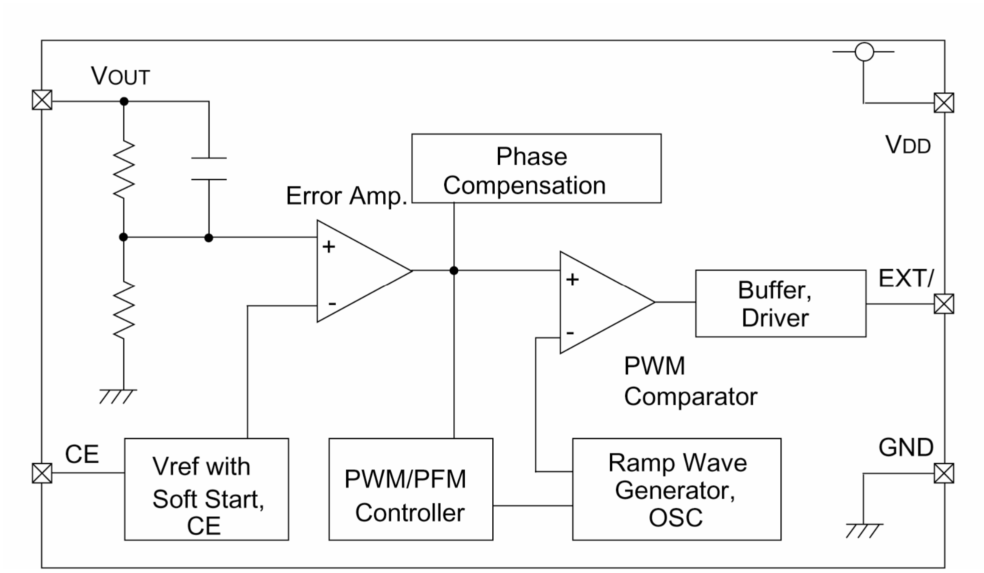
■PRODUCT CLASSIFICATION

●Ordering Information

XC9301 ①②③④⑤⑥: PWM control
XC9302 ①②③④⑤⑥: PWM/PFM switching control

DESIGNATOR	DESCRIPTION	SYMBOL	DESCRIPTION
①	Standard	A	: Fixed
② ③	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
⑤	Package	M	: SOT-25
⑥	Device Orientation	R	: Embossed tape, standard feed
		L	: Embossed tape, reverse feed

■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℃

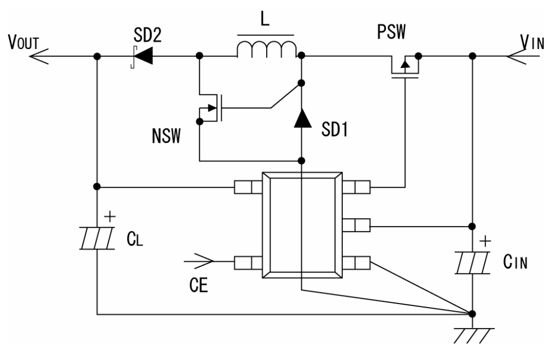
PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Output Voltage	VOUT		3.218	3.300	3.383	V
Supply Voltage	VDD		2.0	-	10.0	V
Supply Current 1	IDD1	VOUT=CE: Setting output voltage × 0.95 applied	-	130	200	μA
Supply Current 2	IDD2	VOUT=CE: Setting output voltage + 0.5 applied	-	20	35	μA
Stand-By Current	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

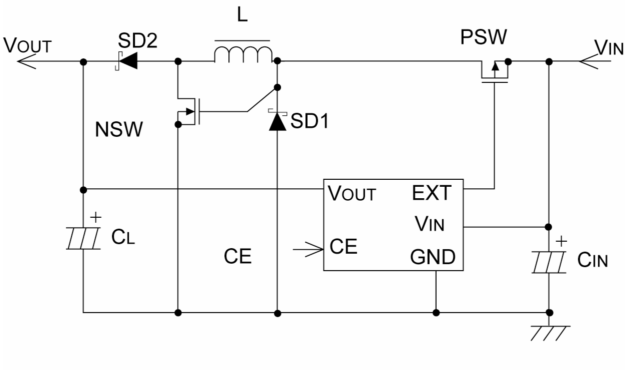


External Components

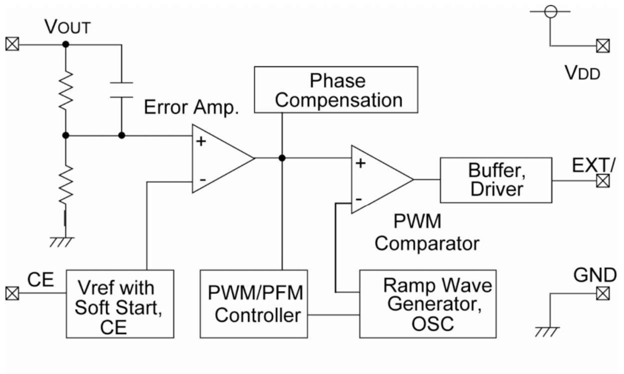
PSW: XP162A12 (SOT-89, TOREX)
NSW: XP161A12 (SOT-89, TOREX)
L : 22μH (CR54, SUMIDA)

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 V_{IN} 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 V_{OUT}: V_{OUT} rises due to the charge stored at L.
By comparing V_{OUT} 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.

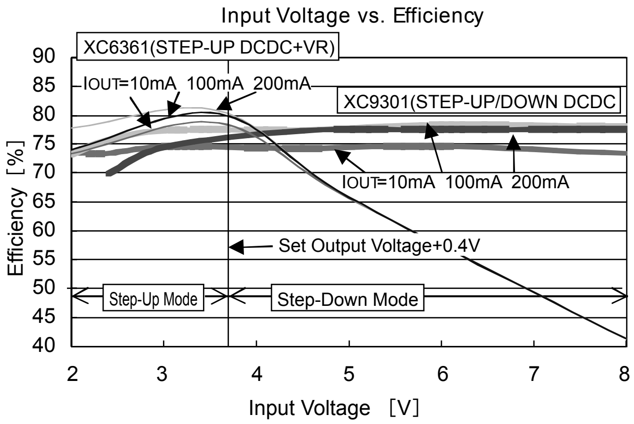
[Step-Up DC/DC Converter + VR] (XC6361/62)

◆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)

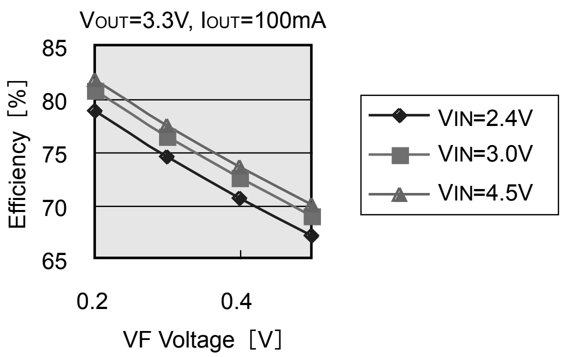
◆Setting output voltage obtained as a result of the automatic switching operations of the IC regardless of the difference between input voltage and set output voltage.



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.

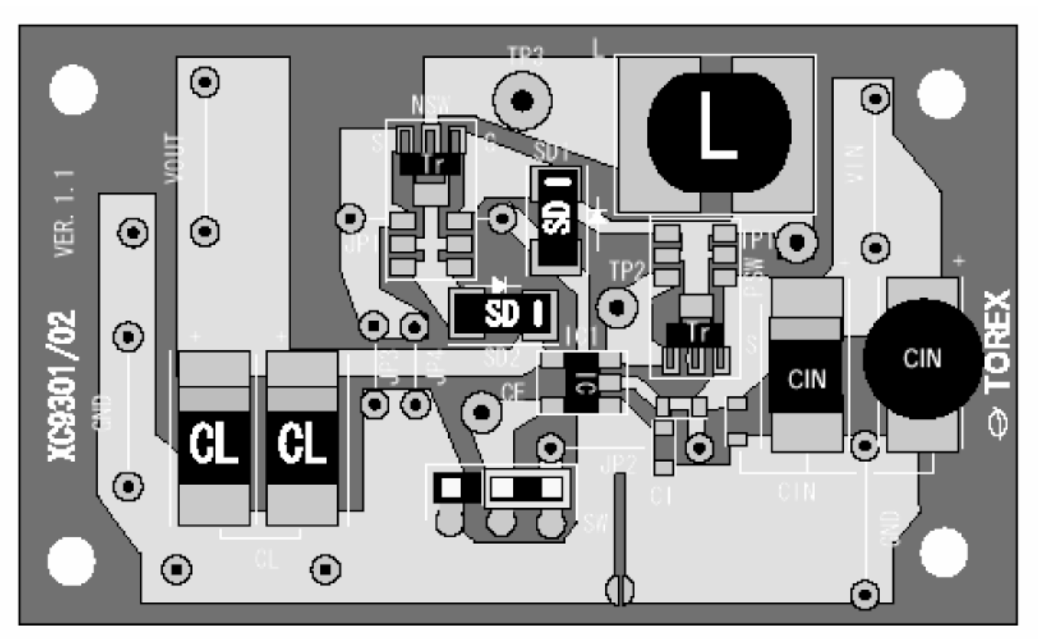
●External Components Selection (Notes)

- 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)

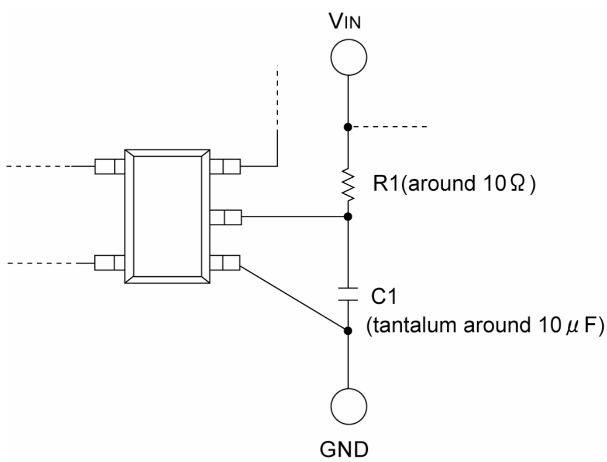
●Demo Board Version 1.1



External Components			Demo Board Connection Layout
PSW	:	XP162A12 (SOT-89)	→suitable for SOT-23, SOT-89, CPH-6 (PSW, NSW)
NSW	:	XP161A12 (SOT-89)	
L	:	22 μH (CR54, SUMIDA)	→suitable for CR43～CR105
SD	:	U2FWJ44N (Schottky, TOSHIBA)	→suitable for MA720, MA735, U2FWJ44N
C_L	:	16V, 47 μF × 2 (Tantalum, MCE series, NICHICON)	→suitable for 1005 type～D2 Package
C_{IN}	:	16V, 22 μF (Tantalum, MCE series, NICHICON) 16V, 220 μF (Electrolytic, NICHICON, PJ type)	

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

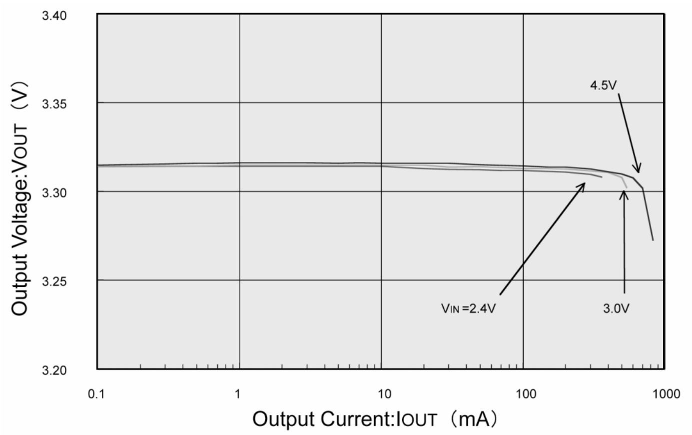
Note:
Oscillation may occur as a result of input voltage instability when the output current is large. At such times, we recommend that in place of the 220 μF, PJ type capacitor, you connect R1 & C1 as shown in the diagram on the right hand side. (In case of demo boards version 1.1, cut the pattern wire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



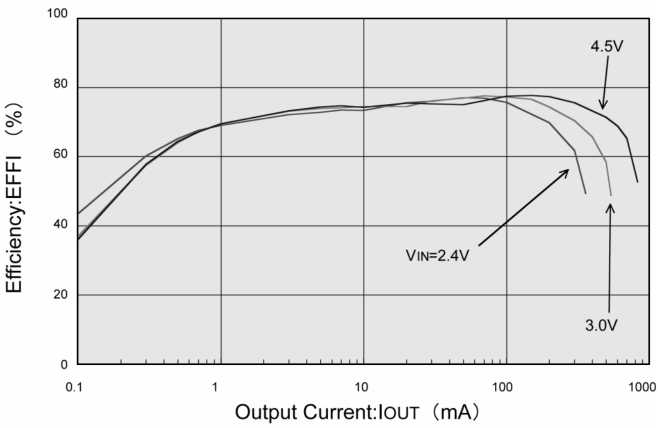
■TYPICAL PERFORMANCE CHARACTERISTICS

XC9302A332 (PWM/PFM switching control, 180kHz, V_{OUT}=3.3V)

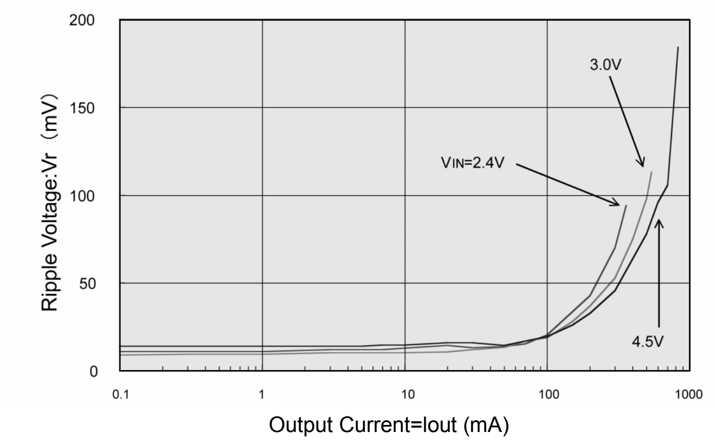
(1) Output Voltage vs. Output Current (Topr=25℃)



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



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



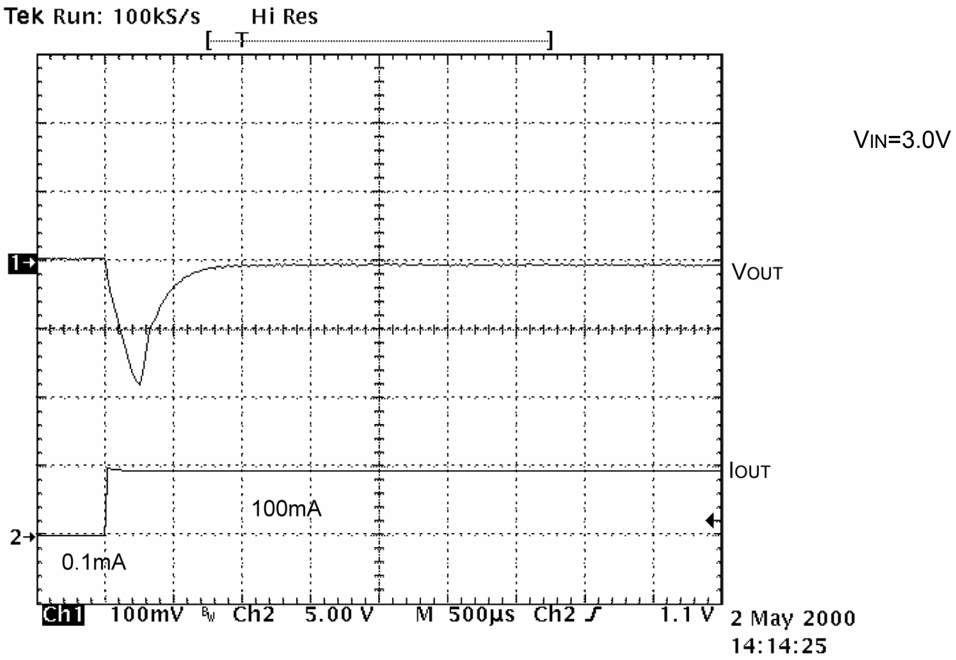
External Components

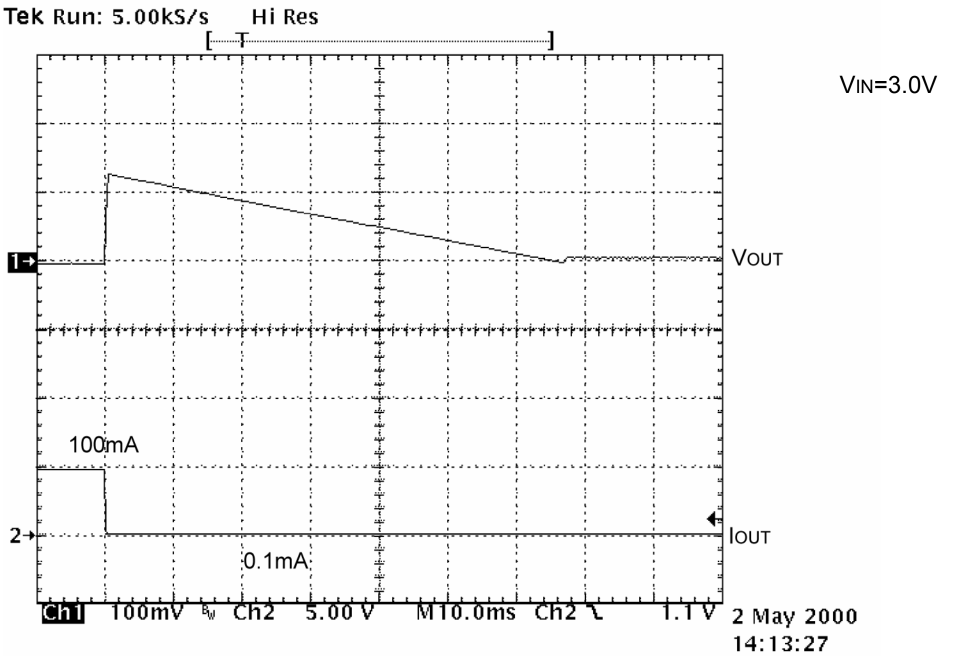
PSW	: XP162A12A6PR	C_L	: 47 μF (MCE series, Tantalum) × 2
NSW	: XP161A1265PR	C_{IN}	: 220 μF (Electrolytic, PJ type)
SD	: U2FWJ44N	R_{DD}	: 10 Ω
L	: 22 μH (CR54)	C_{DD}	: 47 μF (MCE series, Tantalum)
		V_{CE}=V_{IN}	

■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

XC9302A332 (PWM/PFM switching control, 180kHz, V_{OUT}=3.3V) (Continued)

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





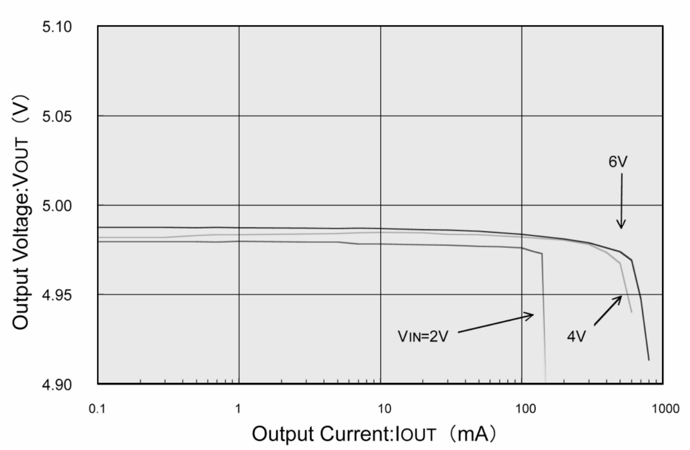
External Components

PSW	: XP162A12A6PR	C_L	: 47 µ F (MCE series, Tantalum) × 2
NSW	: XP161A1265PR	C_{IN}	: 220 µ F (Electrolytic, PJ type)
SD	: U2FWJ44N	R_{DD}	: 10 Ω
L	: 22 µ H (CR54)	C_{DD}	: 47 µ F (MCE series, Tantalum)
		V_{CE}=V_{IN}	

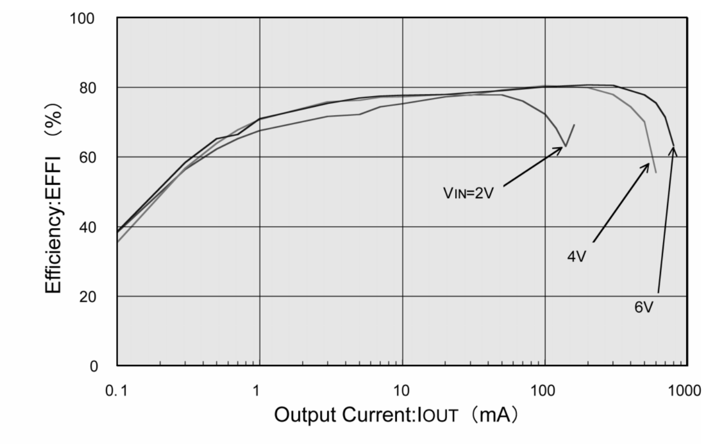
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

XC9302A502 (PWM/PFM switching control, 180kHz, V_{OUT}=5.0V)

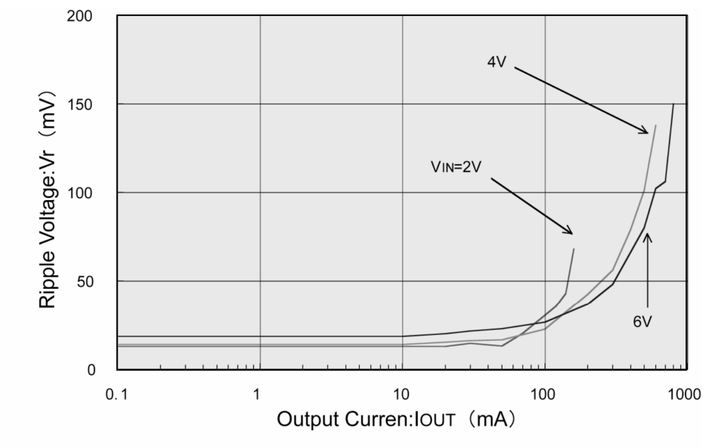
(1) Output Voltage vs. Output Current (Topr=25℃)



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



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



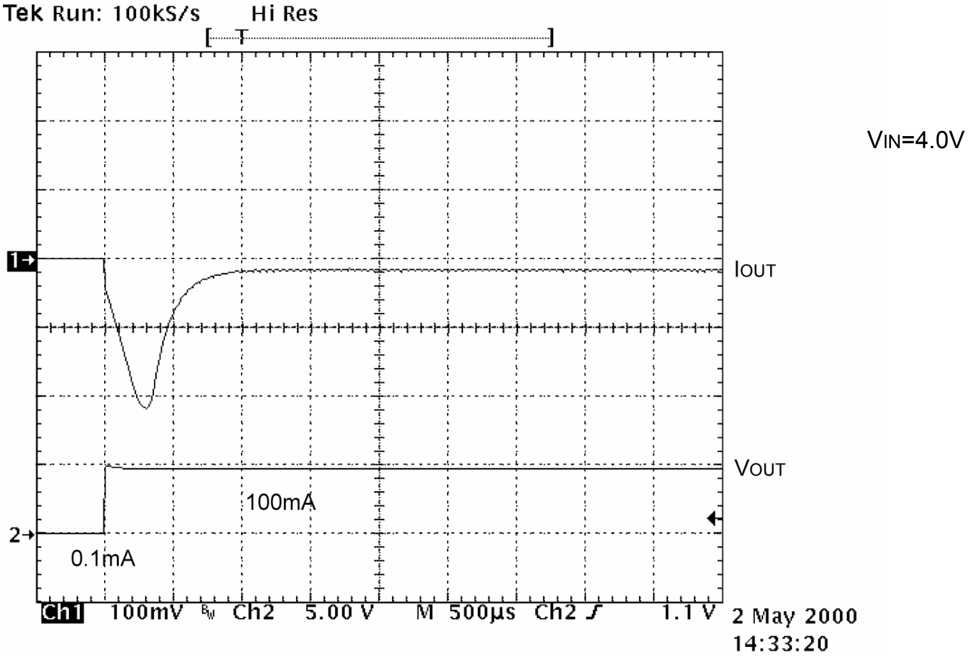
External Components

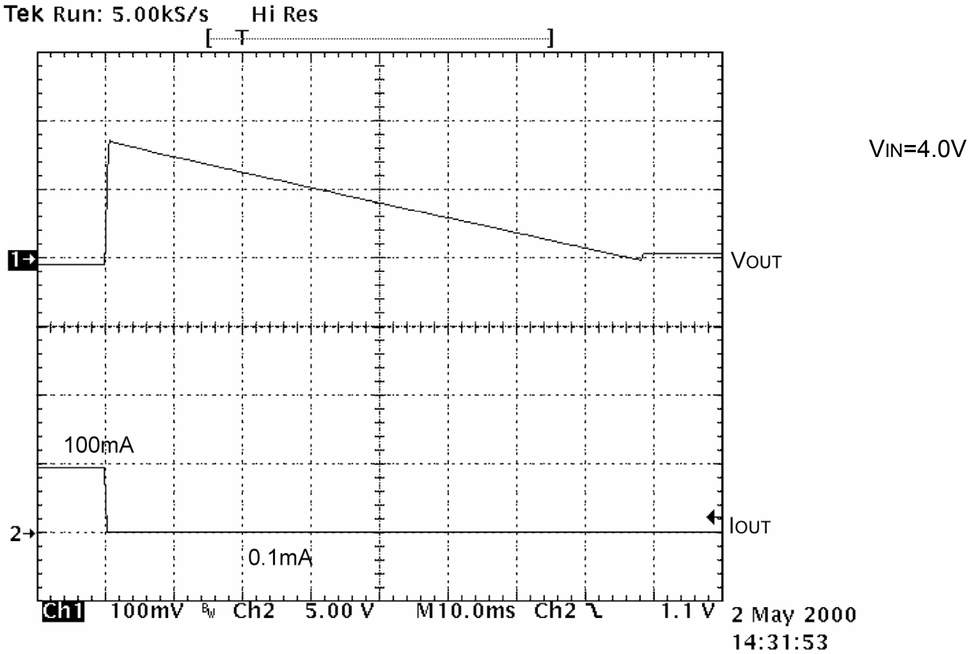
PSW	: XP162A12A6PR	C_L	: 47μF (MCE series, Tantalum) × 2
NSW	: XP161A1265PR	C_{IN}	: 220μF (Electrolytic, PJ type)
SD	: U2FWJ44N	R_{DD}	: 10Ω
L	: 22μH (CR54)	C_{DD}	: 47μF (MCE series, Tantalum)
		V_{CE}=V_{IN}	

■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

XC9302A502 (PWM/PFM switching control, 180kHz, V_{OUT}=5.0V) (Continued)

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





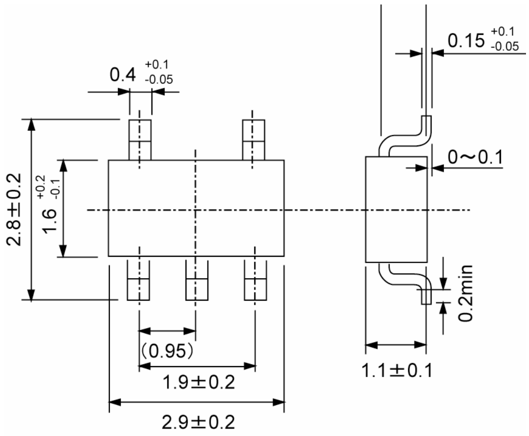
External Components

PSW : XP162A12A6PR
NSW : XP161A1265PR
SD : U2FWJ44N
L : 22 μH (CR54)

C_L : 47 μF (MCE series Tantalum) ×2
C_{IN} : 220 μF (Electrolytic, PJ type)
R_{DD} : 10 Ω
C_{DD} : 47 μF (MCE series Tantalum)
V_{CE}=V_{IN}

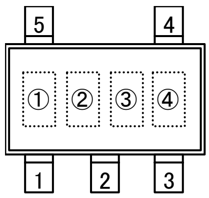
■PACKAGING INFORMATION

●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 excepted)

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