# XC9504 Series

## 2 ch. Step-Up / Inverting DC/DC Controller ICs

☆GreenOperation Compatible

## ■GENERAL DESCRIPTION

The XC9504 series are PWM control, PWM/PFM switching, 2 channel (step-up and inverting) DC/DC controller ICs.
With 0.9V of standard voltage supply internal, and using externally connected components, the output 1 voltage (step-up DC/DC controller) can be set freely within a range of 1.5V ~ 30V. Since output 2 (inverting DC/DC controller) has a built-in 0.9V reference voltage (accuracy ±2%), a negative voltage can be set with the external components.
With a 180kHz frequency, the size of the external components can be reduced. Oscillation frequencies of 300kHz are also available as custom designed products.
The control of the XC9504 series can be switched between PWM control and PWM/PFM automatic switching control using external signals. Control switches from PWM to PFM during light loads when automatic switching is selected and the series is highly efficient from light loads through to large output currents. Noise is easily reduced with PWM control since the frequency is fixed.
The series gives freedom of control selection so that control suited to the application can be selected.
Soft-start time is internally set to 10ms (output 1) which offers protection against rush currents and voltage overshoot when the power is switched on.

## ■APPLICATIONS

- ●Power supplies for LCD
- ●PDAs
- ●Palm top computers
- ●Portable audio systems
- ●Various multi-function power supplies

## ■FEATURES

**2ch. DC/DC Controller (Step-Up + Inverting)**

**<Output 1: Step-Up DC/DC Controller>**

Output Voltage Range : 1.5V ~ 30V (set by FB1 pin)
Output Current : More than 20mA ($V_{IN}$=3.3V, $V_{OUT}$=15V)
Soft-Start Internally Set-Up

**<Output 2: Inverting DC/DC Controller >**

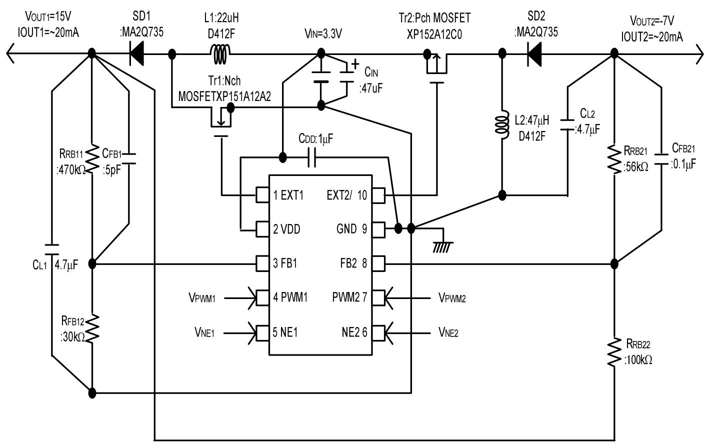
Output Voltage Range : -30V ~ 0V (set by FB2 pin)
Output Current : ≧-20mA ($V_{IN}$=3.3V, $V_{OUT}$=-7.0V)

**<Common>**

Supply Voltage Range : 2.0V ~ 10.0V
Input Voltage Range : 0.9V ~ 10.0V
Oscillation Frequency : 180kHz (±15%)
*300kHz, 500kHz custom
Maximum Duty Cycle : 80% (TYP.)
Control Method : PWM or PWM/PFM Selectable
Stand-by Function : 3.0 μF(MAX.)
Packages : MSOP-10, USP-10
Environmentally Friendly : EU RoHS Compliant, Pb Free

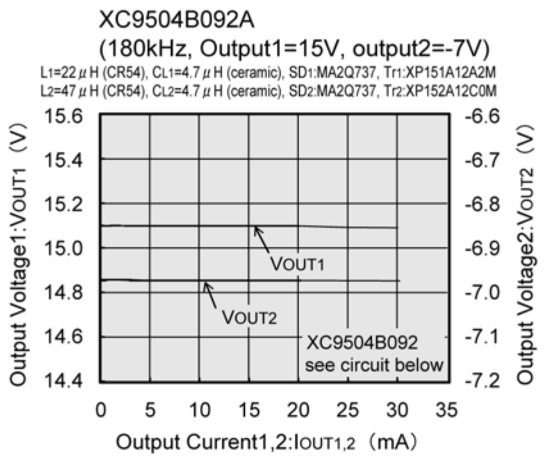
## ■TYPICAL APPLICATION CIRCUIT

＜XC9504B092A Input: 3.3V, Output ①: 15V, Output ②: -7V＞

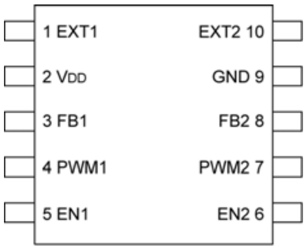



## ■TYPICAL PERFORMANCE CHARACTERISTICS

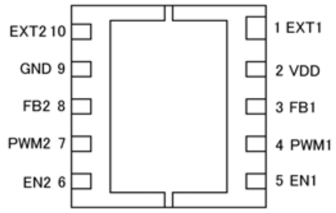
●Output Voltage vs. Output Current



## ■PIN CONFIGURATION




MSOP-10
(TOP VIEW)




USP-10
(BOTTOM VIEW)

## ■PIN ASSIGNMENT

| PIN NUMBER | PIN NAME | FUNCTION |
|---|---|---|
| 1 | EXT 1 | Channel 1: External Transistor Drive Pin<br><Connected to N-ch Power MOSFET Gate> |
| 2 | $V_{DD}$ | Supply Voltage |
| 3 | FB1 | Channel 1: Output Voltage Monitor Feedback Pin <Threshold value: 0.9V. Output voltage can be set freely by connecting split resistor between $V_{OUT1}$ and GND.> |
| 4 | PWM1 | Channel 1: PWM/PFM Switching Pin <Control Output 1. PMW control when connected to $V_{DD}$, PWM/PFM auto switching when connected to GND.> |
| 5 | EN1 | Channel 1: Enable Pin <Connected to GND when Output 1 is in stand-by mode. Connected to $V_{DD}$ when Output 1 is active. EXT1 is low when in stand-by mode.> |
| 6 | EN2 | Channel 2: Enable Pin <Connected to GND when Output 2 is in stand-by mode. Connected to $V_{DD}$ when Output 2 is active. EXT1 is high when in stand-by mode.> |
| 7 | PWM2 | Channel 2: PWM/PFM Switching Pin <Control Output 2. PMW control when connected to $V_{DD}$, PWM/PFM auto switching when connected to GND.> |
| 8 | FB2 | Channel 2: Output Voltage Monitor Feedback Pin <Threshold value: 0.9V. Output voltage can be set freely by connecting split resistor between $V_{OUT2}$ and GND.> |
| 9 | GND | Ground |
| 10 | EXT2/ | Channel 2: External Transistor Drive Pin <Connected to P-ch Power MOSFET Gate> |

## ■PRODUCT CLASSIFICATION

●Ordering Information

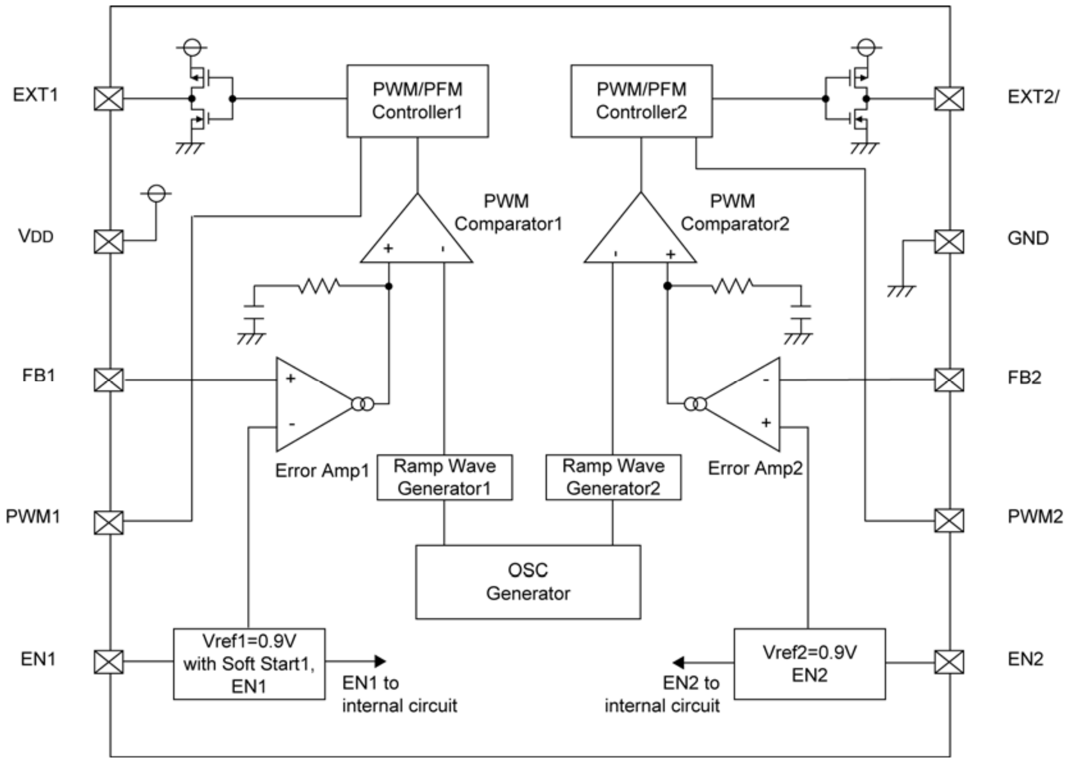
XC9504 ①②③④⑤⑥-⑦(*1)

| DESIGNATOR | DESCRIPTION | SYMBOL | DESCRIPTION |
|---|---|---|---|
| ① | Type of DC/DC Controller | B | Standard type (10 pin) |
| ②③ | Output Voltage | 09 | FB products⇨②=0, ③=9 fixed |
| ④ | Oscillation Frequency | 2 | 180kHz |
| | | 3 | 300kHz (custom) |
| | | 5 | 500kHz (custom) |
| ⑤⑥-⑦ | Packages<br>Taping Type (*2) | AR | MSOP-10 |
| | | AR-G | MSOP-10 |
| | | DR | USP-10 |
| | | DR-G | USP-10 |

(*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 |
|---|---|---|---|---|
| VDD Pin Voltage | | VDD | - 0.3 ~ 12.0 | V |
| FB1, 2 Pin Voltage | | VFB | - 0.3 ~ 12.0 | V |
| EN1, 2 Pin Voltage | | VEN | - 0.3 ~ 12.0 | V |
| PWM1, 2 Pin Voltage | | VPWM | - 0.3 ~ 12.0 | V |
| EXT1, 2 Pin Voltage | | VEXT | - 0.3 ~ VDD + 0.3 | V |
| EXT1, 2 Pin Current | | IEXT | ±100 | mA |
| Power Dissipation | MSOP-10 | Pd | 150 | mW |
| | USP-10 | | 150 | |
| Operating Temperature Range | | Topr | - 40 ~ + 85 | ℃ |
| Storage Temperature Range | | Tstg | - 55 ~ + 125 | ℃ |

## ■ELECTRICAL CHARACTERISTICS

XC9504B092A　Common Characteristics　(FOSC = 180kHz)　Ta=25℃

| PARAMETER | SYMBOL | CONDITIONS | | MIN. | TYP. | MAX. | UNITS | CIRCUIT |
|---|---|---|---|---|---|---|---|---|
| Supply Voltage (*1) | $V_{DD}$ | | | 2.0 | - | 10.0 | V | - |
| Output Voltage Range (*3) | $V_{OUTSET}$ | $V_{DD}$ ≧2.0V　$I_{OUT}$=1mA | $V_{OUT1}$ | 0.9 | - | - | V | ① |
| | | | $V_{OUT2}$ | - | - | 0.0 | V | |
| | | $V_{IN}$ ≧0.9V　$I_{OUT}$=1mA (*2) | $V_{OUT1}$ | 2.0 | - | 10.0 | V | ② |
| | | | $V_{OUT2}$ | - | - | 0.0 | V | |
| Supply Current 1 | $I_{DD1}$ | FB=0V, FB2=0.1 | | - | 90 | 190 | μA | ③ |
| Supply Current 1-1 | $I_{DD1-1}$ | EN1=3.0V, EN2=0V, FB1=0V<br>EN2=3.0V, EN1=0V, FB2=1.2V | | - | 60 | 120 | μA | ③ |
| Supply Current 1-2 | $I_{DD1-2}$ | FB1=0V, FB2=0V<br>FB1=1.2V, FB2=1.2V | | - | 80 | 150 | μA | ③ |
| Supply Current 2 | $I_{DD2}$ | FB1=1.2V, FB2=0V | | - | 70 | 132 | μA | ③ |
| Stand-by Current | $I_{STB}$ | Same as $I_{DD1}$, EN1=EN2=0V | | - | 1.0 | 3.0 | μA | ③ |
| Oscillation Frequency | $F_{OSC}$ | Same as $I_{DD1}$ | | 153 | 180 | 207 | kHz | ③ |
| EN1, 2 "High" Voltage | $V_{ENH}$ | FB1=3.0V, FB2=0V | | 0.65 | - | - | V | ③ |
| EN1, 2 "Low" Voltage | $V_{ENL}$ | FB1=3.0V, FB2=0V | | - | - | 0.20 | V | ③ |
| EN1, 2 "High" Current | $I_{ENH}$ | FB1=3.0V, FB2=0V | | - | - | 0.50 | μA | ③ |
| EN1, 2 "Low" Current | $I_{ENL}$ | EN1, 2=0V, FB1=3.0V, FB2=0V | | - | - | -0.50 | μA | ③ |
| PWM1, 2 "High" Current | $I_{PWMH}$ | FB1=3.0V, FB2=0V, PWM1, 2=3.0V | | - | - | 0.50 | μA | ③ |
| PWM1, 2 "Low" Current | $I_{PWML}$ | FB1=3.0V, FB2=0V, PWM1, 2=0V | | - | - | -0.50 | μA | ③ |
| FB1, 2 "High" Current | $I_{FBH}$ | FB1=3.0V, FB2=0.8V | | - | - | 0.50 | μA | ③ |
| FB1, 2 "Low" Current | $V_{FBL}$ | FB1=1.0V, FB2=0V | | - | - | -0.50 | μA | ③ |

Unless otherwise stated, $V_{DD}$=3.0V, PWM1, 2=3.0V, EN1, 2 = 3.0V

Output 1 Characteristics　Step-Up Controller　(FOSC = 180kHz)　Ta=25℃

| PARAMETER | SYMBOL | CONDITIONS | MIN. | TYP. | MAX. | UNITS | CIRCUIT |
|---|---|---|---|---|---|---|---|
| FB1 Voltage | $V_{FB1}$ | $V_{DD}$=3.0V, $V_{IN}$=1.5V, $I_{OUT}$=10mA | 0.882 | 0.900 | 0.918 | V | ④ |
| Operating Start Voltage 1 (*2) | $V_{ST1-1}$ | Using Tr: 2SD1628,<br>$I_{OUT}$=1.0mA, $R_{FB11}$=200kΩ, $R_{FB12}$=75kΩ | - | - | 0.9 | V | ② |
| | | $V_{DD}$≠$V_{OUT1}$ : $I_{OUT1}$=10mA | - | - | 2.0 | V | ① |
| Oscillation Start Voltage 1 | $V_{ST2-1}$ | FB1=0V | - | - | 0.8 | V | ③ |
| Maximum Duty Ratio 1 | MINDTY1 | Same as $I_{DD1}$ | 75 | 80 | 87 | % | ③ |
| Minimum Duty Ratio 1 | MAXDTY1 | Same as $I_{DD2}$ | - | - | 0 | % | ③ |
| PFM Duty Ratio 1 | PFMDTY1 | No Load, $V_{PWM1}$=0V | 22 | 30 | 38 | % | ⑤ |
| Efficiency 1 | EFFI1 | $I_{OUT1}$= 130mA, N-ch MOSFET: XP161A1355P | - | 85 | - | % | ⑤ |
| Soft-Start Time 1 | TSS1 | $V_{OUT1}$×0.95V, EN1=0V→0.65V | 5.0 | 10.0 | 20.0 | ms | ⑤ |
| EXT1 "High" ON Resistance | $R_{EXTBH1}$ | FB1=0V, EXT1=$V_{DD}$ -0.4V | - | 28 | 47 | Ω | ⑥ |
| EXT1 "Low" ON Resistance | $R_{EXTBL1}$ | EN1=FB1=1.2V, EXT1=0.4V | - | 22 | 30 | Ω | ⑥ |
| PWM1 "High" Voltage | $V_{PWMH1}$ | No Load | 0.65 | - | - | V | ⑤ |
| PWM1 "Low" Voltage | $V_{PWML1}$ | No Load | - | - | 0.20 | V | ⑤ |

Unless otherwise stated, $V_{DD}$=EN1=PWM1=3.0V, EN2=PWM2=GND, EXT2=OPEN, FB2=OPEN, $V_{IN}$=1.8V

Output 2 Characteristics　Inverting DC/DC Controller　(FOSC = 180kHz)　Ta=25℃

| PARAMETER | SYMBOL | CONDITIONS | MIN. | TYP. | MAX. | UNITS | CIRCUIT |
|---|---|---|---|---|---|---|---|
| FB2 Voltage | $V_{FB2}$ | $V_{DD}$=3.0V | 0.882 | 0.900 | 0.918 | V | ③ |
| Operation Start Voltage 2 | $V_{ST1-2}$ | $I_{OUT}$=1.0mA, $R_{FB11}$=200kΩ, $R_{FB12}$=75kΩ<br>$R_{FB21}$=17.5kΩ, $R_{FB22}$=10kΩ,<br>EN1=$P_{WM1}$=3.0V | - | - | 2.0 | V | ①② |
| Oscillating Start Voltage 2 | $V_{ST2-2}$ | FB2=1.2V | - | - | 2.0 | V | ③ |
| Maximum Duty Ratio 2 | MAXDTY2 | Same as $I_{DD1}$ | 75 | 80 | 87 | % | ③ |
| Minimum Duty Ratio 2 | MINDTY2 | Same as $I_{DD2}$ | - | - | 0 | % | ③ |
| PFM Duty Ratio 2 | PFMDTY2 | No Load, $V_{PWM2}$=0V | 22 | 30 | 38 | % | ⑦ |
| Efficiency 2 | EFFI2 | $I_{OUT2}$=-150mA, P-ch MOSFET: XP162A12A6P | - | 76 | - | % | ⑦ |
| EXT2 "High" ON Resistance | $R_{EXTBH2}$ | EN2=FB2= 0V, EXT2=$V_{DD}$-0.4V | - | 28 | 47 | Ω | ⑥ |
| EXT2 "Low" ON Resistance | $R_{EXTBL2}$ | FB2=3.0V, EXT2=0.4V | - | 22 | 30 | Ω | ⑥ |
| PWM2 "High" Voltage | $V_{PWMH2}$ | No Load | 0.65 | - | - | V | ⑦ |
| PWM2 "Low" Voltage | $V_{PWML2}$ | No Load | - | - | 0.20 | V | ⑦ |

Unless otherwise stated, $V_{DD}$=EN2=PWM2=3.0V, PWM1=EN1=GND, EXT1=OPEN, FB1=OPEN, $V_{IN}$=3.0V

# ■ELECTRICAL CHARACTERISTICS (Continued)

XC9504B093A Common Characteristics

(FOSC = 300kHz) Ta=25℃

| PARAMETER | SYMBOL | CONDITIONS | | MIN. | TYP. | MAX. | UNITS | CIRCUIT |
|---|---|---|---|---|---|---|---|---|
| Supply Voltage (*1) | $V_{DD}$ | | | 2.0 | - | 10.0 | V | - |
| Output Voltage Range (*3) | $V_{OUTSET}$ | $V_{DD}$ ≧2.0V, $I_{OUT}$=1mA | $V_{OUT1}$ | 0.9 | - | - | V | ① |
| | | $V_{DD}$ ≠$V_{OUT}$ | $V_{OUT2}$ | - | - | 0.0 | | |
| | | $V_{IN}$ ≧0.9V, $I_{OUT}$=1mA (*2) | $V_{OUT1}$ | 2.0 | - | 10.0 | V | ② |
| | | $V_{DD}$=$V_{OUT}$ | $V_{OUT2}$ | - | - | 0.0 | | |
| Supply Current 1 | $I_{DD1}$ | FB=0V, FB2=1.2V | | - | 110 | 250 | μA | ③ |
| Supply Current 1-1 | $I_{DD1-1}$ | EN1=3.0V, EN2=0, FB1=0V<br>EN2=3.0V, EN1=0V, FB2=1.2V | | - | 80 | 150 | μA | ③ |
| Supply Current 1-2 | $I_{DD1-2}$ | FB1=0V, FB2=0V<br>FB1=1.2V, FB2=1.2V | | - | 90 | 200 | μA | ③ |
| Supply Current 2 | $I_{DD2}$ | FB1=1.2V, FB2=0V | | - | 80 | 160 | μA | ③ |
| Stand-by Current | $I_{STB}$ | Same as $I_{DD1}$, EN1=EN2=0V | | - | 1.0 | 3.0 | μA | ③ |
| Oscillation Frequency | FOSC | Same as $I_{DD1}$ | | 255 | 300 | 345 | kHz | ③ |
| EN1, 2 "High" Voltage | $V_{ENH}$ | FB1=0V, FB2=3.0V | | 0.65 | - | - | V | ③ |
| EN1, 2 "Low" Voltage | $V_{ENL}$ | FB1=0V, FB2=3.0V | | - | - | 0.20 | V | ③ |
| EN1, 2 "High" Current | $I_{ENH}$ | FB1=3.0V, FB2=0V | | - | - | 0.50 | μA | ③ |
| EN1, 2 "Low" Current | $I_{ENL}$ | EN1, 2=0V, FB1=3.0V, FB2=0V | | - | - | -0.50 | μA | ③ |
| PWM1, 2 "High" Current | $I_{PWMH}$ | FB1=3.0V, FB2=0V, PWM1, 2=3.0V | | - | - | 0.50 | μA | ③ |
| PWM1, 2 "Low" Current | $I_{PWML}$ | FB1=3.0V, FB2=0V, PWM1, 2=0V | | - | - | -0.50 | μA | ③ |
| FB1, 2 "High" Current | $I_{FBH}$ | FB1=3.0V, FB2=0.8V | | - | - | 0.50 | μA | ③ |
| FB1, 2 "Low" Current | $V_{FBL}$ | FB1=1.0V, FB2=0V | | - | - | -0.50 | μA | ③ |

Unless otherwise stated, $V_{DD}$=3.0V, PWM1, 2=3.0V, EN1, 2 = 3.0V

Output 1 Characteristics Step-Up Controller

(FOSC = 300kHz) Ta=25℃

| PARAMETER | SYMBOL | CONDITIONS | MIN. | TYP. | MAX. | UNITS | CIRCUIT |
|---|---|---|---|---|---|---|---|
| FB 1 Voltage | $V_{FB1}$ | $V_{DD}$=3.0V, $V_{IN}$=1.5V, $I_{OUT1}$=10mA | 0.882 | 0.900 | 0.918 | V | ④ |
| Operating Start Voltage 1(*2) | $V_{ST1-1}$ | Using Tr: 2SD1628,<br>$I_{OUT}$=1.0mA, $R_{FB11}$=200kΩ, $R_{FB12}$=75kΩ | - | - | 0.9 | V | ② |
| | | $V_{DD}$ ≠$V_{OUT1}$ : $I_{OUT1}$=10mA | - | - | 2.0 | V | ① |
| Oscillation Start Voltage 1 | $V_{ST2-1}$ | FB1=0V | - | - | 0.8 | V | ③ |
| Maximum Duty Ratio 1 | MINDTY1 | Same as $I_{DD1}$ | 75 | 80 | 87 | % | ③ |
| Minimum Duty Ratio 1 | MAXDTY2 | Same as $I_{DD2}$ | - | - | 0 | % | ③ |
| PFM Duty Ratio 1 | PFMDTY1 | No Load, $V_{PWM1}$=0V | 22 | 30 | 38 | % | ⑤ |
| Efficiency 1 | EFFI1 | $I_{OUT1}$= 130mA, N-ch MOSFET: XP161A1355P | - | 85 | - | % | ⑤ |
| Soft-Start Time 1 | $T_{SS1}$ | $V_{OUT1}$×0.95V, EN1=0V→0.65V | 5.0 | 10.0 | 20.0 | ms | ⑤ |
| EXT1 "High" ON Resistance | $R_{EXTBH1}$ | FB1=0V, EXT1=$V_{DD}$ -0.4V | - | 28 | 47 | Ω | ⑥ |
| EXT1 "Low" ON Resistance | $R_{EXTBL1}$ | EN1=FB1=1.2V, EXT1=0.4V | - | 22 | 30 | Ω | ⑥ |
| PWM1 "High" Voltage | $V_{PWMH1}$ | No Load | 0.65 | - | - | V | ⑤ |
| PWM1 "Low" Voltage | $V_{PWML1}$ | No Load | - | - | 0.20 | V | ⑤ |

Unless otherwise stated, $V_{DD}$=EN1=PWM1=3.0V, EN2=PWM2=GND, EXT2=OPEN, FB2=OPEN, $V_{IN}$=1.8V

Output 2 Characteristics Inverting DC/DC Controller

(FOSC = 300kHz) Ta=25℃

| PARAMETER | SYMBOL | CONDITIONS | MIN. | TYP. | MAX. | UNITS | CIRCUIT |
|---|---|---|---|---|---|---|---|
| FB 2 Voltage | $V_{FB2}$ | $V_{DD}$=3.0V | 0.882 | 0.900 | 0.918 | V | ③ |
| Operating Start Voltage 2 | $V_{ST1-2}$ | $I_{OUT2}$=1.0mA, $R_{FB11}$=200kΩ, $R_{FB12}$=75kΩ<br>$R_{FB21}$=17.5kΩ,$R_{FB22}$=10k, EN1=PWM1=3.0V | - | - | 2.0 | V | ①② |
| Oscillation Start Voltage 2 | $V_{ST2-2}$ | FB2=1.2V | - | - | 2.0 | V | ③ |
| Maximum Duty Ratio 2 | MAXDTY2 | Same as $I_{DD1}$ | 75 | 80 | 87 | % | ③ |
| Minimum Duty Ratio 2 | MINDTY3 | Same as $I_{DD2}$ | - | - | 0 | % | ③ |
| PFM Duty Ratio 2 | PFMDTY2 | No Load, $V_{PWM2}$=0V | 22 | 30 | 38 | % | ⑦ |
| Efficiency 2 (*4) | EFFI2 | $I_{OUT2}$= -150mA, P-ch MOSFET: XP162A12A6P | - | 75 | - | % | ⑦ |
| EXT2 "High" ON Resistance | $R_{EXTBH2}$ | EN2=FB2= 0V, EXT2=$V_{DD}$-0.4V | - | 28 | 47 | Ω | ⑥ |
| EXT2 "Low" ON Resistance | $R_{EXTBL2}$ | FB2=3.0V, EXT2=0.4V | - | 22 | 30 | Ω | ⑥ |
| PWM2 "High" Voltage | $V_{PWMH2}$ | No Load | 0.65 | - | - | V | ⑦ |
| PWM2 "Low" Voltage | $V_{PWML2}$ | No Load | - | - | 0.20 | V | ⑦ |

Unless otherwise stated, $V_{DD}$=EN2=PWM2=3.0V, PWM1=EN1=GND, EXT1=OPEN, FB1=OPEN, $V_{IN}$=3.0V

## ■ELECTRICAL CHARACTERISTICS (Continued)

XC9504B095A Common Characteristics (FOSC = 500kHz) Ta=25℃

| PARAMETER | SYMBOL | CONDITIONS | MIN. | TYP. | MAX. | UNITS | CIRCUIT |
|---|---|---|---|---|---|---|---|
| Supply Voltage (*1) | $V_{DD}$ | | 2.0 | - | 10.0 | V | - |
| Output Voltage Range (*3) | $V_{OUTSET}$ | $V_{DD}$≧2.0V, $I_{OUT}$=1mA $V_{OUT1}$ | 0.9 | - | - | V | ① |
| | | $V_{DD}$≠$V_{OUT}$ $V_{OUT2}$ | - | - | 0.0 | | |
| | | $V_{IN}$≧0.9V, $I_{OUT}$=1mA (note 2) $V_{OUT1}$ | 2.0 | - | 10.0 | V | ② |
| | | $V_{DD}$=$V_{OUT}$ $V_{OUT2}$ | - | - | 0.0 | | |
| Supply Current 1 | $I_{DD1}$ | FB=0V, FB2=1.2V | - | 165 | 350 | μA | ③ |
| Supply Current 1-1 | $I_{DD1-1}$ | EN1=3.0V, EN2=0, FB1=0V<br>EN2=3.0V, EN1=0V, FB2=1.2V | - | 110 | 220 | μA | ③ |
| Supply Current 1-2 | $I_{DD1-2}$ | FB1=0V, FB2=0V<br>FB1=1.2V, FB2=1.2V | - | 130 | 270 | μA | ③ |
| Supply Current 2 | $I_{DD2}$ | FB1=1.2V, FB2=0V | - | 100 | 200 | μA | ③ |
| Stand-by Current | $I_{STB}$ | Same as $I_{DD1}$, EN1=EN2=0V | - | 1.0 | 3.0 | μA | ③ |
| Oscillation Frequency | FOSC | Same as $I_{DD1}$ | 425 | 500 | 575 | kHz | ③ |
| EN1, 2 "High" Voltage | $V_{ENH}$ | FB1=0V, FB2=3.0V | 0.65 | - | - | V | ③ |
| EN1, 2 "Low" Voltage | $V_{ENL}$ | FB1=0V, FB2=3.0V | - | - | 0.20 | V | ③ |
| EN1, 2 "High" Current | $I_{ENH}$ | FB1=3.0V, FB2=0V | - | - | 0.50 | μA | ③ |
| EN1, 2 "Low" Current | $I_{ENL}$ | EN1, 2=0V, FB1=3.0V, FB2=0V | - | - | -0.50 | μA | ③ |
| PWM1, 2 "High" Current | $I_{PWMH}$ | FB1=3.0V, FB2=0V, PWM1, 2=3.0V | - | - | 0.50 | μA | ③ |
| PWM1, 2 "Low" Current | $I_{PWML}$ | FB1=3.0V, FB2=0V, PWM1, 2=0V | - | - | -0.50 | μA | ③ |
| FB1, 2 "High" Current | $I_{FBH}$ | FB1=3.0V, FB2=0.8V | - | - | 0.50 | μA | ③ |
| FB1, 2 "Low" Current | $V_{FBL}$ | FB1=1.0V, FB2=0V | - | - | -0.50 | μA | ③ |

Unless otherwise stated, $V_{DD}$=3.0V, PWM1, 2=3.0V, EN1, 2 = 3.0V

Output 1 Characteristics Step-Up Controller (FOSC = 500kHz) Ta=25℃

| PARAMETER | SYMBOL | CONDITIONS | MIN. | TYP. | MAX. | UNITS | CIRCUIT |
|---|---|---|---|---|---|---|---|
| FB 1 Voltage | $V_{FB1}$ | $V_{DD}$=3.0V, $V_{IN}$=1.5V, $I_{OUT1}$=10mA | 0.882 | 0.900 | 0.918 | V | ④ |
| Operating Start Voltage 1 (*2) | $V_{ST1-1}$ | Using Tr: 2SD1628,<br>$I_{OUT}$=1.0mA, $R_{FB11}$=200kΩ, $R_{FB12}$=75kΩ | - | - | 0.9 | V | ② |
| | | $V_{DD}$ ≠$V_{OUT1}$ : $I_{OUT1}$=10mA | - | - | 2.0 | V | ① |
| Oscillation Start Voltage 1 | $V_{ST2-1}$ | FB1=0V | - | - | 0.8 | V | ③ |
| Maximum Duty Ratio 1 | MINDTY1 | Same as $I_{DD1}$ | 75 | 80 | 87 | % | ③ |
| Minimum Duty Ratio 1 | MAXDTY2 | Same as $I_{DD2}$ | - | - | 0 | % | ③ |
| PFM Duty Ratio 1 | PFMDTY1 | No Load, $V_{PWM1}$=0V | 22 | 30 | 38 | % | ⑤ |
| Efficiency 1 | EFFI1 | $I_{OUT1}$= 130mA, N-ch MOSFET: XP161A1355P | - | 83 | - | % | ⑤ |
| Soft-Start Time 1 | $T_{SS1}$ | $V_{OUT1}$×0.95V, EN1=0V→0.65V | 5.0 | 10.0 | 20.0 | ms | ⑤ |
| EXT1 "High" ON Resistance | $R_{EXTBH1}$ | FB1=0V, EXT1=$V_{DD}$ -0.4V | - | 28 | 47 | Ω | ⑥ |
| EXT1 "Low" ON Resistance | $R_{EXTBL1}$ | EN1=FB1=1.2V, EXT1=0.4V | - | 22 | 30 | Ω | ⑥ |
| PWM1 "High" Voltage | $V_{PWMH1}$ | No Load | 0.65 | - | - | V | ⑤ |
| PWM1 "Low" Voltage | $V_{PWML1}$ | No Load | - | - | 0.20 | V | ⑤ |

Unless otherwise stated, $V_{DD}$=EN1=PWM1=3.0V, EN2=PWM2=GND, EXT2=OPEN, FB2=OPEN, $V_{IN}$=1.8V

Output 2 Characteristics Inverting DC/DC Controller (FOSC = 500kHz) Ta=25℃

| PARAMETER | SYMBOL | CONDITIONS | MIN. | TYP. | MAX. | UNITS | TEST CIRCUIT |
|---|---|---|---|---|---|---|---|
| FB 2 Voltage | $V_{FB2}$ | $V_{DD}$=3.0V | 0.882 | 0.900 | 0.918 | V | ③ |
| Operating Start Voltage 2 | $V_{ST1-2}$ | $I_{OUT2}$=1.0mA, $R_{FB11}$=200kΩ, $R_{FB12}$=75kΩ<br>$R_{FB21}$=17.5kΩ, $R_{FB22}$=10kΩ,<br>EN1=PWM1=3.0V | - | - | 2.0 | V | ①② |
| Oscillation Start Voltage 2 | $V_{ST2-2}$ | FB2=1.2V | - | - | 2.0 | V | ③ |
| Maximum Duty Ratio 2 | MAXDTY2 | Same as $I_{DD1}$ | 75 | 80 | 87 | % | ③ |
| Minimum Duty Ratio 2 | MINDTY2 | Same as $I_{DD2}$ | - | - | 0 | % | ③ |
| PFM Duty Ratio 2 | PFMDTY2 | No Load, $V_{PWM2}$=0V | 22 | 30 | 38 | % | ⑦ |
| Efficiency 2 (*4) | EFFI2 | $I_{OUT2}$= -150mA, P-ch MOSFET: XP162A12A6P | - | 71 | - | % | ⑦ |
| EXT2 "High" ON Resistance | $R_{EXTBH2}$ | EN2=FB2= 0V, EXT2=$V_{DD}$-0.4V | - | 28 | 47 | Ω | ⑥ |
| EXT2 "Low" ON Resistance | $R_{EXTBL2}$ | FB2=3.0V, EXT2=0.4V | - | 22 | 30 | Ω | ⑥ |
| PWM2 "High" Voltage | $V_{PWMH2}$ | No Load | 0.65 | - | - | V | ⑦ |
| PWM2 "Low" Voltage | $V_{PWML2}$ | No Load | - | - | 0.20 | V | ⑦ |

Unless otherwise stated, $V_{DD}$=EN2=PWM2=3.0V, PWM1=EN1=GND, EXT1=OPEN, FB1=OPEN, $V_{IN}$=3.0V

# ■ELECTRICAL CHARACTERISTICS (Continued)

NOTE:
*1 Although the IC's step-up switching operations start from a $V_{DD}$ of 0.8V, the output voltage and oscillation frequency are stabilized at $V_{DD}$ ≧2.0V. Therefore, a $V_{DD}$ of more than 2.0V is recommended when $V_{DD}$ is supplied from $V_{IN}$ or other power sources.
*2 Although the IC's operations start from a $V_{IN}$ of 0.9V, the IC's power supply pin ($V_{DD}$) and output voltage monitor pin (FB1) should be connected to $V_{OUT1}$. With operations from $V_{IN}$=0.9V, the 2nd channel's (output 2) EN2 pin should be disabled. Once output voltage $V_{OUT1}$ is more than 2.0V, the EN2 pin should be enabled.
*3 Please be careful not to exceed the breakdown voltage level of the peripheral parts.
*4 EFFI={ [ (output voltage) x (output current) ] / [ (input voltage) x (input current) ] } x 100

## ■OPERATIONAL EXPLANATION

The XC9504 series are dual DC/DC (step-up + inverting) converter controller ICs with built-in high speed, low ON resistance buffers.

<Error Amp. 1>
Error amplifier 1 is designed to monitor the output voltage and it compares the feedback voltage1 (FB1) with the reference voltage Vref1. In response to feedback of a voltage lower than the reference voltage Vref1, the output voltage of the error amp. decreases

<Error Amp. 2>
Error amplifier 2 is designed to monitor the output voltage and it compares the feedback voltage 2 (FB2) with the reference voltage Vref 2. In response to feedback of a voltage lower than the reference voltage Vref2, the output voltage of the error amp. decreases.

<OSC Generator>
This circuit generates the internal reference clock.

<Ramp Wave Generator 1, 2>
The ramp wave generator generates a saw-tooth waveform based on outputs from the OSC generator.

<PWM Comparator 1, 2>
The PWM comparator compares outputs from the error amp. and saw-tooth waveform. When the voltage from the error amp's output is low, the external will be set to ON.

<PWM/PFM Controller 1, 2>
This circuit generates PFM pulses.
Control can be switched between PWM control and PWM/PFM automatic switching control using external signals.
The PWM/PFM automatic switching mode is selected when the voltage of the PWM1 (2) pin is less than 0.2V, and the control switches between PWM and PFM automatically depending on the load. As the PFM circuit generates pulses based on outputs from the PWM comparator, shifting between modes occurs smoothly. PWM control mode is selected when the voltage of the PWM1 (2) pin is more than 0.65V. Noise is easily reduced with PWM control since the oscillation frequency is fixed. Control suited to the application can easily be selected which is useful in audio applications, for example, where traditionally, efficiencies have been sacrificed during stand-by as a result of using PWM control (due to the noise problems associated with the PFM mode in stand-by).

<Vref 1 with Soft Start 1>
The reference voltage, Vref1 (FB1 pin voltage)=0.9V, is adjusted and fixed by laser trimming (for output voltage settings, please refer to the functional settings notes below.). To protect against inrush current, when the power is switched on, and also to protect against voltage overshoot, soft-start time is set internally to 10ms. It should be noted, however, that this circuit does not protect the load capacitor ($C_L$) from inrush current. With the Vref voltage limited, and depending upon the input to error amp 1, the operation maintains a balance between the two inputs of error amps and controls the EXT pin's ON time so that it doesn't increase more than is necessary.

<Vref 2>
The reference voltage, Vref2 (FB2 pin voltage)=0.9V, is adjusted and fixed by laser trimming.

<Enable Function 1,2>
This function controls the operation and shutdown of the IC. When the voltage of the EN1 or EN2 pins is 0.2V or less, the mode will be disable, the channel's operations will stop and the EXT1 pin will be kept at a low level (the external N-ch MOSFET will be OFF) and the EXT2 pin will be kept at a high level (the external P-ch MOSFET will be OFF). When both EN1 and EN2 are in a state of chip disable, current consumption will be no more than 3.0 $\mu$A.
When the EN1 or EN2 pin's voltage is 0.65V or more, the mode will be enable and operations will recommence. With channel one (output 1) soft-start, 95% of the set output voltage will be reached within 10msec (TYP.) from the moment of enable.

# ■OPERATIONAL EXPLANATION (Continued)

< Output Voltage Setting, Ch.1 (Step-Up DC/DC Converter Controller) >

Output voltage can be set by adding external split resistors. Output voltage is determined by the following equation, based on the values of $R_{FB11}$ and $R_{FB12}$. The sum of $R_{FB11}$ and $R_{FB12}$ should normally be 1 MΩ or less.

$$V_{OUT1}=0.9\times(R_{FB11}+R_{FB12})/R_{FB12}$$

The speed-up capacitor for phase compensation's ($C_{FB1}$) value should be adjusted using the formula $fzfb=1/(2\times\pi\times C_{FB1}\times R_{FB11})$ so that it equals 12kHz. Depending on the application, the inductance value L, and the load capacity value $C_L$, adjustments to this value are suggested so that the value is somewhere between 1kHz to 50kHz.

[Calculation Example]

*When* $R_{FB11}$ = 470kΩ *and* $R_{FB12}$ = 30kΩ : $V_{OUT1} = 0.9\times(470k+30k) / 30k = 15.0V.$

[Typical Example]

| $V_{OUT}$ (V) | $R_{FB11}$ (kΩ) | $R_{FB12}$ (kΩ) | $C_{FB1}$ (pF) | $V_{OUT}$ (V) | $R_{FB11}$ (kΩ) | $R_{FB12}$ (kΩ) | $C_{FB1}$ (pF) | $V_{OUT}$ (V) | $R_{FB11}$ (kΩ) | $R_{FB12}$ (kΩ) | $C_{FB1}$ (pF) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.5 | 220 | 330 | 62 | 2.7 | 360 | 180 | 33 | 10.0 | 680 | 68 | 18 |
| 1.8 | 220 | 220 | 62 | 3.0 | 560 | 240 | 24 | 12.0 | 160 | 13 | 82 |
| 2.0 | 330 | 330 | 39 | 3.3 | 200 | 75 | 62 | 15.0 | 470 | 30 | 27 |
| 2.2 | 390 | 390 | 33 | 5.0 | 82 | 18 | 160 | 20.0 | 470 | 22 | 27 |
| 2.5 | 390 | 390 | 33 | 8.0 | 120 | 15 | 100 | 30.0 | 390 | 12 | 34 |

< Output Voltage Setting, Ch. 2 (Inverting DC/DC Converter) >

Output voltage can be set by adding reference voltage and split resistors externally. Output voltage is determined using the following equation and is based on the values of $R_{FB21}$ and $R_{FB22}$. The sum of $R_{FB21}$ and $R_{FB22}$ should normally be 200kΩ or less. The equation uses Ch 1's ($V_{OUT1}$) output voltage calculation method for the reference voltage.

$$V_{OUT2} = (0.9-V_{OUT1})\times(R_{FB21}/R_{FB22}) + 0.9V$$

[Calculation Example]

*When* $R_{FB21}$ =17.5kΩ, $R_{FB22}$ =10kΩ, $V_{OUT1}$ =3.3V, $V_{OUT2}$ = - 3.3V

The value of speed-up capacitor for phase compensation $C_{FB21}$:

**[Conditions: Heavy load (when coil current is continuous.)]**

$fzfb2 = 1/2\times\pi\times C_{FB21}\times R_{FB21}) = 10kHz$

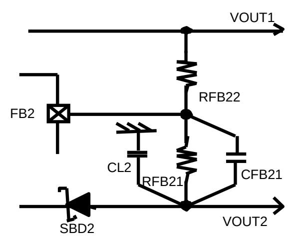
Depending on the application, the inductance value L, and the load capacity value $C_L$, adjustments to this value are suggested so that the value is somewhere between 1kHz to 50kHz.

**[Conditions: Light load (when coil current is discontinuous.)]**

Less than $C_{FB21}$=0.1μF

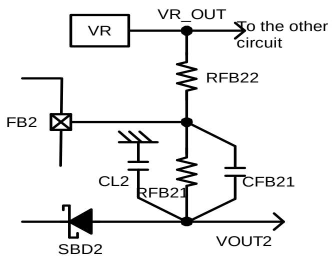
Depending on the application, the inductance value L, and the load capacity value $C_L$, adjustments to this value are suggested.

> Example Circuit 1: Using voltage of Ch 1 (Step-Up)




Channel 1 (Step-Up) circuits should be enable by setting EN1 to High level so that a stable voltage is provided. Inrush current to the inverter when the supply voltage $V_{DD}$ of the IC is 2.0 V or higher can be controlled by setting EN 1 and EN 2 to enable (“H” level) simultaneously.

> Example Circuit 2: Using a positive regulator




A stable positive voltage produced by a positive voltage regulator or by other means is usable.

$$V_{OUT2} = (0.9 - V_{ROUT})\ x\ (R_{FB21} / R_{FB22}) + 0.9V$$

# ■NOTES ON USE

## ●External Components

**Conditions: Light load (when coil current is discontinuous.)**

**Channel One: Step-Up DC/DC Converter Controller ICs**

* MOSFET

Tr.1: XP151A12A2 (N-ch Power MOSFET, TOREX)
Note: $V_{GS}$ break down voltage of the XP151A12A2 is 12V so please be careful with the power supply voltage.

SD1: MA2Q737 (Schottky diode, MATSUSHITA)

L1: 15μH (D412F, TOKO, FOSC=300kHz)
22μH (D412F, TOKO, FOSC=180kHz)
Please set so that the coil current is discontinuous.

$C_{L1}$: 25V, 4.7μF (Ceramic)

* NPN Tr.

Tr.1: 2SD1628 (SANYO)

$R_{B1}$: 500Ω Adjust in accordance with load & Tr.'s hFE.
$R_{B1} \leqq (V_{IN} - 0.7) \times (hFE/IC - R_{EXTBH})$

$C_{B1}$: 2200pF (Ceramic)
$C_{B1} \leqq (2\pi \times R_{B1} \times FOSC \times 0.7)$

**Channel Two: Inverter DC/DC Converter**

* MOSFET

Tr.2: XP151A12C0 (P-ch Power MOSFET, TOREX)
Note: $V_{GS}$ break down voltage of the XP151A12C0 is 12V so please be careful with the power supply voltage.

SD2: MA2Q737 (Schottky diode, MATSUSHITA)

L2: 22μH (D412F, TOKO, FOSC=300kHz)
44μH (D412F, TOKO, FOSC=180kHz)
Please set so that the coil current is discontinuous.

$C_{L2}$: 10V, 4.7μF (Ceramic)

* PNP Tr.

Tr.2: 2SA1213 (TOSHIBA)

$R_{B2}$: 500Ω Adjust in accordance with load & Tr.'s hFE.
$R_{B2} \leqq (V_{IN} - 0.7) \times (hFE/IC - R_{EXTBL})$

$C_{B2}$: 2200pF (Ceramic)
$C_{B2} \leqq (2\pi \times R_{B2} \times FOSC \times 0.7)$

**Conditions: Light load (when coil current is discontinuous.)**

**Channel One: Step-Up DC/DC Converter Controller ICs**

* MOSFET

Tr.1: XP151A12A2 (N-ch Power MOSFET, TOREX)
Note: $V_{GS}$ break down voltage of the XP151A12A2 is 12V so please be careful with the power supply voltage.

SD1: MA2Q737 (Schottky diode, MATSUSHITA)

L1: 15μH (CDRH5D28, SUMIDA, FOSC=300kHz)
22μH (CDRH5D28, SUMIDA, FOSC=180kHz)

$C_{L1}$: 16V, 4.7μF (Tantalum)
Increase capacity according to the equation below when the step-up voltage ratio is large and output current is high.
$C_L$=($C_L$ standard value) x ($I_{OUT1}$ (mA) / 300mA x $V_{OUT1}$ / $V_{IN}$

* NPN Tr.

Tr.1: 2SD1628 (SANYO)

$R_{B1}$: 500Ω Adjust in accordance with load & Tr.'s hFE.
$R_{B1} \leqq (V_{IN} - 0.7) \times (hFE/IC - R_{EXTBH})$

$C_{B1}$: $C_{B1} \leqq (2\pi \times R_{B1} \times FOSC \times 0.7)$

**Channel Two: Inverter DC/DC Converter**

* MOSFET

Tr.2: XP151A12C0 (P-ch Power MOSFET, TOREX)
Note: $V_{GS}$ break down voltage of the XP151A12C0 is 12V so please be careful with the power supply voltage.

SD2: MA2Q737 (Schottky diode, MATSUSHITA)
CRS02, CMS02 (Schottky diode, TOSHIBA)

L2: 15μH (CDRH5D28, SUMIDA, FOSC=300kHz)
22μH (CDRH5D28, SUMIDA, FOSC=180kHz)

$C_{L2}$: 16V, 4.7μF (Tantalum)
Increase capacity according to the equation below when the step-up voltage ratio is large and output current is high.
$C_L$=($C_L$ standard value) x ($I_{OUT2}$ (mA) / 300mA x $V_{OUT2}$ / $V_{IN}$

* PNP Tr.

Tr.2: 2SA1213 (TOSHIBA)

$R_{B2}$: 500Ω Adjust in accordance with load & Tr.'s hFE.
$R_{B2} \leqq (V_{IN} - 0.7) \times (hFE/IC - R_{EXTBL})$

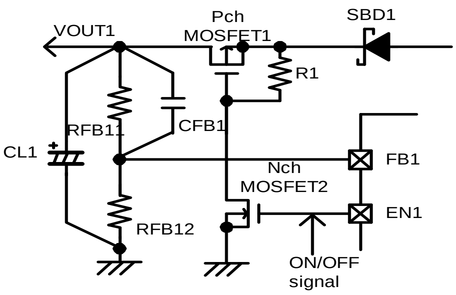
$C_{B2}$: 2200pF (Ceramic)
$C_{B2} \leqq (2\pi \times R_{B2} \times FOSC \times 0.7)$

# ■NOTES ON USE (Continued)

●Hint on application

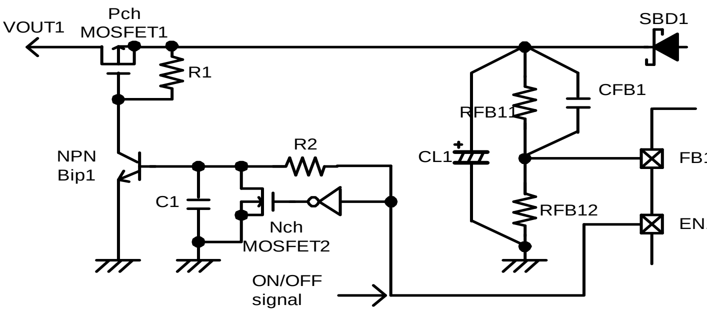
1. Channel 1 (Step-Up) How to shut down the output voltage during standby mode
If the circuit configuration shown as an example of typical application circuits is used, voltage $V_{IN}$ will occur at $V_{OUT1}$ when the IC is in standby, the diode being bypassed. This can cause circuits connected to $V_{OUT1}$ to malfunction.

> Example of typical application circuit 1:




Set R1 so as to prevent leakage current of N-ch MOSFET 2.

> Example of typical application circuit 2: Power Ready Function




The combination of R 2, C 1, and the threshold voltage of approximately 0.7 V of NPN Bip 1 is used to produce a delay time between the circuits being enabled and P-ch MOSFET 1 being switched on. Delay time set to 20ms ensures power to be made ready in a favorable manner, as soft start of this product is completed during the delay time.

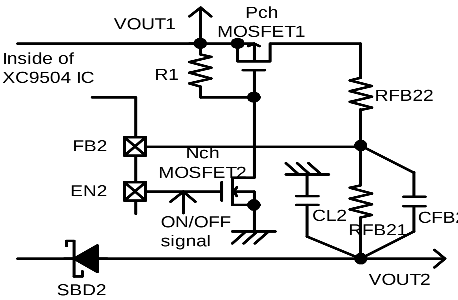
Set Value (Example)

| VOLTAGE (V) | R2 (kΩ) | C1 (μF) |
|---|---|---|
| 2.5 | 430 | 0.15 |
| 3.3 | 470 | 0.18 |
| 5.0 | 430 | 0.33 |

Time to make power ready is calculated by the equation below.
*Time = - R2 x C1 x Ln (1 - 0.7 / [ON / OFF Signal Voltage ]*
Set R1 so as to prevent leakage current of NPN (Bip 1).
N-ch MOSFET 2 and the inverter enables power to be turned off quickly.

2. Channel 2 (Inverting): Soft start circuit
Channel 2 (inverting) is subject to the overshoot of output voltage 2 ($V_{OUT2}$) at start-up. It is possible to control the overshoot of output voltage 2 ($V_{OUT2}$), as shown by circuit example 1 in “Output Voltage Settings for Channel 2” in “Function Settings.” In this circuit configuration, EN 1 and EN 2 are enabled (set to “H” level) simultaneously. This lets output voltage 1 ($V_{OUT1}$) of channel 1 increase gently as soft start, thereby controlling the overshoot.

> Example of typical application circuit: Improved Soft start
This example is effective when EN 1 and EN 2 are enabled with different timings under light load condition (the coil current being discontinuous).




Time to make soft start time is calculated by the equation below.

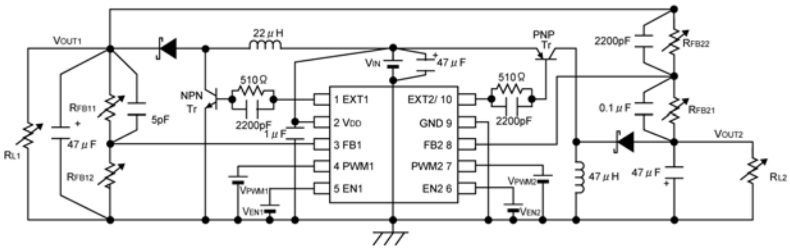
$$Time_{ss2} = -R_{FB21} \times C_{FB21} / Ln\left(1 - \frac{(0.9 - V_{OUT2}) \times R_{FB22}}{(V_{OUT1} - 0.9) \times R_{FB21}}\right)$$

Example)
When $V_{OUT1} = 15V$ and $V_{OUT2} = -7.5V$,
$R_{FB21}$ = 59.6kΩ, $R_{FB22}$ = 100kΩ by the equation below.
$V_{OUT2} = (0.9 - V_{OUT1}) \times (R_{FB21} / R_{FB22}) + 0.9$
When the light load, $C_{FB21}$=0.1μF or lower value can be used.
Therefore, when $C_{FB21}$=0.027μF,
Time_ss2 = 5.0ms and $V_{OUT2}$ = 95% of setting value

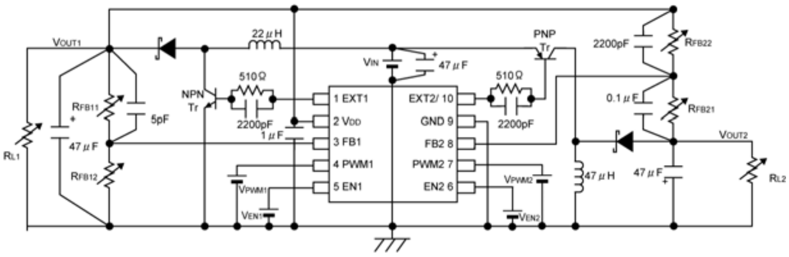
3. Channel 2 (Inverting): Withstand voltage of transistor
The voltage applied between the drain and source is the sum of $V_{IN}$ and $V_{OUT2}$. Select a transistor with an absolute $V_{DSS}$ rating that is suitable for your operating conditions. Example: The voltage applied across $V_{DS}$ of a transistor will be 20.0V if $V_{IN}$ = 5.0 V and $V_{OUT2}$ = -15.0 V. Under this condition, a transistor with $V_{DSS}$ higher than 20.0V should be selected. (Use a transistor with VDSS that is 1.5 times the applied voltage or more, as a standard.)

## ■TEST CIRCUITS

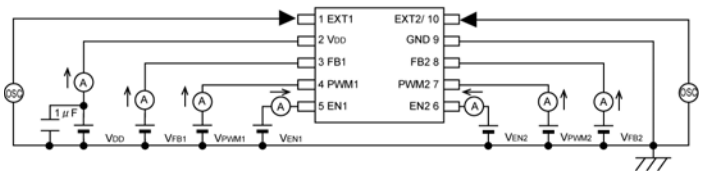
Circuit 1



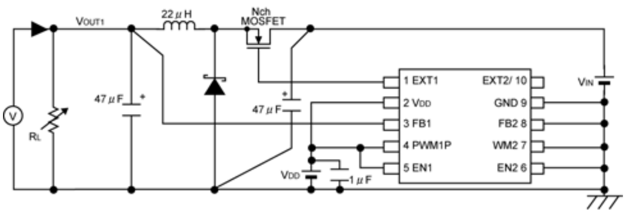

Circuit 2




Circuit 3

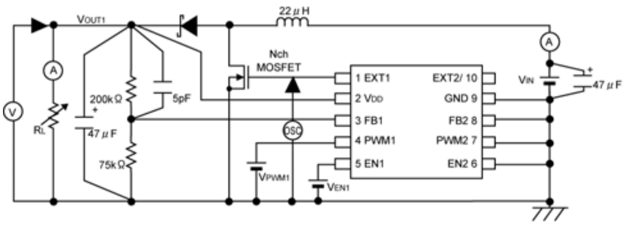



Circuit 4

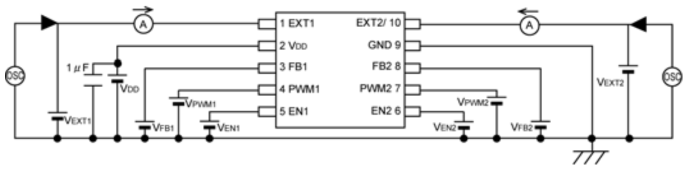


## ■TEST CIRCUITS(Continued)

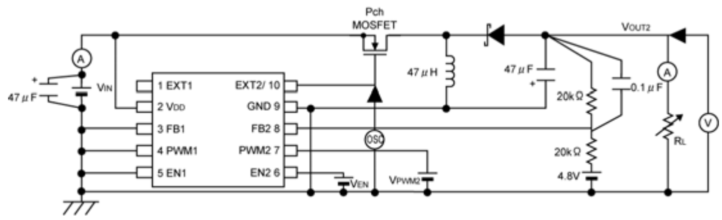
Circuit 5




Circuit 6




Circuit 7



## ■EXTERNAL COMPONENTS USED FOR THE TEST CIRCUITS

**Circuit 1, Circuit 2**

L1, L2: 22 μH (CDRH5D28, SUMIDA) : XC9504B092A
15 μH (CDRH5D28, SUMIDA) : XC9504B093A
10 μH (CDRH5D28, SUMIDA) : XC9504B095A
SD1, SD2 : CRS02 (Schottky, TOSHIBA)
EC10QS06 (Schottky, NIHON INTER)
$C_{L1}$, $C_{L2}$ : 16MCE476MD2 (Tantalum, NIHON CHEMICON)
35MCE335MB x 3 (Tantalum, NIHON CHEMICON)
$C_{IN}$ : 16MCE476MD2
NPN Tr 1 : 2SD1628 (SANYO)
PNP Tr 2 : 2SA1213 (TOSHIBA)
$R_{FB}$ : Please use by the conditions as below.
$R_{FB11} + R_{FB12} \leqq 1M\Omega$
$R_{FB21} + R_{FB22} \leqq 1M\Omega$
$R_{FB11} / R_{FB12}$ = (Setting Output Voltage / 0.9) - 1
$V_{OUT2} = (0.9 - V_{OUT1}) / (R_{FB21} / R_{FB22}) + 0.9$
$C_{FB}$ : $fzfb = 1 /(2 \times \pi \times C_{FB1} \times R_{FB11})$ = 1kHz to 50kHz (12kHz usual)
$fzfb = 1 /(2 \times \pi \times C_{FB2} \times R_{FB21})$ = 1kHz to 50kHz (12kHz usual).

**Circuit 4**

L1 : 22 μH (CDRH5D28 SUMIDA)
SD 1 : MA2Q737 (Schottky, MATSUSHITA)
$C_{L1}$ : 16MCE476MD2 (Tantalum, NIHONCHEMICON)
$C_{IN}$ : 16MCE476MD2 (Tantalum, NIHONCHEMICON)
N-ch MOSFET : XP161A1355P (TOREX)

**Circuit 5**

L1 : 22 μH (CDRH5D28, SUMIDA) : XC9504B092A
15 μH (CDRH5D28, SUMIDA) : XC9504B093A
10 μH (CDRH5D28, SUMIDA) : XC9504B095A
SD 1 : MA2Q737 (Schottky, MATSUSHITA)
$C_{L1}$ : 16MCE476MD2 (Tantalum, NIHONCHEMICON)
$C_{IN}$ : 16MCE476MD2 (Tantalum, NIHONCHEMICON)
N-ch MOSFET : XP161A1355P (TOREX)

**Circuit 7**

L2 : 22 μH (CDRH5D28, SUMIDA) : XC9504B092A
15 μH (CDRH5D28, SUMIDA) : XC9504B093A
10 μH (CDRH5D28, SUMIDA) : XC9504B095A
SD 2 : MA2Q737 (Schottky, MATSUSHITA)
$C_{L2}$ : 16MCE476MD2 (Tantalum, NIHONCHEMICON)
$C_{IN}$ : 16MCE476MD2 (Tantalum, NIHONCHEMICON)
P-ch MOSFET : XP162A12A6P (TOREX)

## ■NOTE ON USE

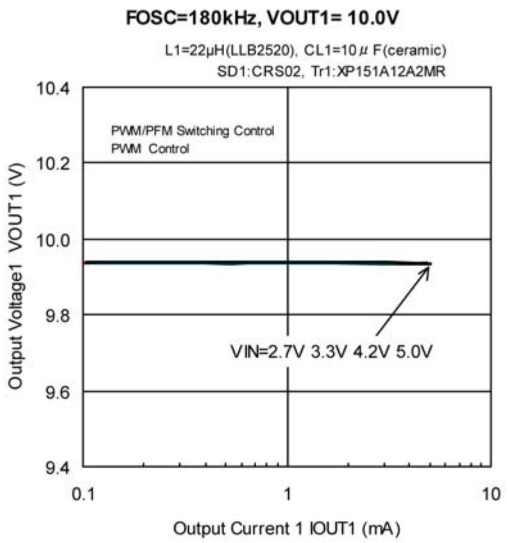
1. PWM/PFM Automatic Switching
If PWM/PFM automatic switching control is selected and the step-up ratio is low (e.g., from 4.5 V to 5.0 V), the control mode remains in PFM setting over the whole load range, since the duty ratio under continuous-duty condition is smaller than the PFM duty ratio of the XC9504 series. The output voltage's ripple voltage becomes substantially high under heavy load conditions, with the XC9504 series appearing to be producing an abnormal oscillation. If this operation becomes a concern, set pins PWM to High to set the control mode to PWM setting. For use under the above-mentioned condition, measured data of PWM/PFM automatic switching control shown on the data sheets are available up to $I_{OUT}$ = 100 mA.

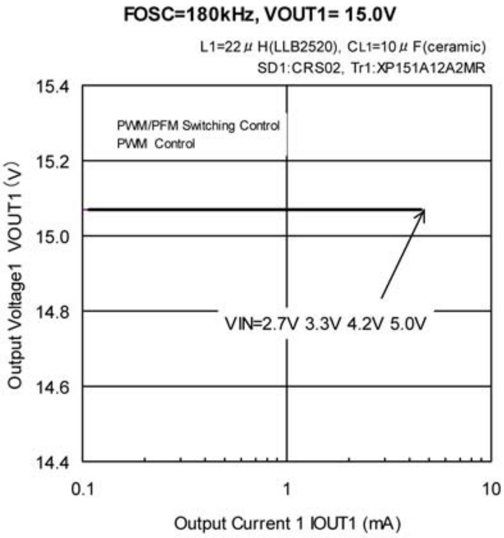
2. Ratings
Use the XC9504 series and peripheral components within the limits of their ratings.

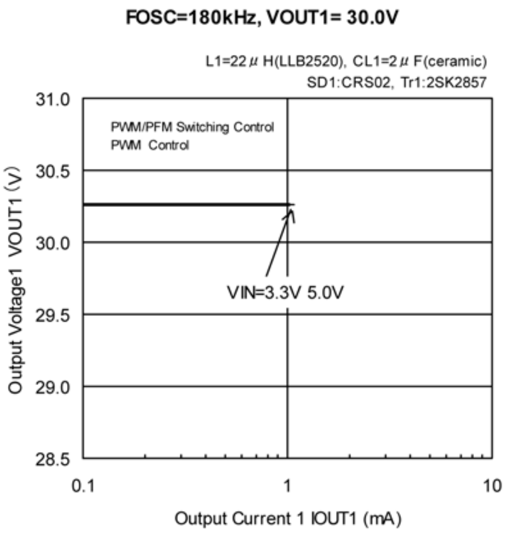
## ■TYPICAL PERFORMANCE CHARACTERISTICS

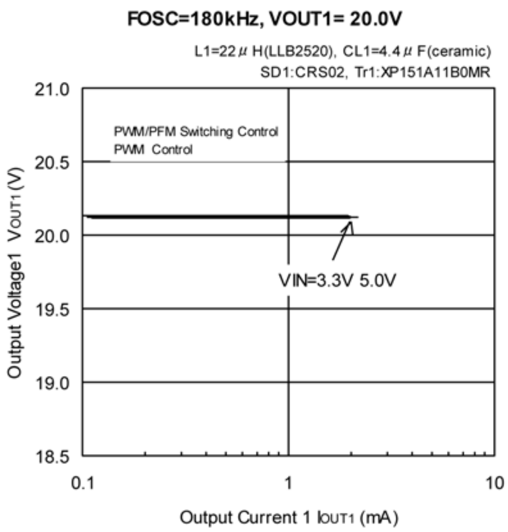
< 1 ch. Step-Up DC/DC Controller >

(1) Output Voltage vs. Output Current (Ceramic capacitor and compact Inductor use )



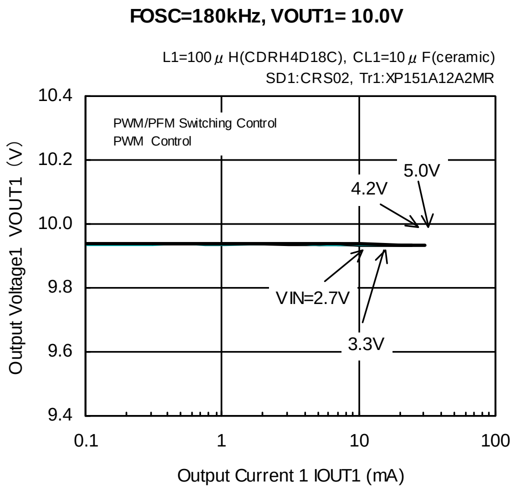



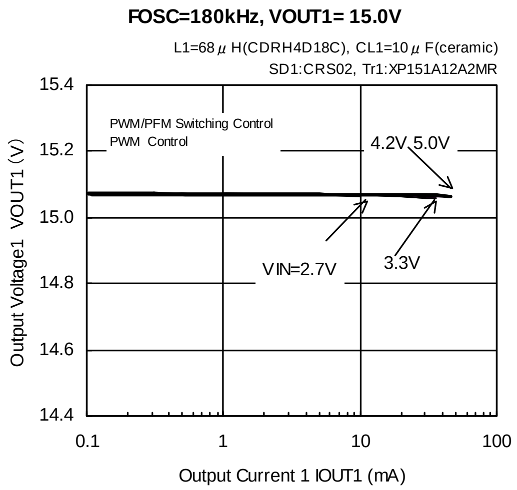
## ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

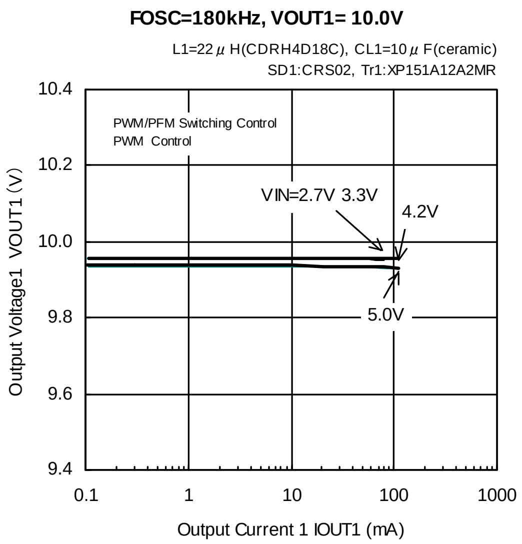
< 1 ch. Step-Up DC/DC Controller > (Continued)

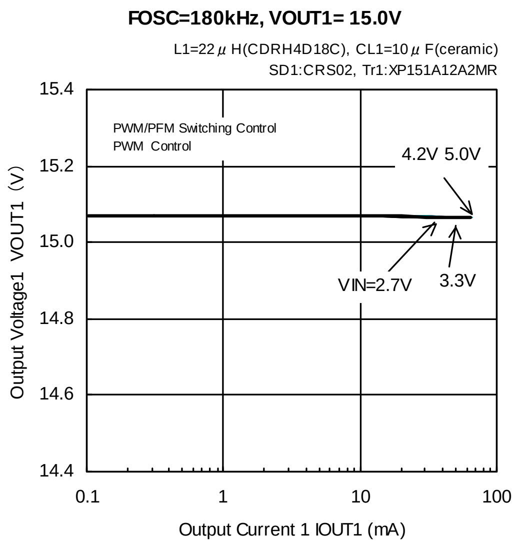
(1) Output Voltage vs. Output Current (Continued)

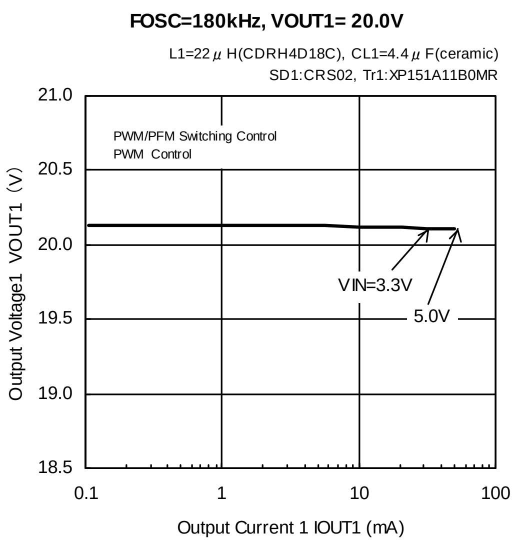
(Ceramic capacitor use)

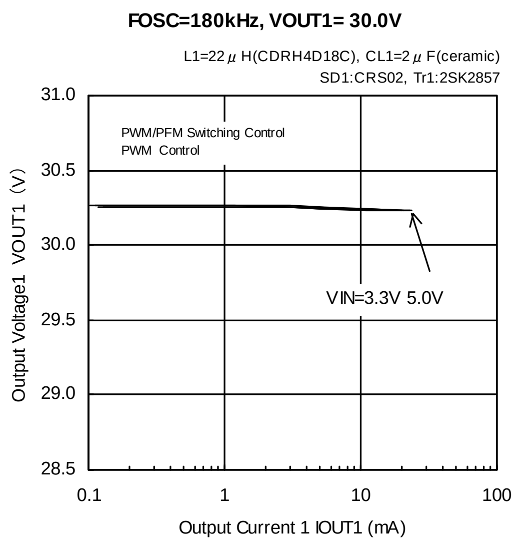


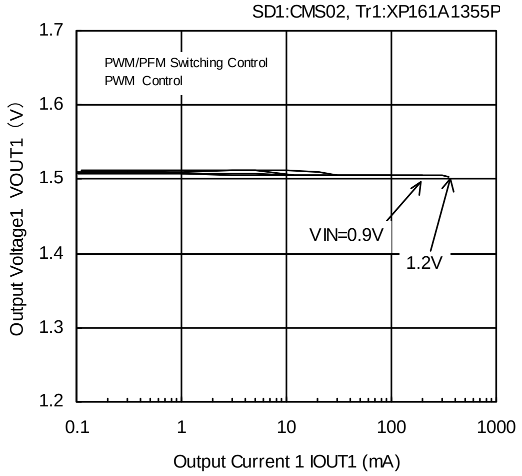
# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

< 1 ch. Step-Up DC/DC Controller > (Continued)

(1) Output Voltage vs. Output Current (Continued) (Tantalum capacitor use)

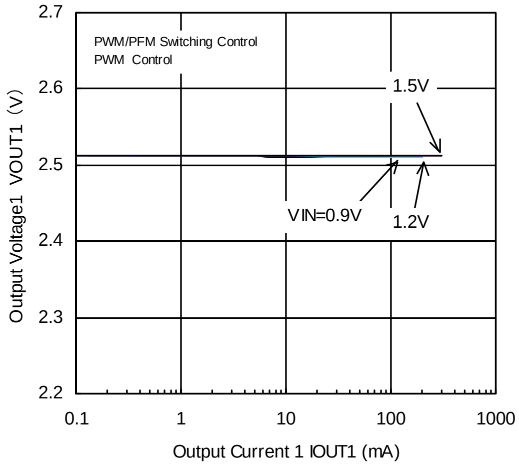
**FOSC=180kHz, VOUT1= 1.5V**

L1=22 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P



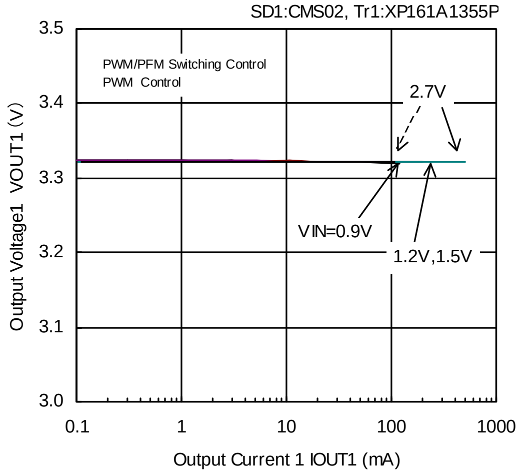

**FOSC=180kHz, VOUT1= 2.5V**

L1=22 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P



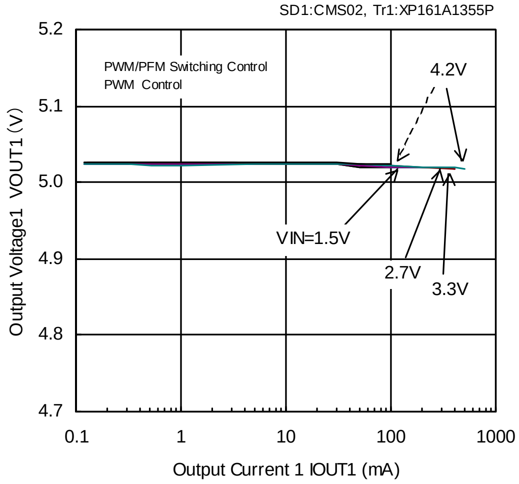

**FOSC=180kHz, VOUT1= 3.3V**

L1=22 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P



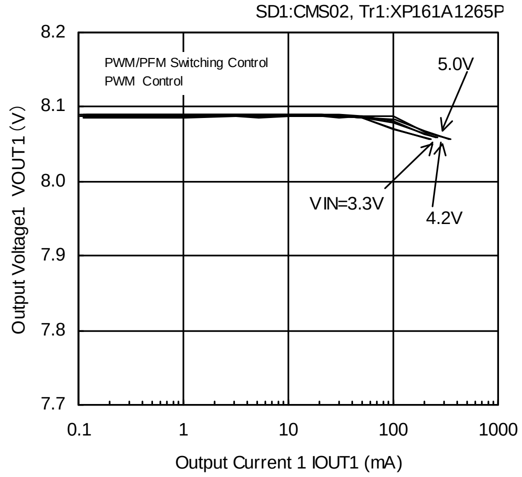

**FOSC=180kHz, VOUT1= 5.0V**

L1=22 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P




**FOSC=180kHz, VOUT1= 8.0V**

L1=22 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1265P




* Dotted Arrow Head - - - -> PWM/PFM Switching Control

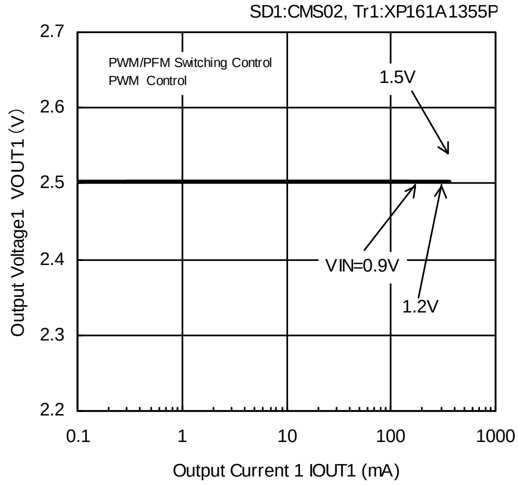
## ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

< 1 ch. Step-Up DC/DC Controller > (Continued)

(1) Output Voltage vs. Output Current (Continued)　　(Tantalum capacitor use)

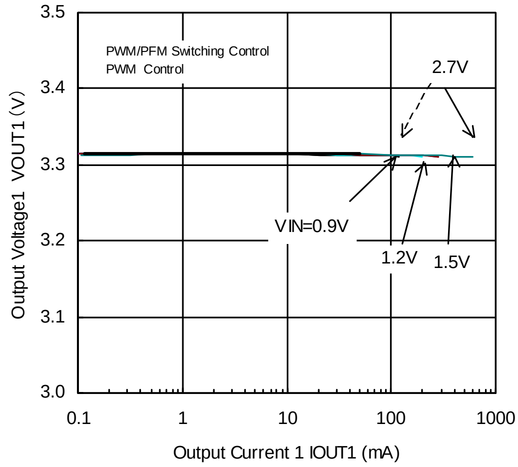
**FOSC=300kHz, VOUT1= 2.5V**

L1=15 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P



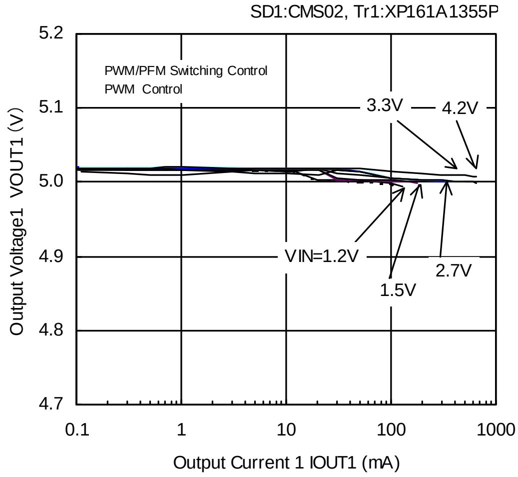

**FOSC=300kHz, VOUT1= 3.3V**

L1=15 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P



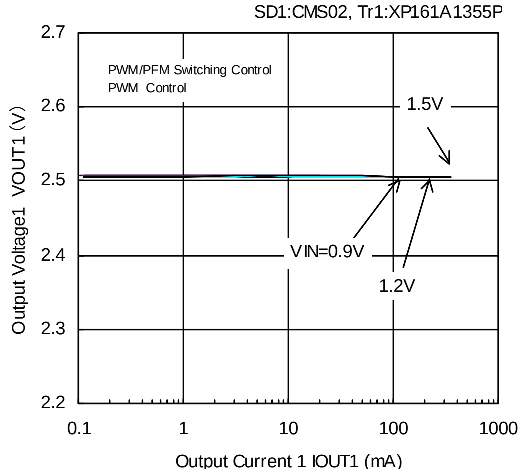

**FOSC=300kHz, VOUT1= 5.0V**

L1=15 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P



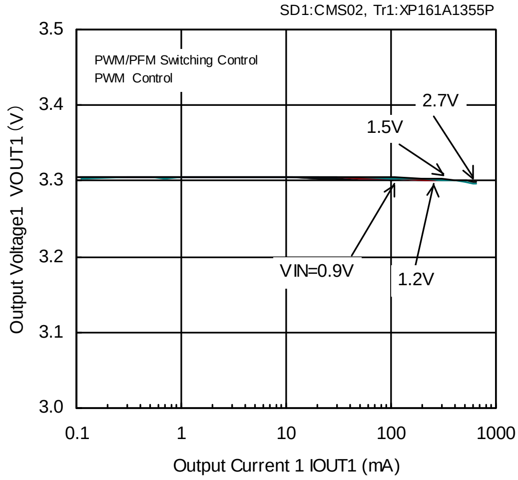

**FOSC=500kHz, VOUT1= 2.5V**

L1=10 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P



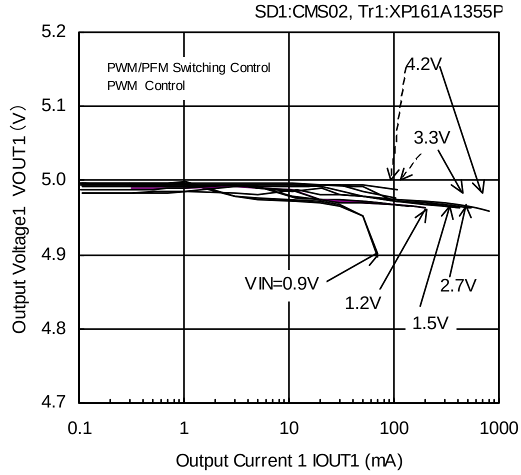

**FOSC=500kHz, VOUT1= 3.3V**

L1=10 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P




**FOSC=500kHz, VOUT1= 5.0V**

L1=10 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P

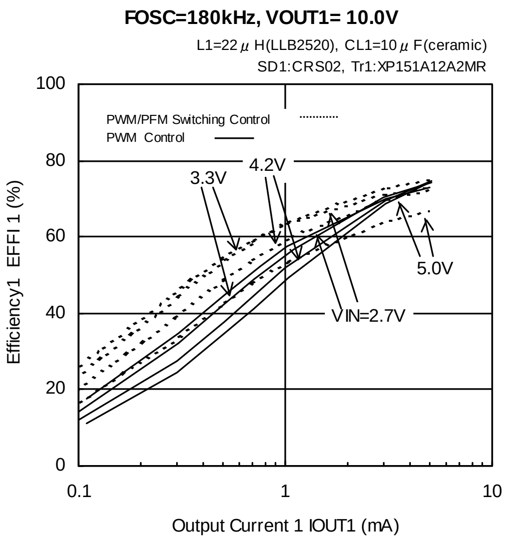


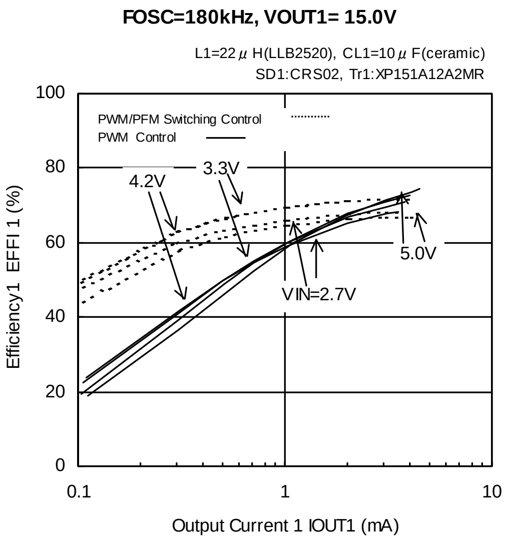

* Dotted Arrow Head - - - -> PWM/PFM Switching Control

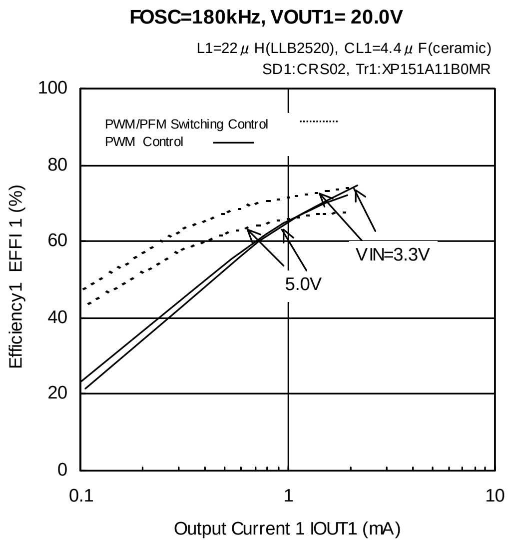
# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

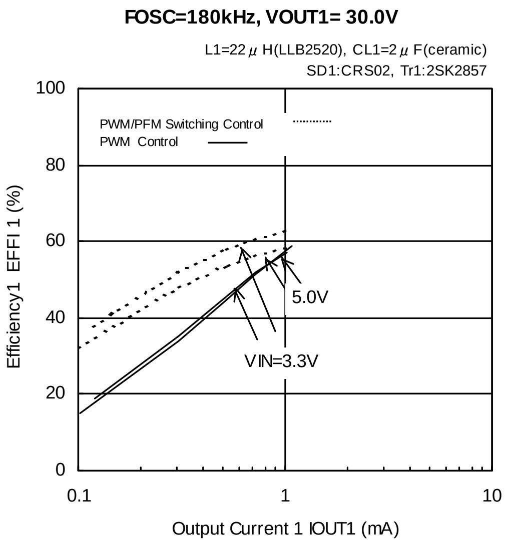
< 1 ch. Step-Up DC/DC Controller > (Continued)

(2) Efficiency vs. Output Current (Ceramic capacitor and compact inductor use)



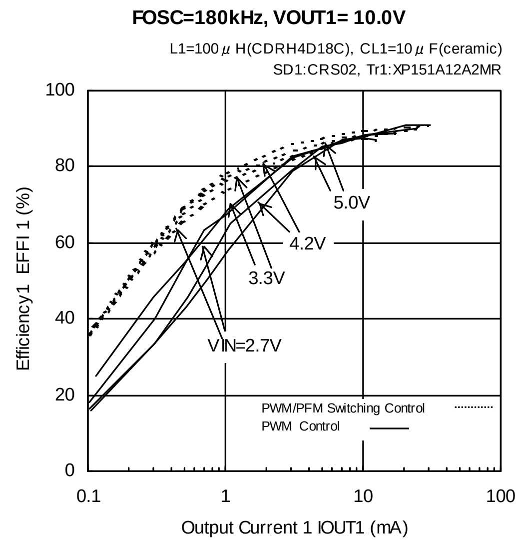



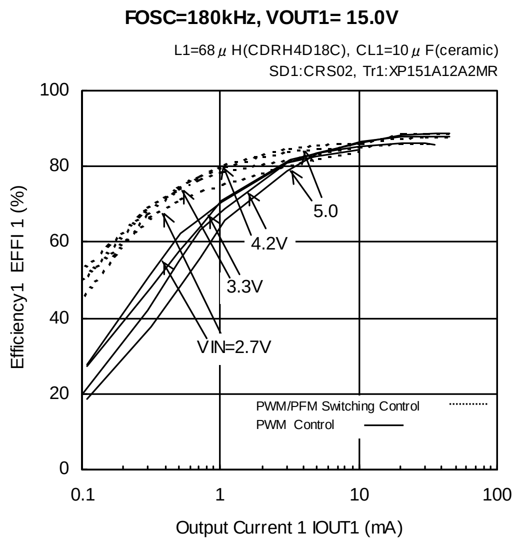
# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

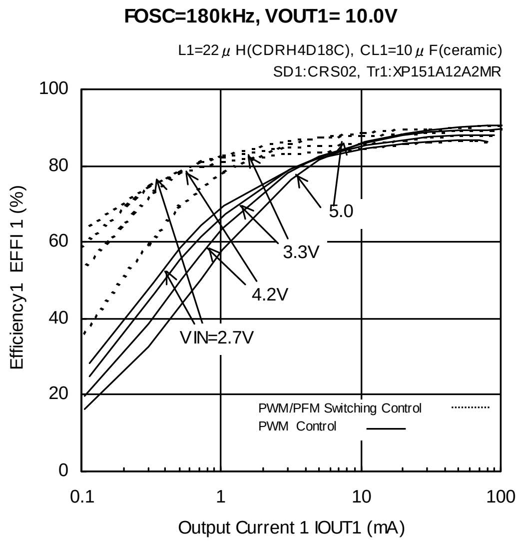
< 1 ch. Step-Up DC/DC Controller > (Continued)

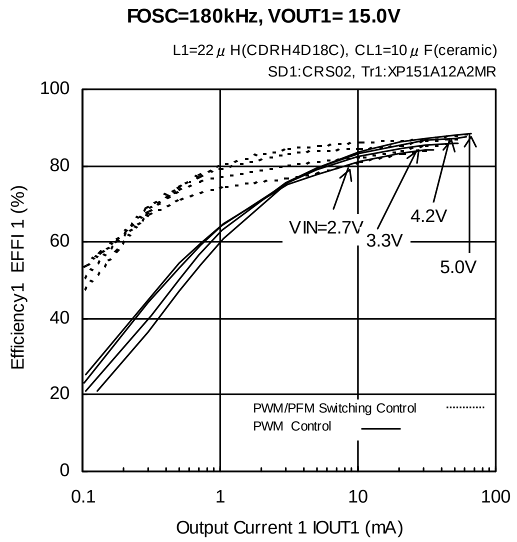
(2) Efficiency vs. Output Current (Continued)

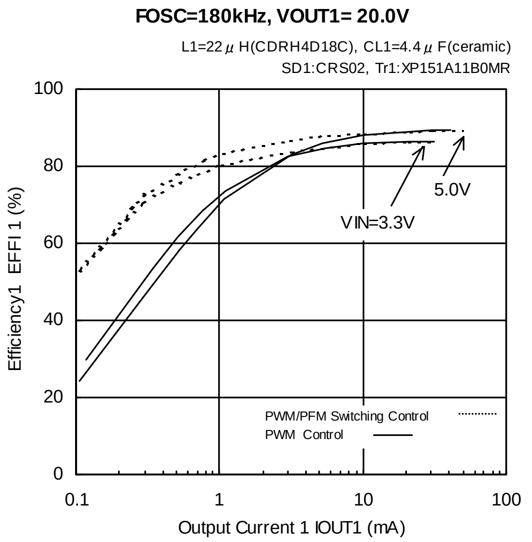
(Ceramic capacitor use)

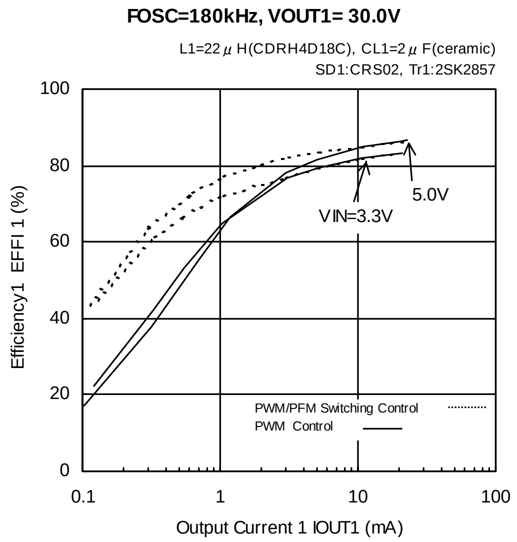


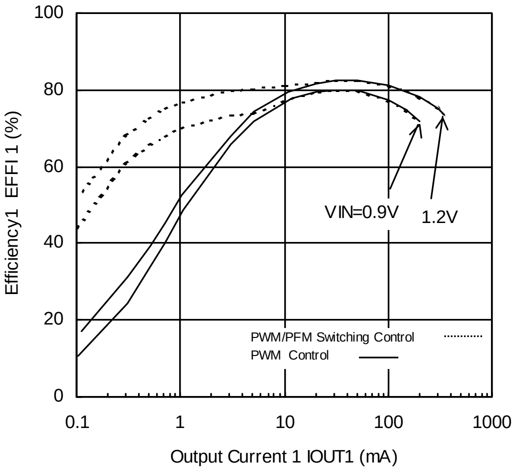
# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

< 1 ch. Step-Up DC/DC Controller > (Continued)

(2) Efficiency vs. Output Current (Continued) (Tantalum capacitor use)

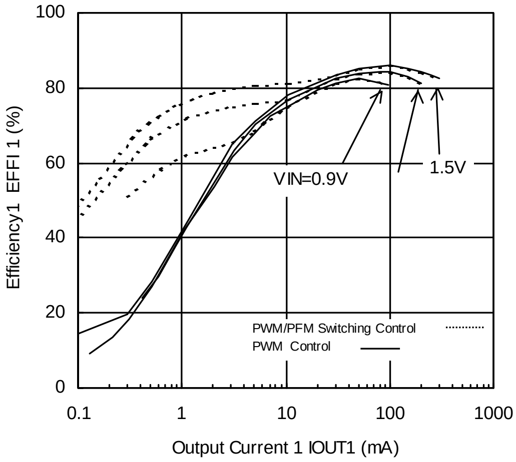
**FOSC=180kHz, VOUT1= 1.5V**

L1=22μH(CDRH5D28), CL1=94μF(Tantalum)
SD1:CMS02, Tr1:XP161A1355P



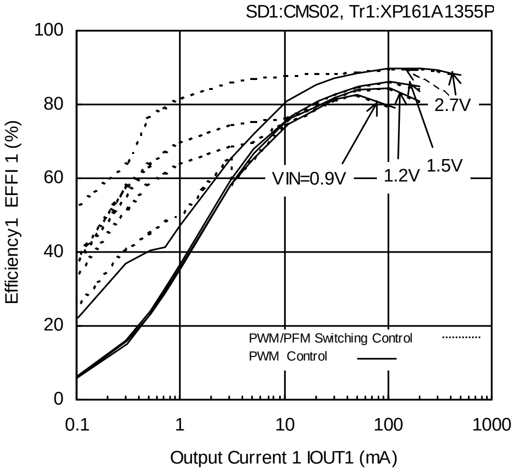

**FOSC=180kHz, VOUT1= 2.5V**

L1=22μH(CDRH5D28), CL1=94μF(Tantalum)
SD1:CMS02, Tr1:XP161A1355P



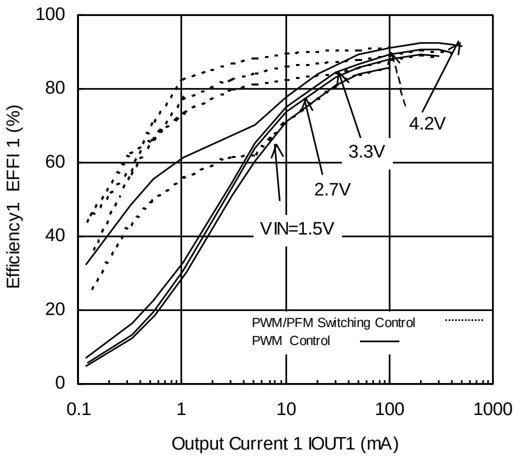

FOSC=180kHz, VOUT1= 3.3V

L1=22μH(CDRH5D28), CL1=94μF(Tantalum)
SD1:CMS02, Tr1:XP161A1355P



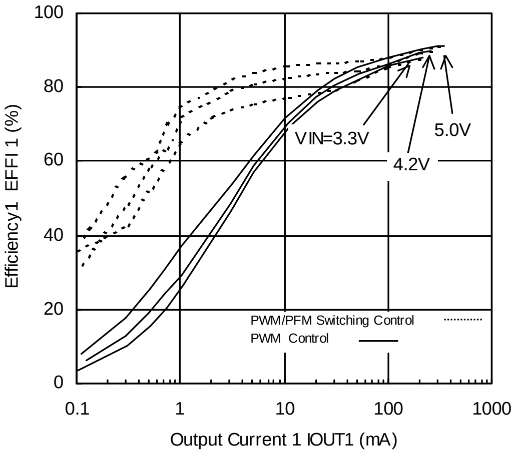

**FOSC=180kHz, VOUT1= 5.0V**

L1=22μH(CDRH5D28), CL1=94μF(Tantalum)
SD1:CMS02, Tr1:XP161A1355P




**FOSC=180kHz, VOUT1= 8.0V**

L1=22μH(CDRH5D28), CL1=94μF(Tantalum)
SD1:CMS02, Tr1:XP161A1265P




* Dotted Arrow Head ----> PWM/PFM Switching Control

## ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

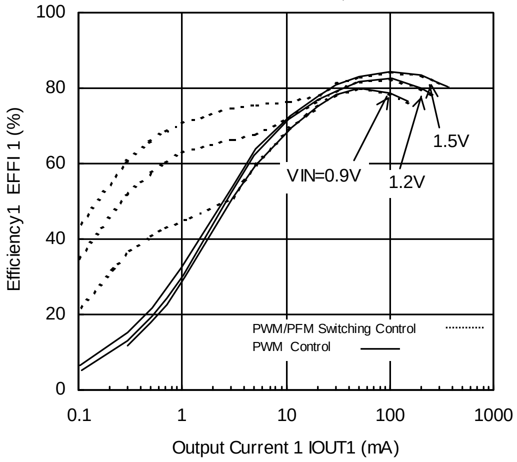
< 1 ch. Step-Up DC/DC Controller > (Continued)

(2) Efficiency vs. Output Current (Continued)

(Tantalum capacitor use)

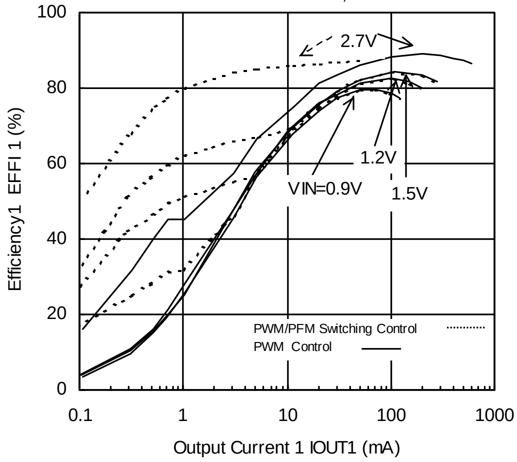
**FOSC=300kHz, VOUT1= 2.5V**

L1=15 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P



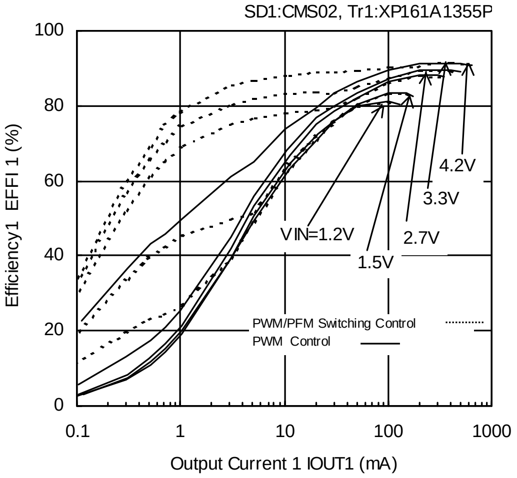

**FOSC=300kHz, VOUT1= 3.3V**

L1=15 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P



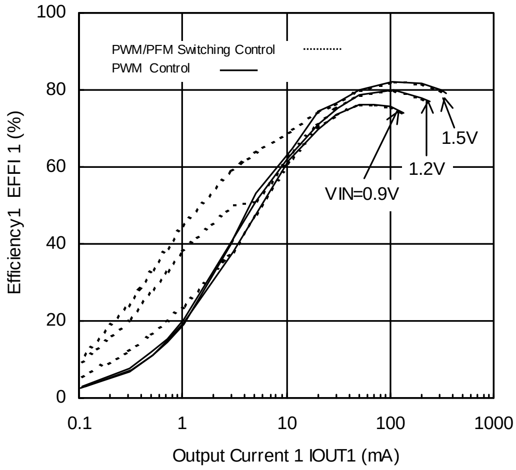

**FOSC=300kHz, VOUT1= 5.0V**

L1=15 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P



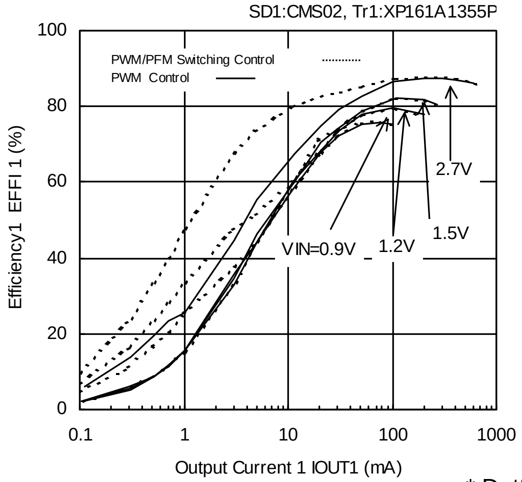

**FOSC=500kHz, VOUT1= 2.5V**

L1=10 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P



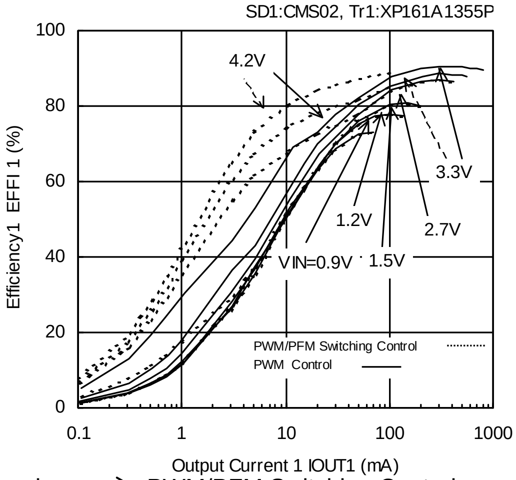

**FOSC=500kHz, VOUT1= 3.3V**

L1=10 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P




**FOSC=500kHz, VOUT1= 5.0V**

L1=10 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P

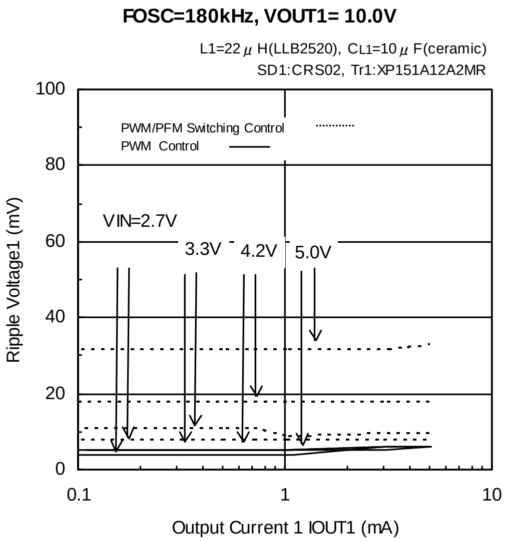


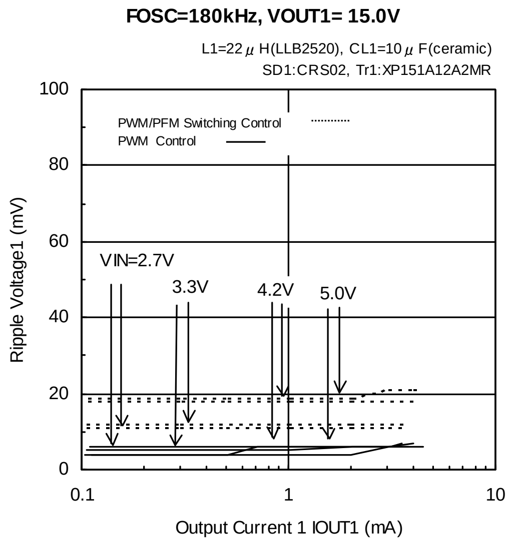

* Dotted Arrow Head - - - -> PWM/PFM Switching Control

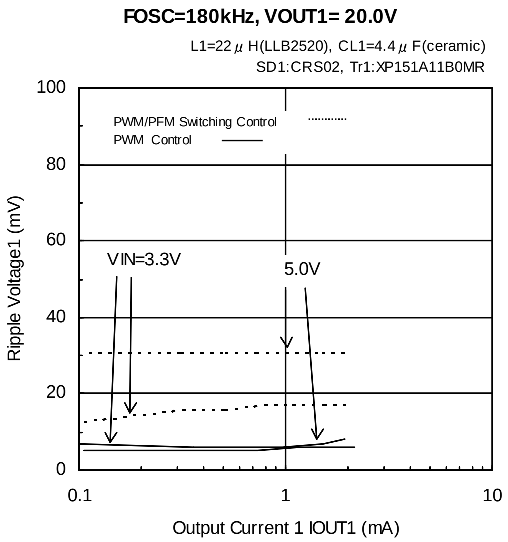
# ■TYPICAL PERFOMANCE CHARACTERISTICS (Continued)

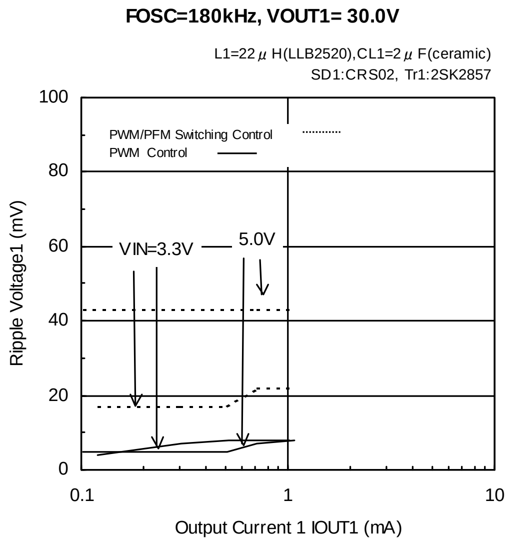
< 1 ch. Step-Up DC/DC Controller > (Continued)

(3) Ripple Voltage vs. Output Current (Ceramic capacitor and compact inductor use)



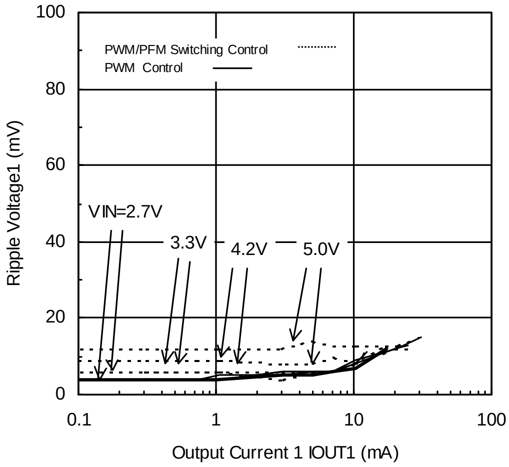
## ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

< 1 ch. Step-Up DC/DC Controller > (Continued)

(3) Ripple Voltage vs. Output Current (Continued) (Ceramic capacitor use)

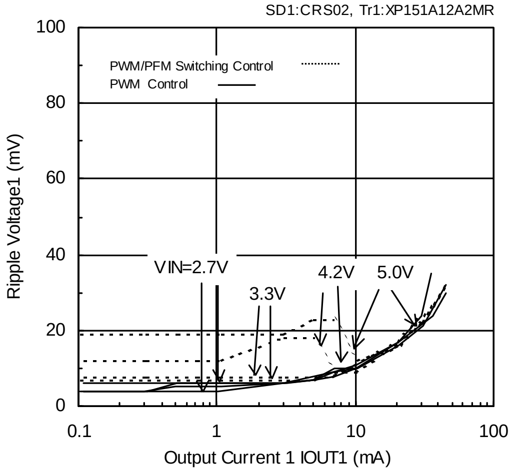
**FOSC=180kHz, VOUT1= 10.0V**

L1=100μH(CDRH4D18C), CL1=10μF(ceramic)
SD1:CRS02, Tr1:XP151A12A2MR



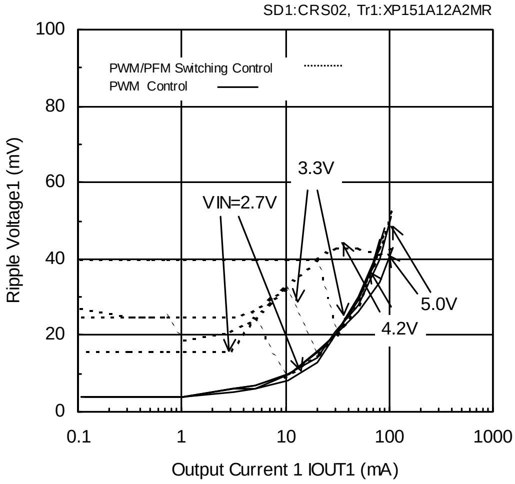

**FOSC=180kHz, VOUT1= 15.0V**

L1=68μH(CDRH4D18C), CL1=10μF(ceramic)
SD1:CRS02, Tr1:XP151A12A2MR



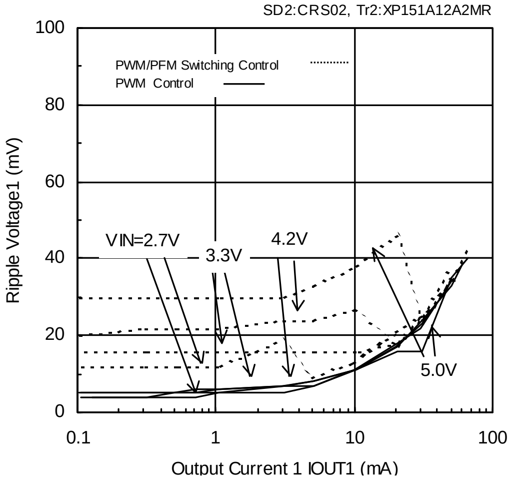

**FOSC=180kHz, VOUT1= 10.0V**

L1=22μH(CDRH4D18C), CL1=10μF(ceramic)
SD1:CRS02, Tr1:XP151A12A2MR



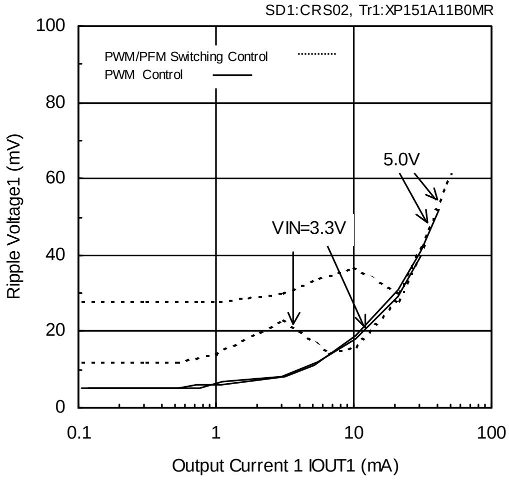

**FOSC=180kHz, VOUT1= 15.0V**

L2=22μH(CDRH4D18C), CL2=10μF(ceramic)
SD2:CRS02, Tr2:XP151A12A2MR



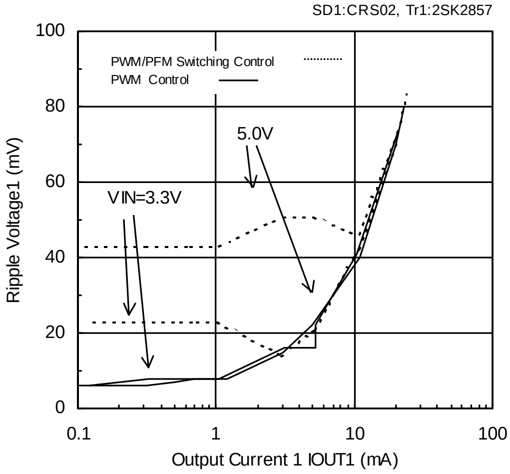

**FOSC=180kHz, VOUT1= 20.0V**

L1=22μH(CDRH4D18C), CL1=4.4μF(ceramic)
SD1:CRS02, Tr1:XP151A11B0MR




**FOSC=180kHz, VOUT1= 30.0V**

L1=22μH(CDRH4D18C), CL1=2μF(ceramic)
SD1:CRS02, Tr1:2SK2857



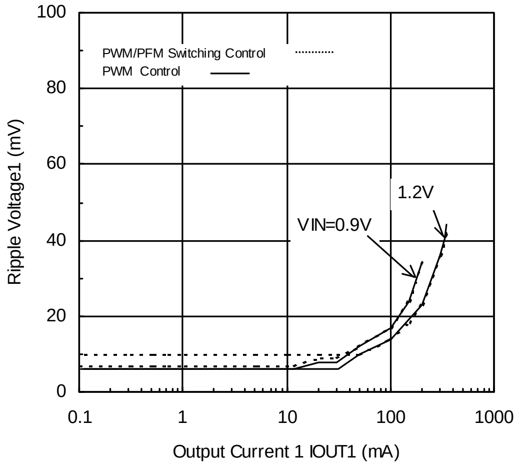
# ■TYPICAL PERFOMANCE CHARACTERISTICS (Continued)

< 1 ch. Step-Up DC/DC Controller > (Continued)

(3) Ripple Voltage vs. Output Current (Continued) (Tantalum capacitor use)

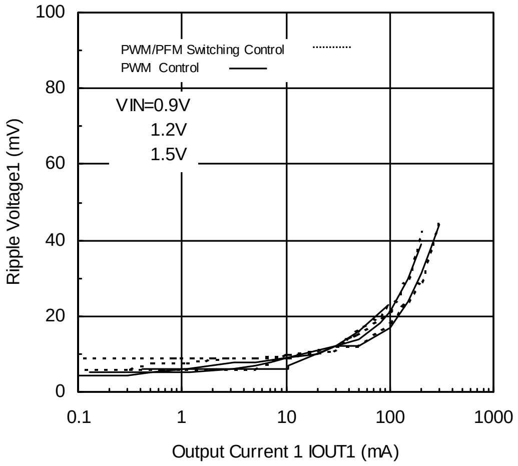
**FOSC=180kHz, VOUT1= 1.5V**

L1=22 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P



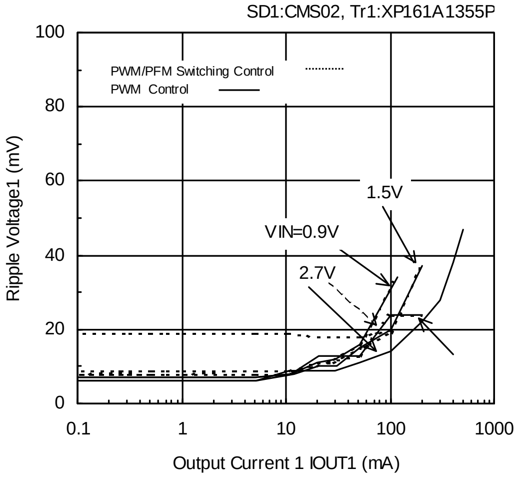

**FOSC=180kHz, VOUT1= 2.5V**

L1=22 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P



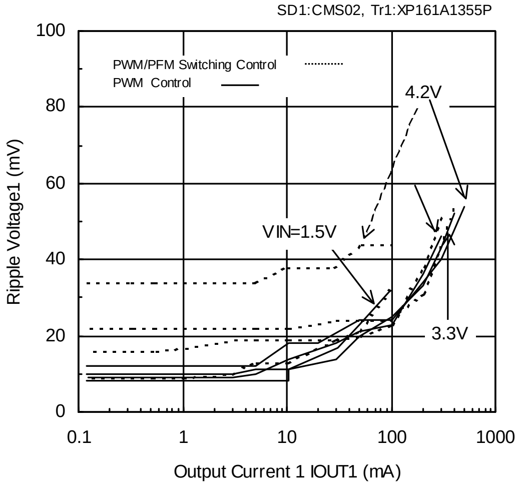

**FOSC=180kHz, VOUT1= 3.3V**

L1=22 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P



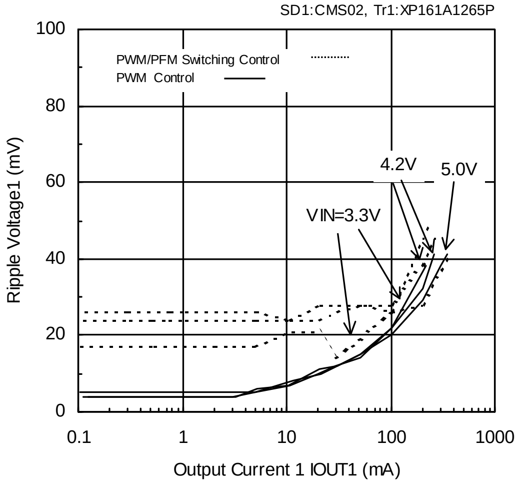

**FOSC=180kHz, VOUT1= 5.0V**

L1=22 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P




**FOSC=180kHz, VOUT1= 8.0V**

L1=22 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1265P




* Dotted Arrow Head ----> PWM/PFM Switching Control

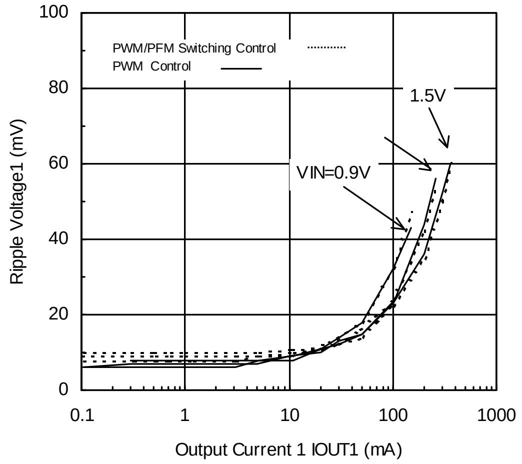
## ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

< 1 ch. Step-Up DC/DC Controller > (Continued)

(3) Ripple Voltage vs. Output Current (Continued) (Tantalum capacitor use)

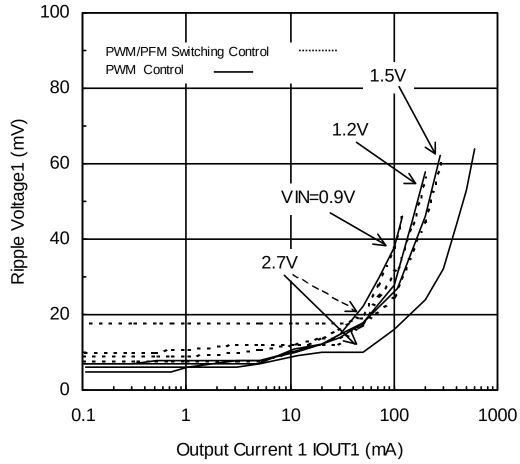
**FOSC=300kHz, VOUT1= 2.5V**

L1=15 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P



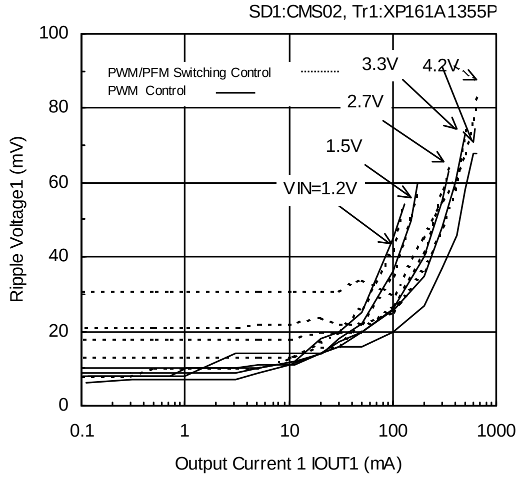

**FOSC=300kHz, VOUT1= 3.3V**

L1=15 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P



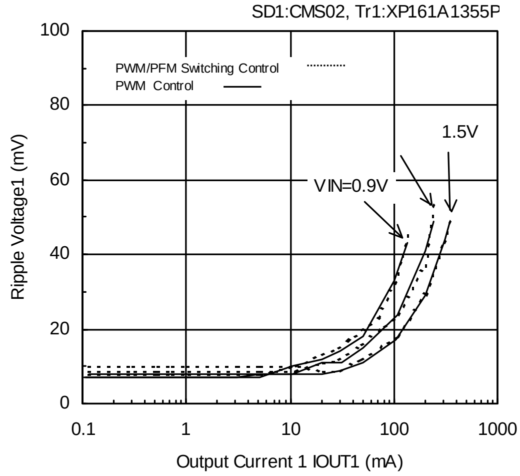

**FOSC=300kHz, VOUT1= 5.0V**

L1=15 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P



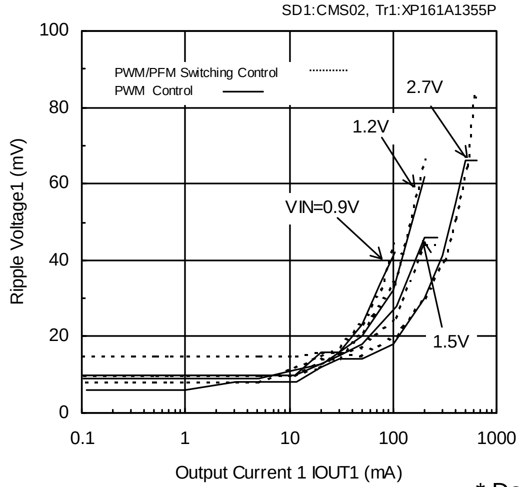

**FOSC=500kHz, VOUT1= 2.5V**

L1=10 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P



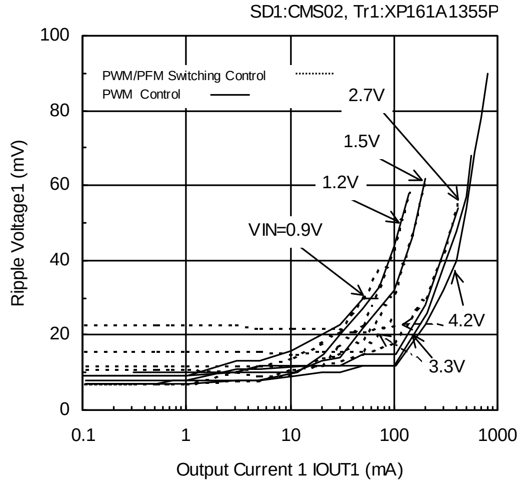

**FOSC=500kHz, VOUT1= 3.3V**

L1=10 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P




**FOSC=500kHz, VOUT1= 5.0V**

L1=10 μ H(CDRH5D28), CL1=94 μ F(Tantalum)
SD1:CMS02, Tr1:XP161A1355P

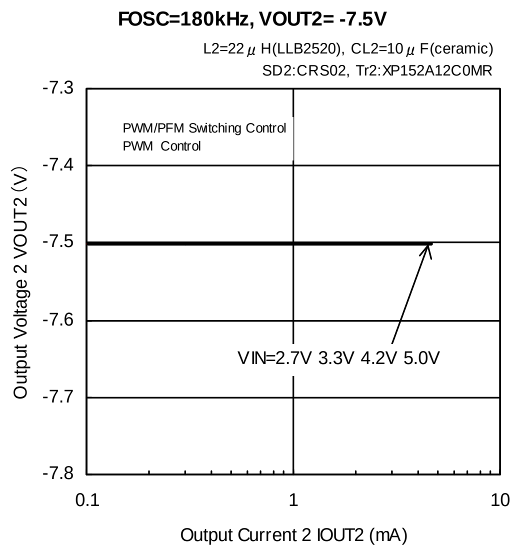


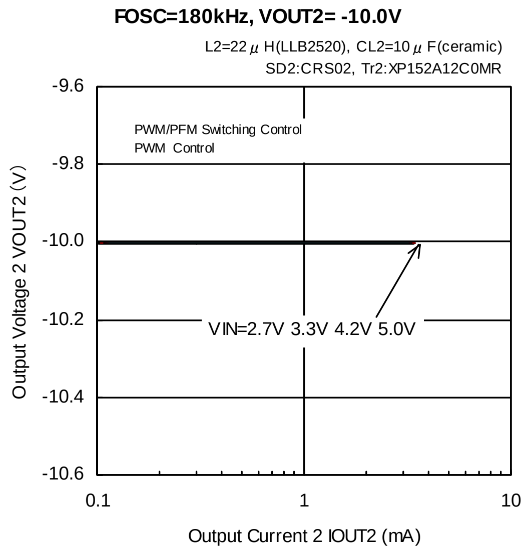

* Dotted Arrow Head ----> PWM/PFM Switching Control

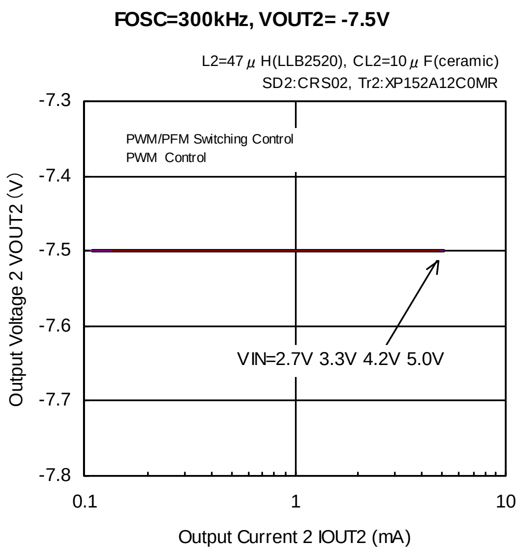
# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

< 2 ch. Inverting DC/DC Controller >

(4) Output Voltage vs. Output Current (Ceramic capacitor and compact inductor use )



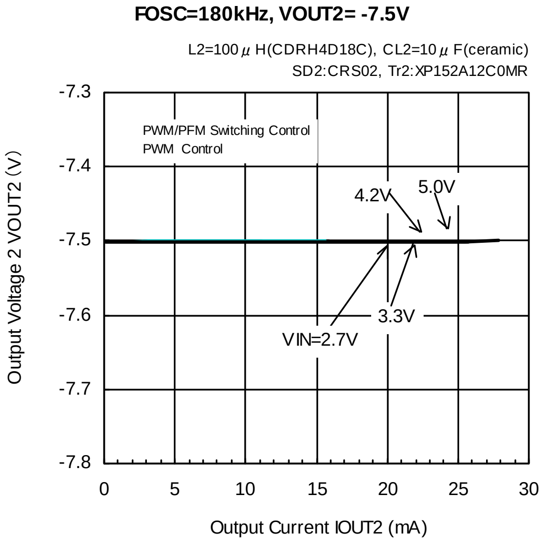



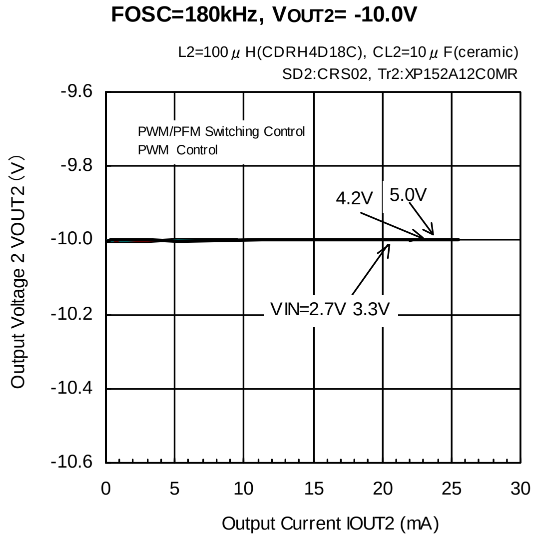



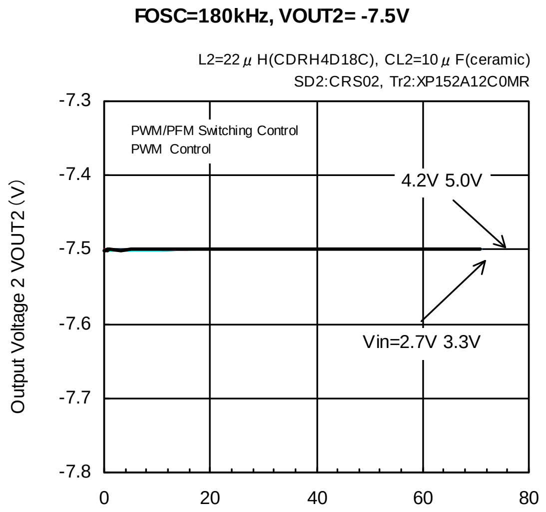
# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

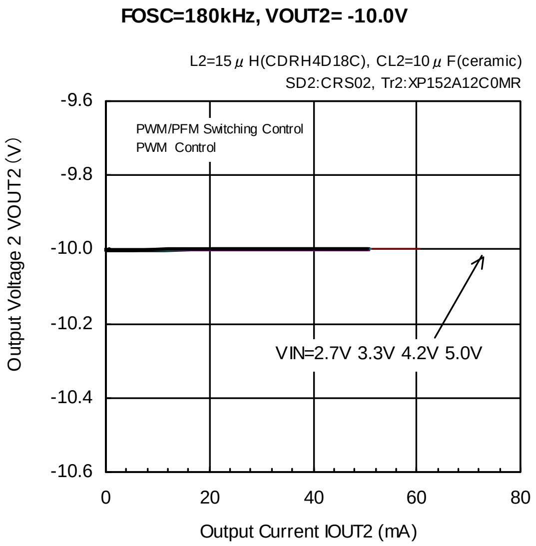
< 2 ch. Inverting DC/DC Controller > (Continued)

(4) Output Voltage vs. Output Current (Continued) (Ceramic capacitor use)



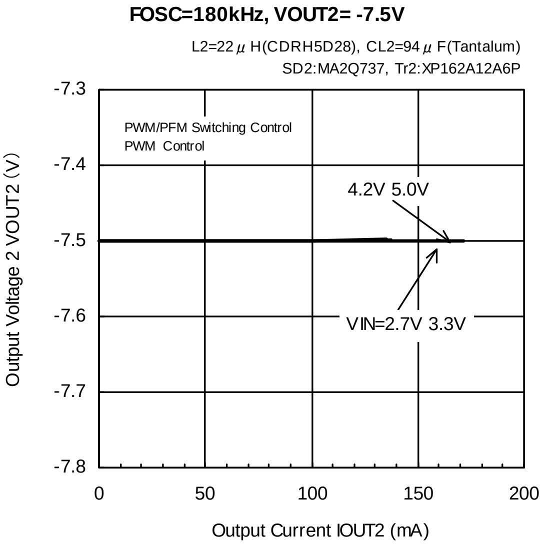



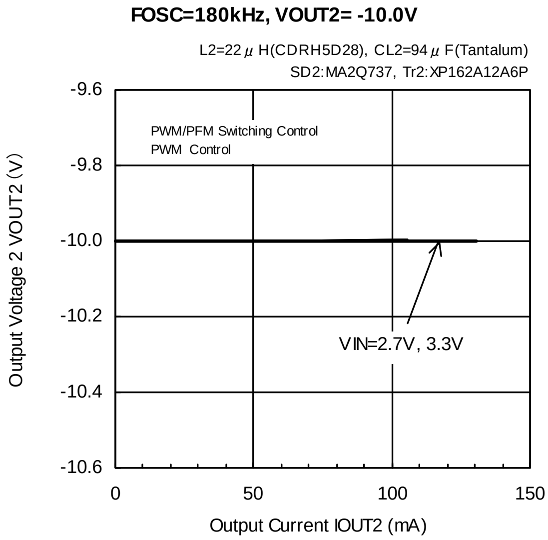



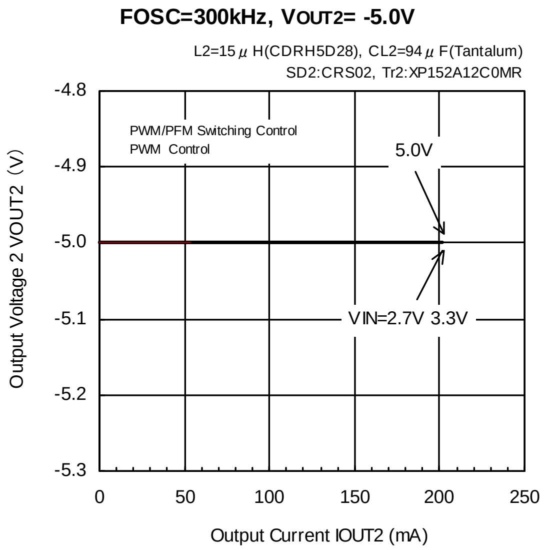
## ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

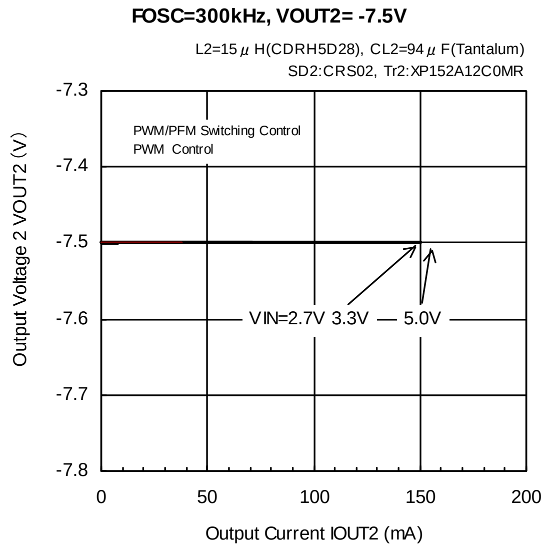
< 2 ch. Inverting DC/DC Controller > (Continued)

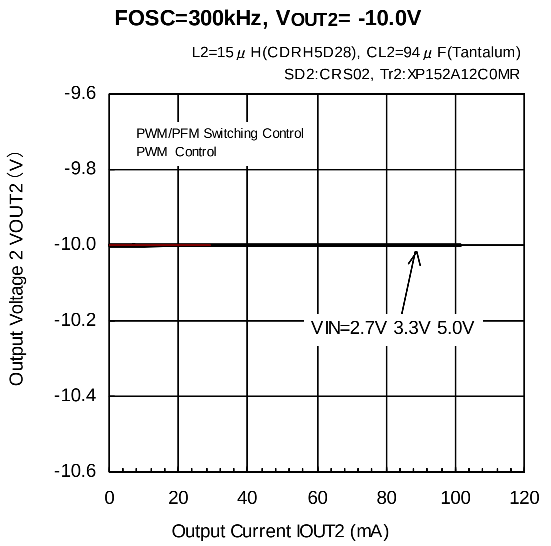
(4) Output Voltage vs. Output Current (Continued) (Tantalum capacitor use)

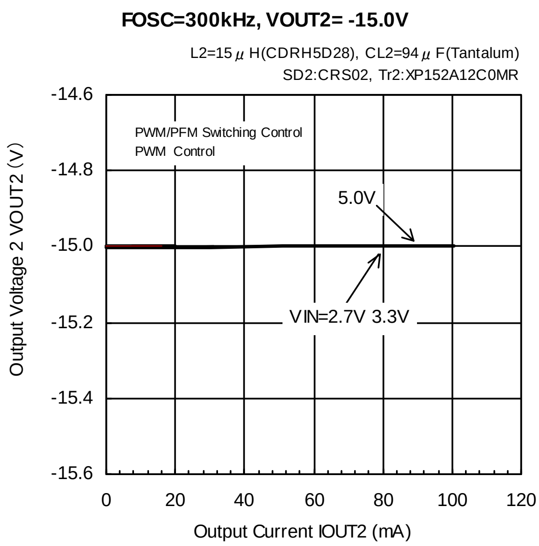


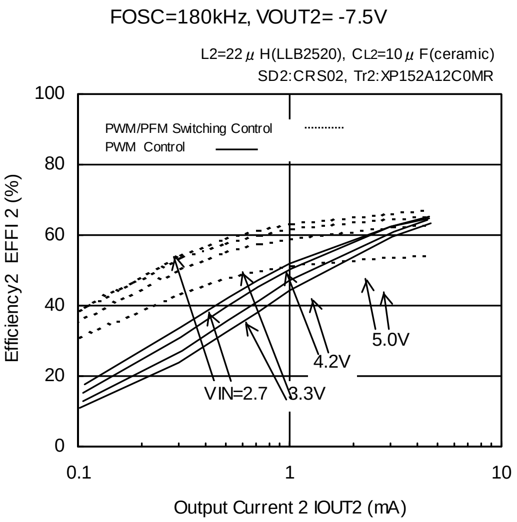



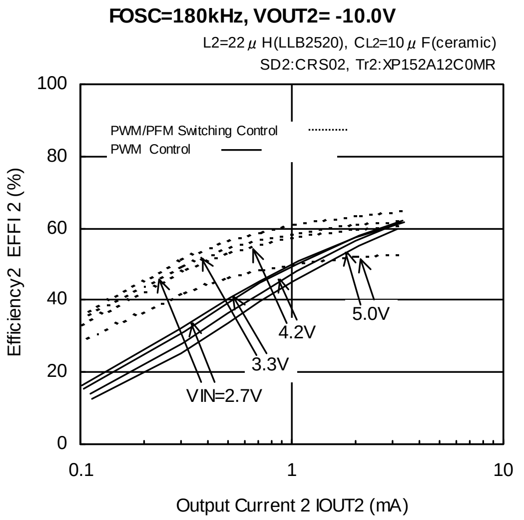



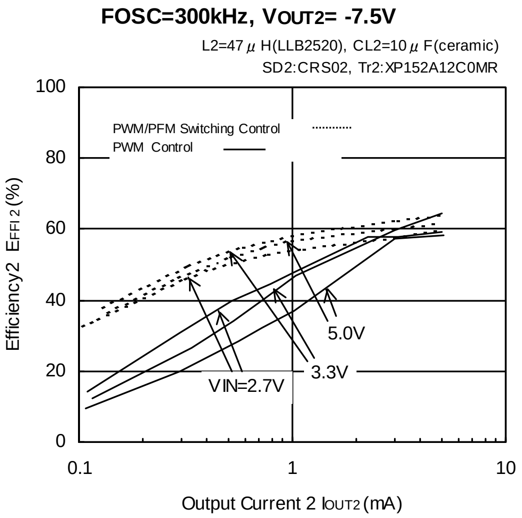
## ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

< 2 ch. Inverting DC/DC Controller > (Continued)

(5) Efficiency vs. Output Current (Ceramic capacitor and compact inductor use)



## ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

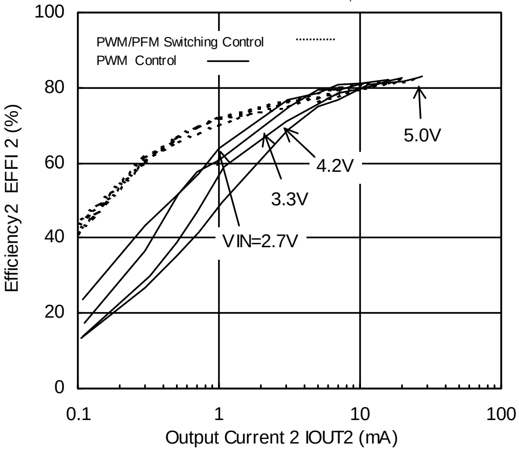
< 2 ch. Inverting DC/DC Controller > (Continued)

(5) Efficiency vs. Output Current (Continued)

(Ceramic capacitor use)

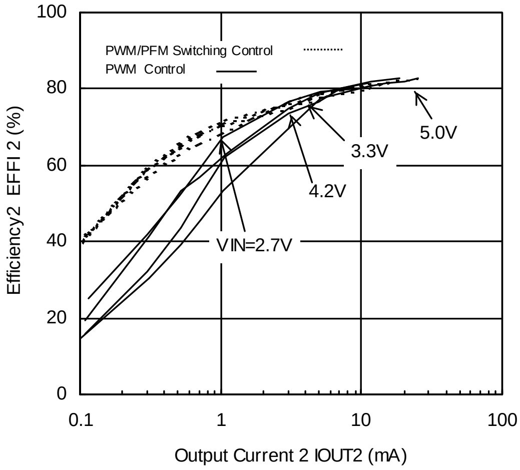
**FOSC=180kHz, VOUT2= -7.5V**

L2=100μH(CDRH4D18C), CL2=10μF(ceramic)
SD2:CRS02, Tr2:XP152A12C0MR



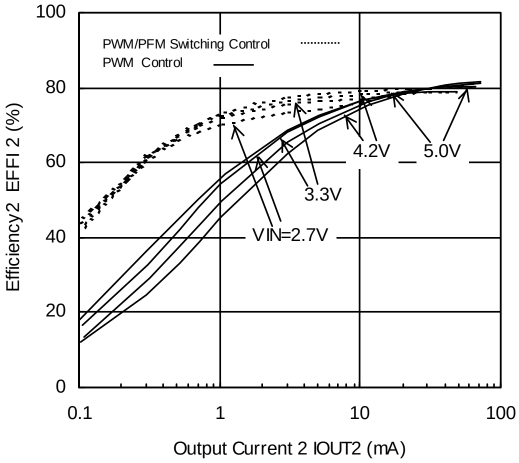

**FOSC=180kHz, VOUT2= -10.0V**

L2=100μH(CDRH4D18C), CL2=10μF(ceramic)
SD2:CRS02, Tr2:XP152A12C0MR



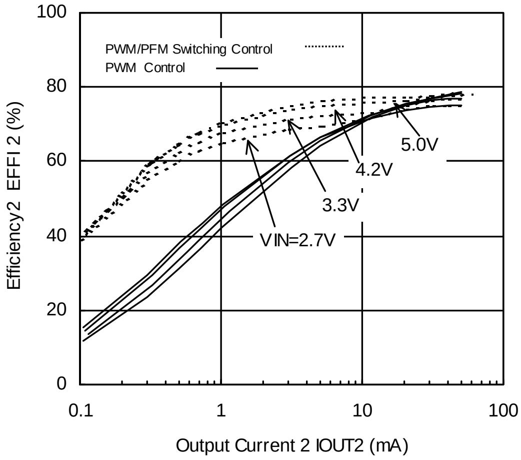

**FOSC=180kHz, VOUT2= -7.5V**

L2=22μH(CDRH4D18C), CL2=10μF(ceramic)
SD2:CRS02, Tr2:XP152A12C0MR




**FOSC=180kHz, VOUT2= -10.0V**

L2=15μH(CDRH4D18C), CL2=10μF(ceramic)
SD2:CRS02, Tr2:XP152A12C0MR



## ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

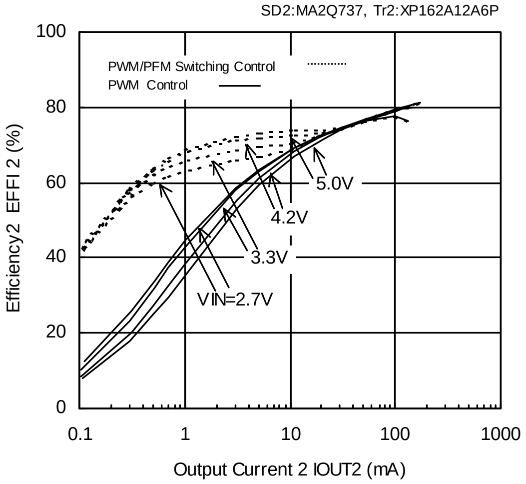
< 2 ch. Inverting DC/DC Controller > (Continued)

(5) Efficiency vs. Output Current (Continued)

(Tantalum capacitor use)

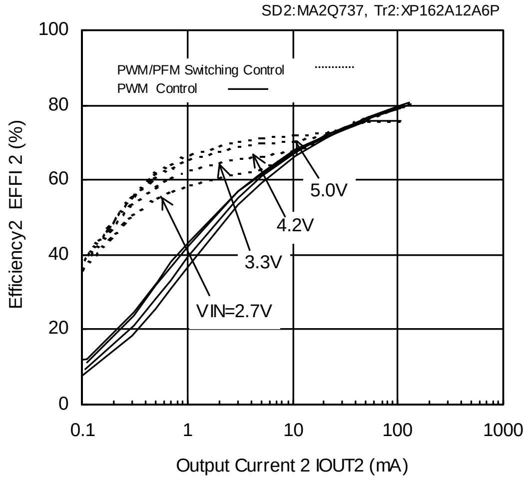
**FOSC=180kHz, VOUT2= -7.5V**

L2=22μH(CDRH5D28), CL2=94μF(Tantalum)
SD2:MA2Q737, Tr2:XP162A12A6P



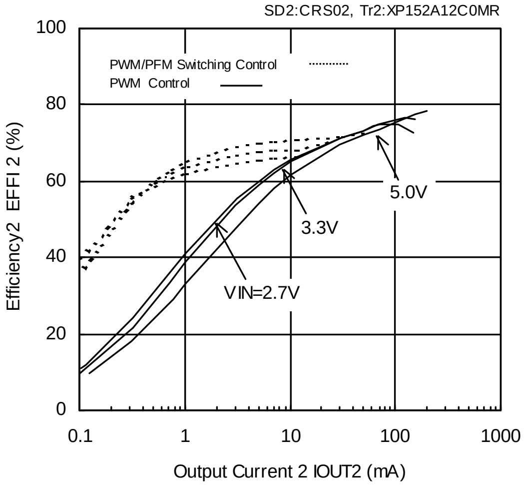

**FOSC=180kHz, VOUT2= -10.0V**

L2=22μH(CDRH5D28), CL2=94μF(Tantalum)
SD2:MA2Q737, Tr2:XP162A12A6P



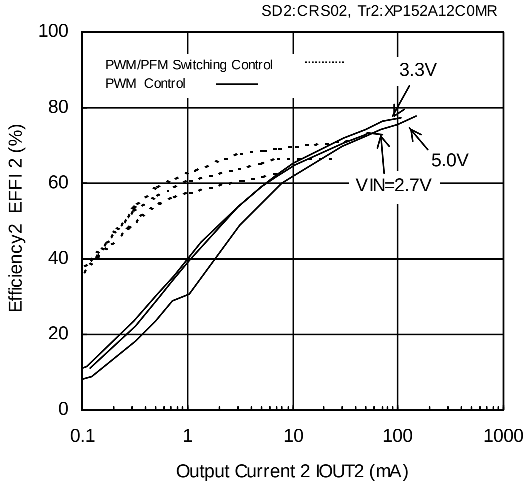

**FOSC=300kHz, VOUT2= -5.0V**

L2=15μH(CDRH5D28), CL2=94μF(Tantalum)
SD2:CRS02, Tr2:XP152A12C0MR



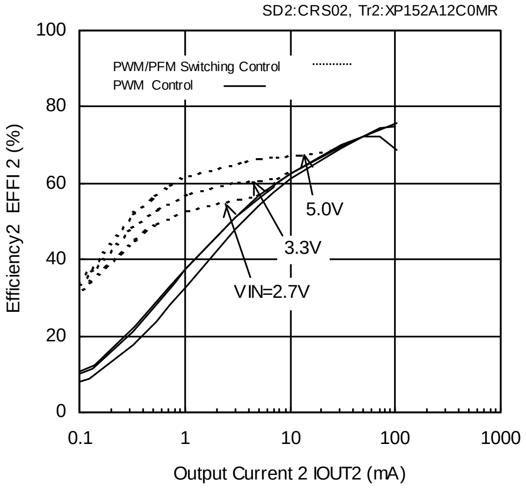

**FOSC=300kHz, VOUT2= -7.5V**

L2=15μH(CDRH5D28), CL2=94μF(Tantalum)
SD2:CRS02, Tr2:XP152A12C0MR



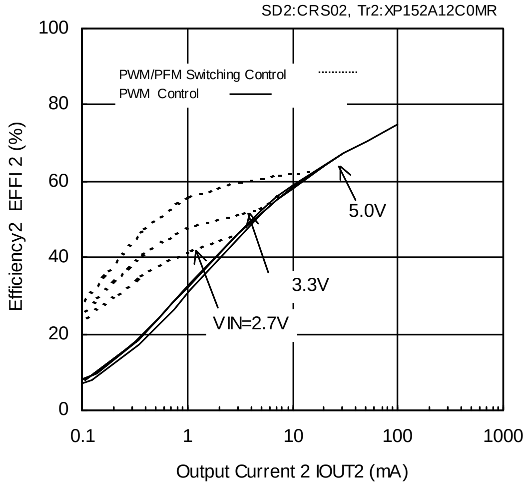

**FOSC=300kHz, VOUT2= -10.0V**

L2=15μH(CDRH5D28), CL2=94μF(Tantalum)
SD2:CRS02, Tr2:XP152A12C0MR




**FOSC=300kHz, VOUT2= -15.0V**

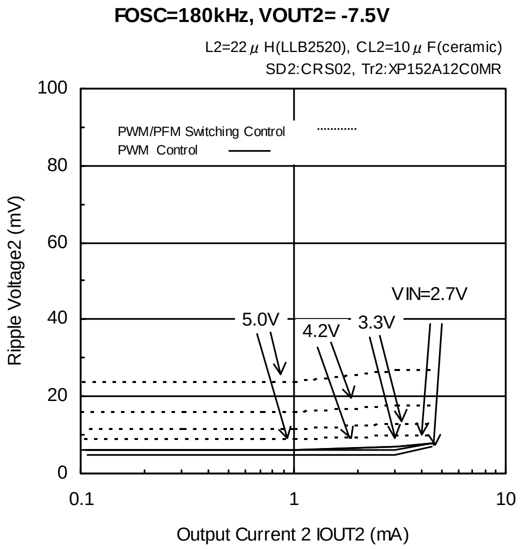
L2=15μH(CDRH5D28), CL2=94μF(Tantalum)
SD2:CRS02, Tr2:XP152A12C0MR

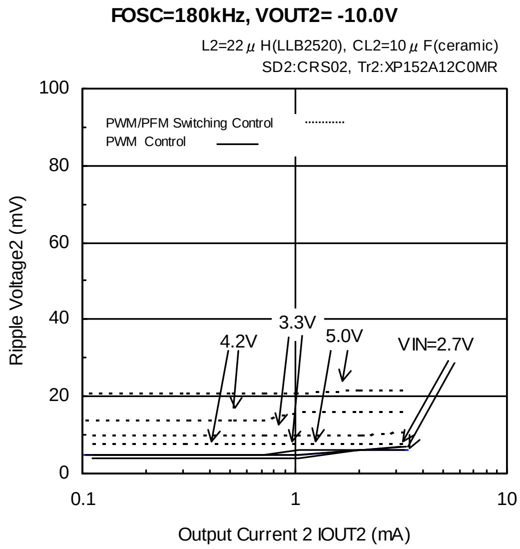


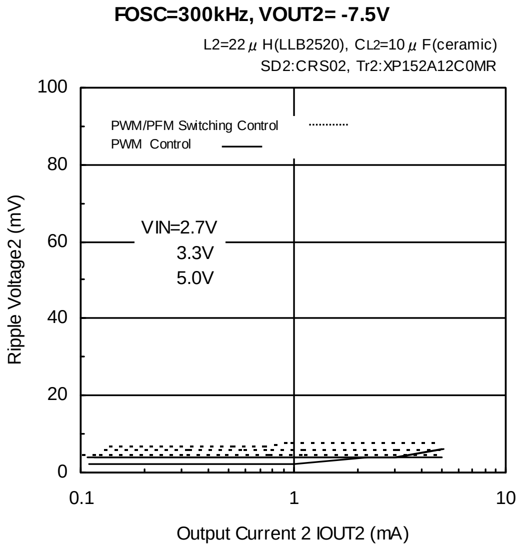
# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

< 2 ch. Inverting DC/DC Controller > (Continued)

(5) Ripple Voltage vs. Output Current (Ceramic capacitor and compact inductor use)



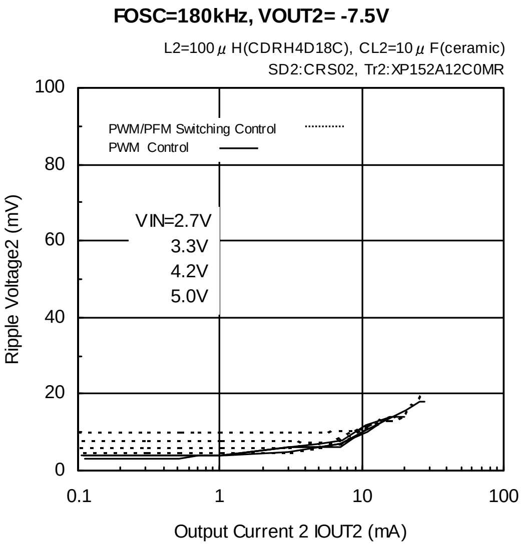



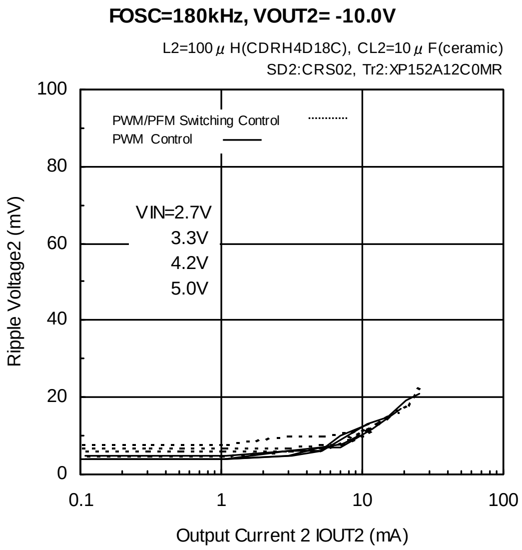



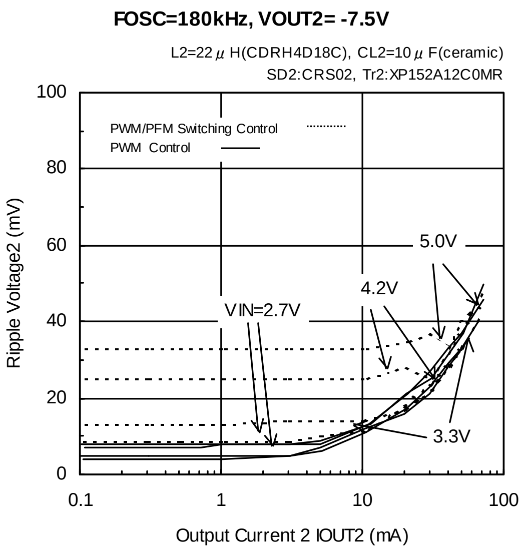
## ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

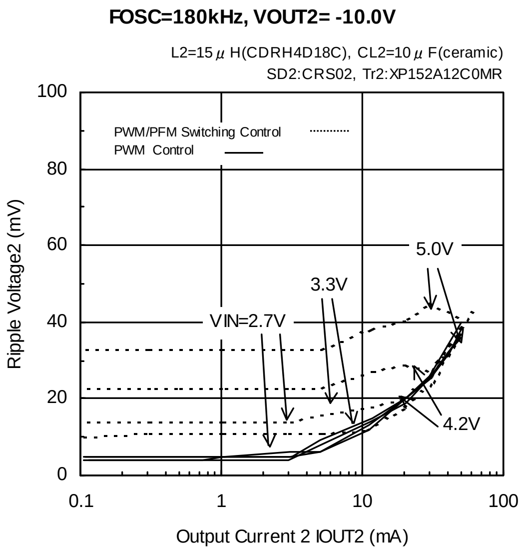
< 2 ch. Inverting DC/DC Controller > (Continued)

(5) Ripple Voltage vs. Output Current (Continued) (Ceramic capacitor use)



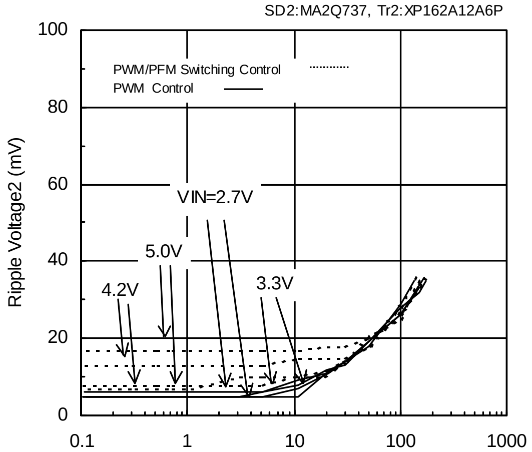
# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

< 2 ch. Inverting DC/DC Controller > (Continued)

(5) Ripple Voltage vs. Output Current (Continued) (Tantalum capacitor use)

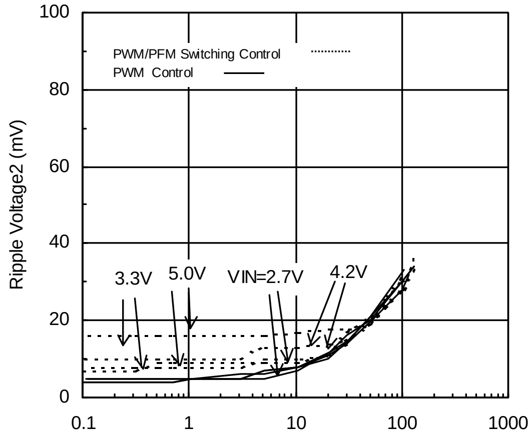
**FOSC=180kHz, VOUT2= -7.5V**

L2=22 μ H(CDRH5D28), CL2=94 μ F(Tantalum)
SD2:MA2Q737, Tr2:XP162A12A6P



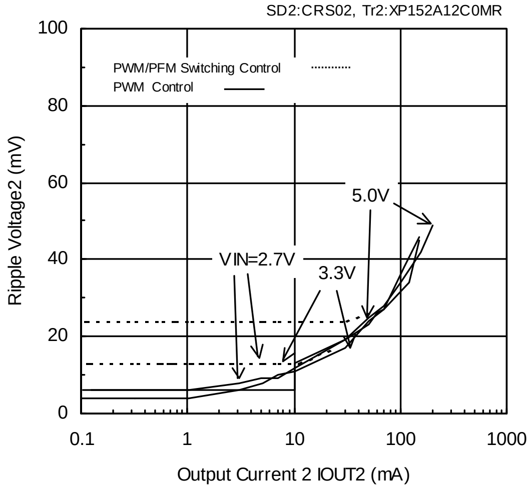

**FOSC=180kHz, VOUT2= -10.0V**

L2=22 μ H(CDRH5D28), CL2=94 μ F(Tantalum)
SD2:MA2Q737, Tr2:XP162A12A6P



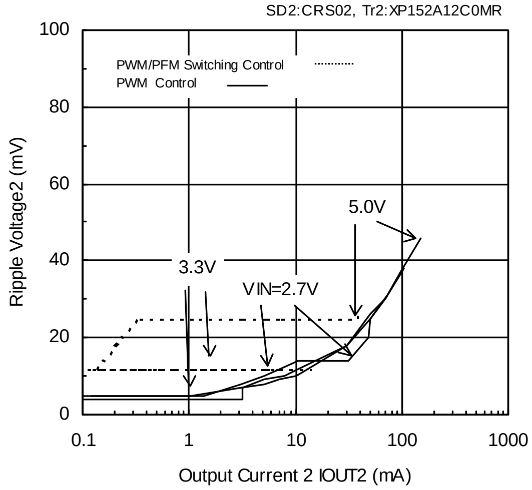

**FOSC=300kHz, VOUT2= -5.0V**

L2=15 μ H(CDRH5D28), CL2=94 μ F(Tantalum)
SD2:CRS02, Tr2:XP152A12C0MR



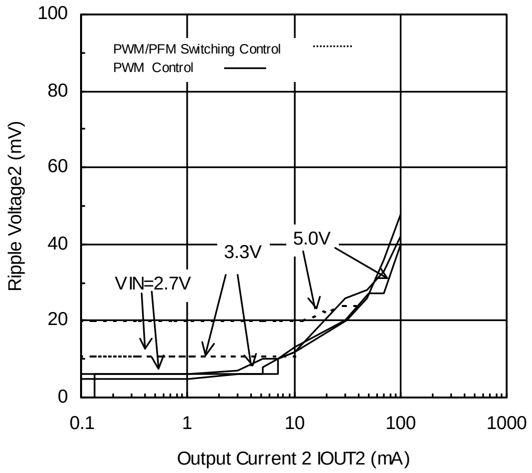

**FOSC=300kHz, VOUT2= -7.5V**

L2=15 μ H(CDRH5D28), CL2=94 μ F(Tantalum)
SD2:CRS02, Tr2:XP152A12C0MR



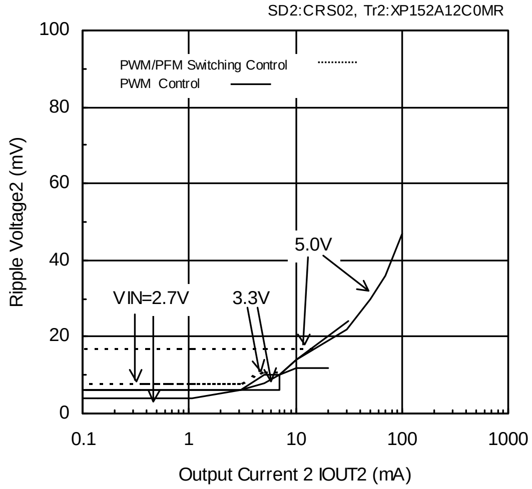

**FOSC=300kHz, VOUT2= -10.0V**

L2=15 μ H(CDRH5D28), CL2=94 μ F(Tantalum)
SD2:CRS02, Tr2:XP152A12C0MR




**FOSC=180kHz, VOUT2= -15.0V**

L2=15 μ H(CDRH5D28), CL2=94 μ F(Tantalum)
SD2:CRS02, Tr2:XP152A12C0MR

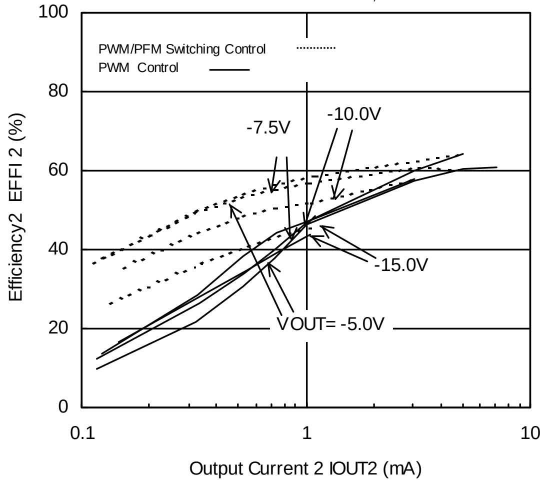


# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

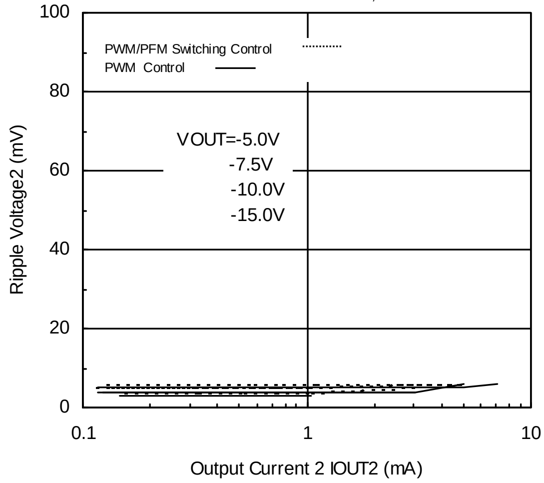
< 2 ch. Inverting DC/DC Controller > (Continued)

(6) Breakdown of Output Voltage

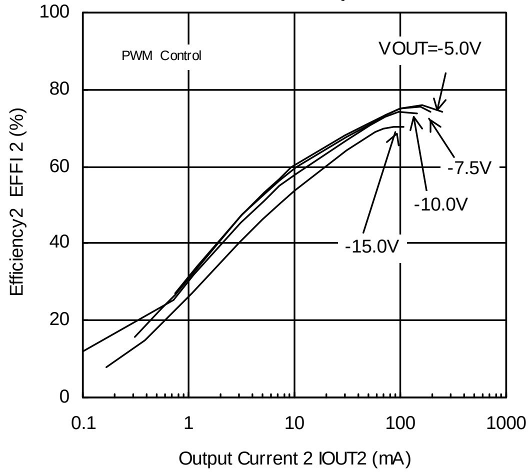
**FOSC=300kHz,VIN= 3.3V**
L2=47μH(LLB2520), CL2=10μF(ceramic)
SD2:CRS02, Tr2:XP152A12C0MR



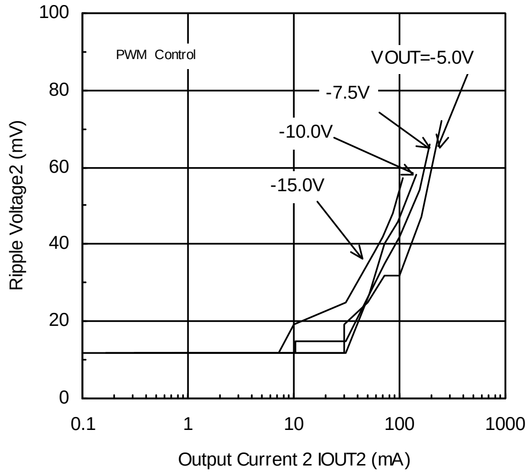

**FOSC=300kHz,VIN= 3.3V**
L2=47μH(LLB2520), CL2=10μF(ceramic)
SD2:CRS02, Tr2:XP152A12C0MR



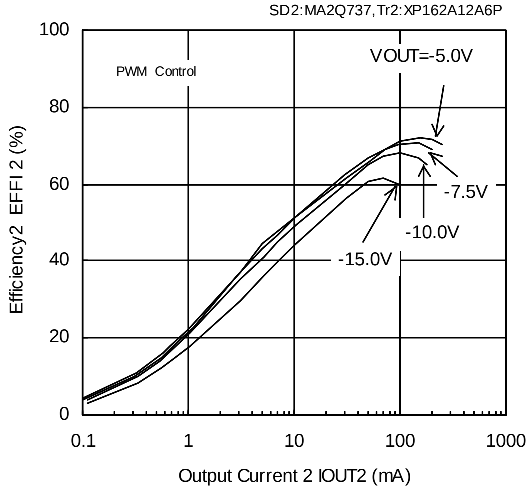

**FOSC=300kHz,VIN= 3.3V**
L2=15μH(CDRH5D28), CL2=94μF(Tantalum)
SD2:MA2Q737,Tr2:XP162A12A6P



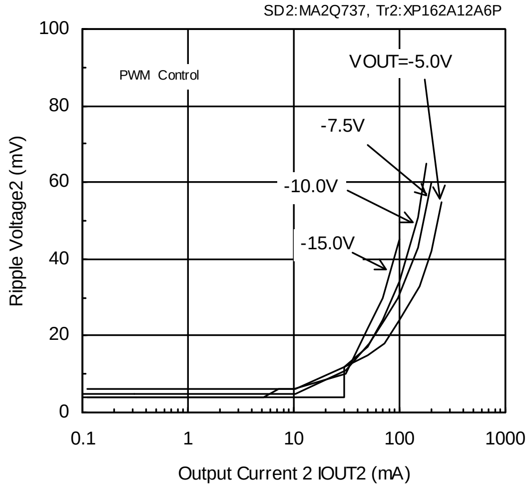

**FOSC=300kHz,VIN= 3.3V**
L2=15μH(CDRH5D28), CL2=94μF(Tantalum)
SD2:MA2Q737, Tr2:XP162A12A6P




**FOSC=500kHz,VIN= 3.3V**
L2=10μH(CDRH5D28), CL2=94μF(Tantalum)
SD2:MA2Q737,Tr2:XP162A12A6P



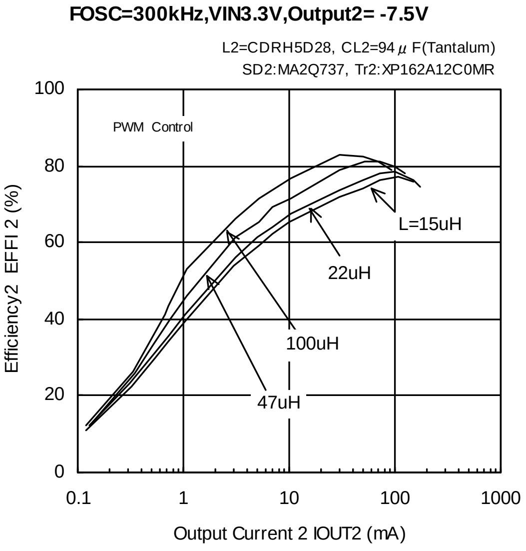

**FOSC=500kHz,VIN= 3.3V**
L2=10μH(CDRH5D28), CL2=94μF(Tantalum)
SD2:MA2Q737, Tr2:XP162A12A6P

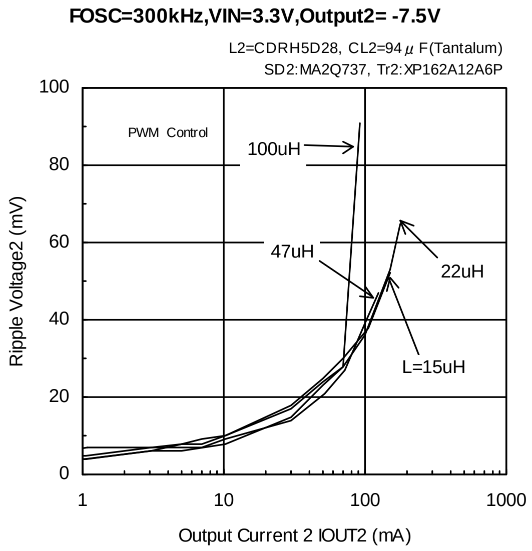


# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

< 2 ch. Inverting DC/DC Controller > (Continued)

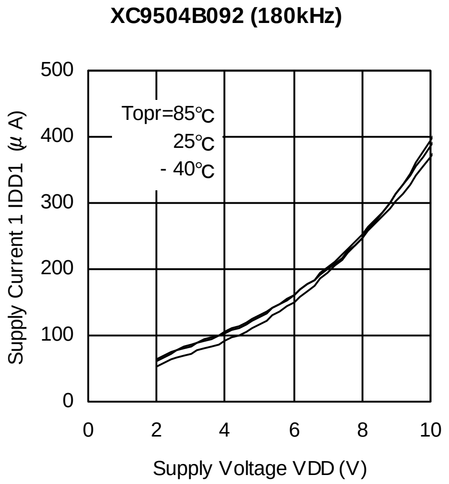
(7) Breakdown of Coil Inductance Value



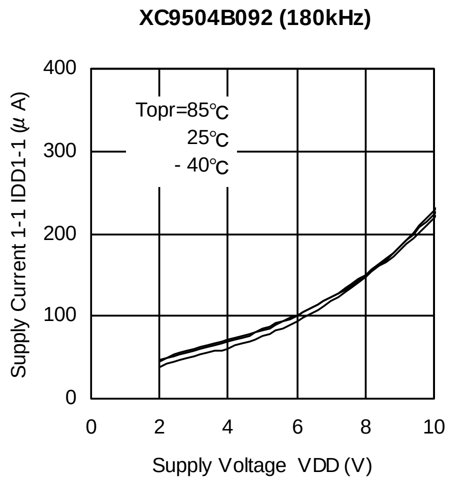



## ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

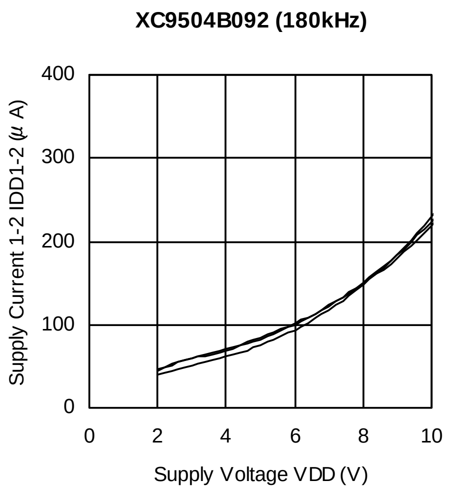
(8) Supply Current vs. Supply Voltage



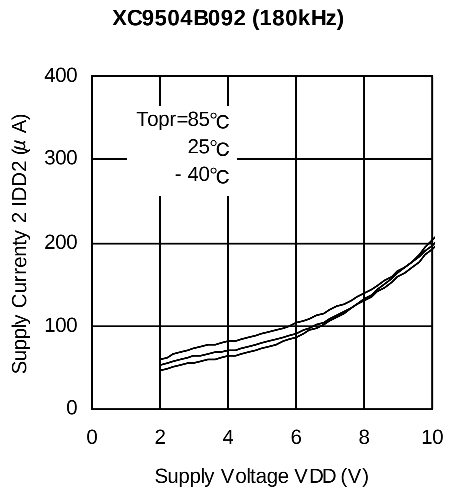

(9) Supply Current vs. Supply Voltage



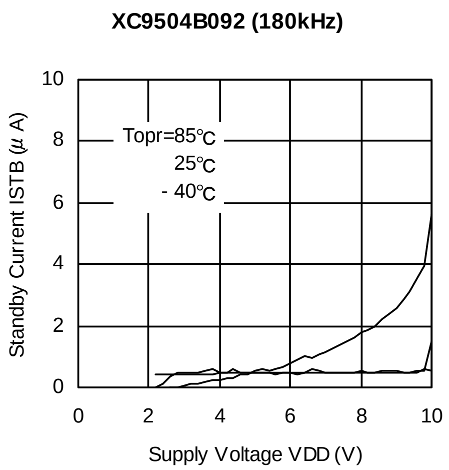

(10) Supply Current 1-2 vs. Supply Voltage



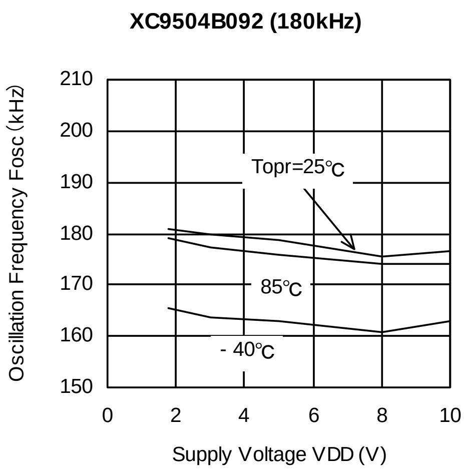

(11) Supply Current 2 vs. Supply Voltage




(12) Standby Current vs. Supply Voltage

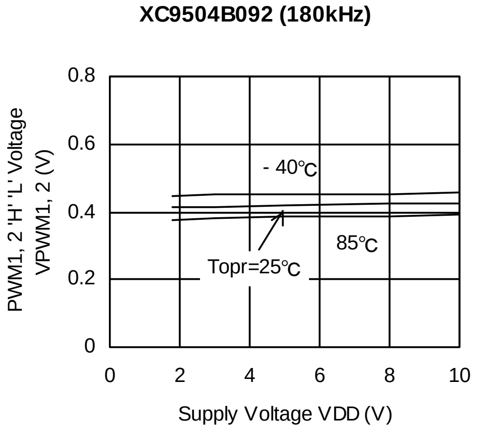



(13) Oscillation Frequency vs. Supply Voltage

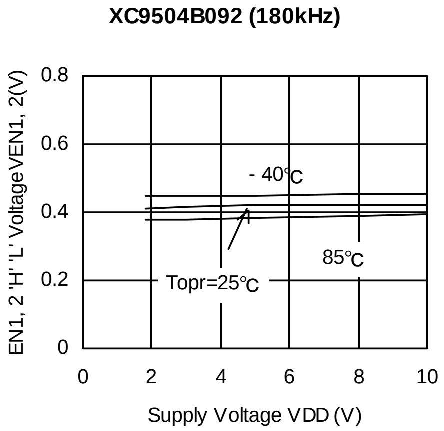


## ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

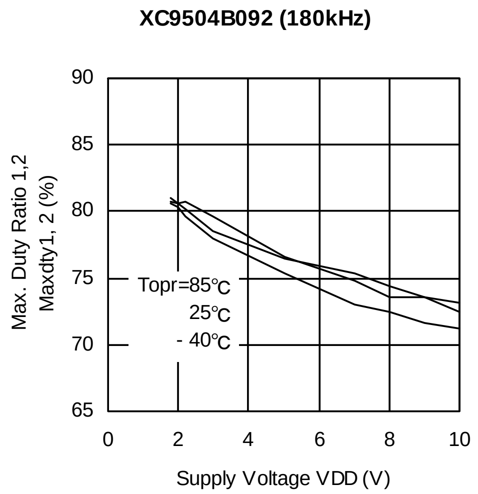
(14) PWM1, 2 'H''L' Voltage vs. Supply Voltage



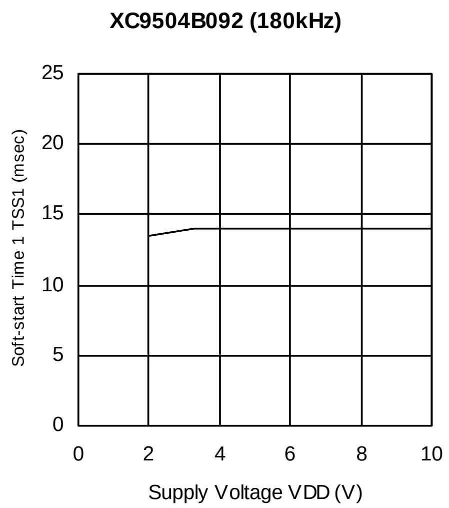

(15) EN1, 2 'H''L' Voltage vs. Supply Voltage



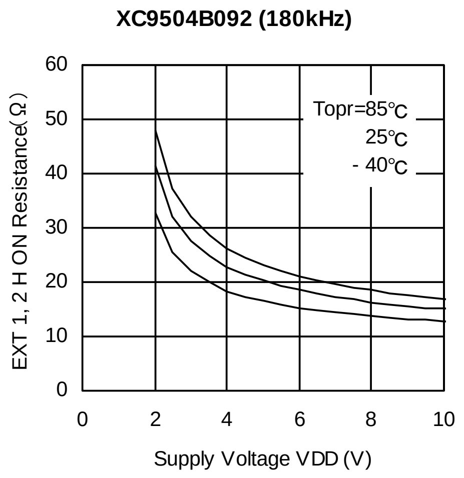

(16) Maximum Duty Ratio 1, 2 vs. Supply Voltage



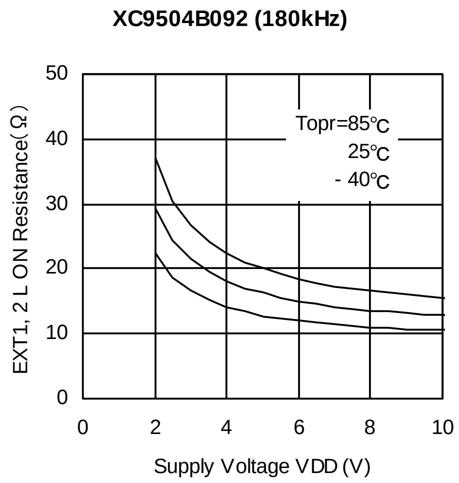

(17) Soft-Start Time 1 vs. Supply Voltage




(18) EXT1, 2 High ON Resistance vs. Supply Voltage

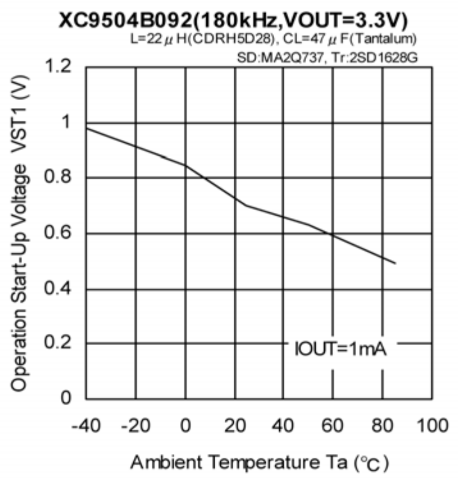



(19) EXT1, 2 Low ON Resistance vs. Supply Voltage

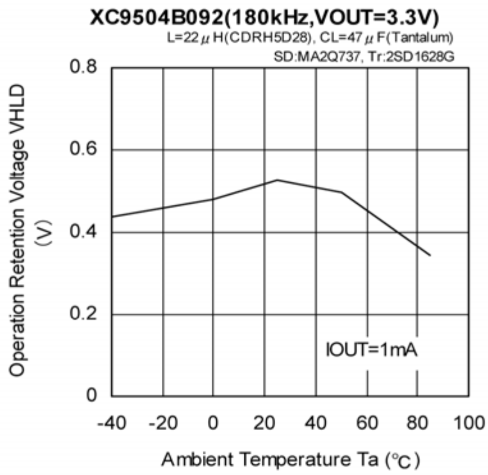


## ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

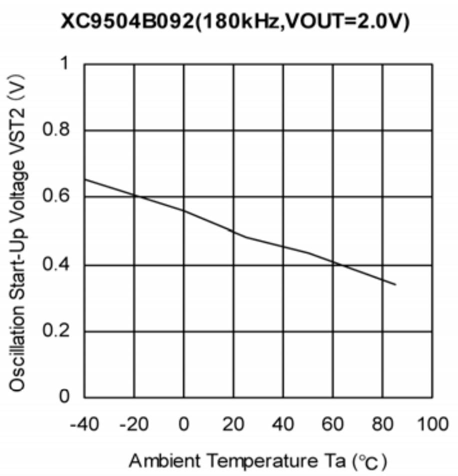
(20) Operation Start Voltage vs. Ambient Temperature



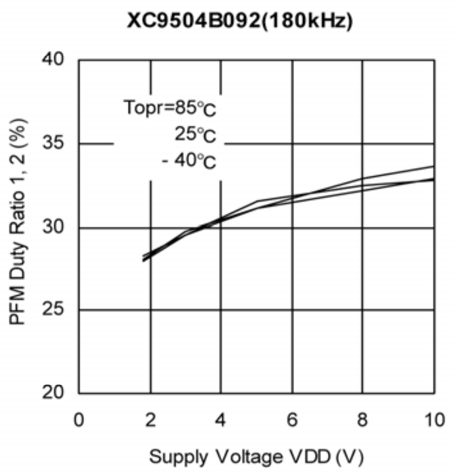

(21) Operation Retention Voltage vs. Ambient Temperature



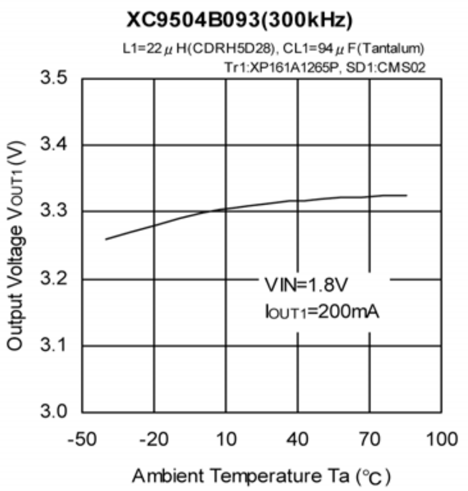

(22) Oscillation Start Voltage vs. Ambient Temperature




(23) PFM Duty Ratio1, 2 vs. Supply Voltage




(24) Output Voltage vs. Ambient Temperature



## ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

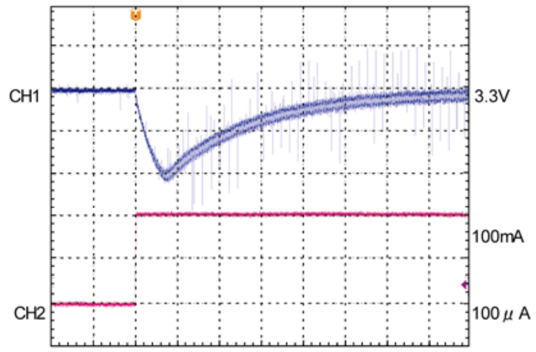
< 1 ch. Step-Up DC/DC Controller >

(25) Load Transient Response (Tantalum capacitor use)

< $V_{OUT1}$ = 3.3V, $V_{IN}$ = 2.0V, $I_{OUT1}$ =100 μ A ⇔ 100mA >

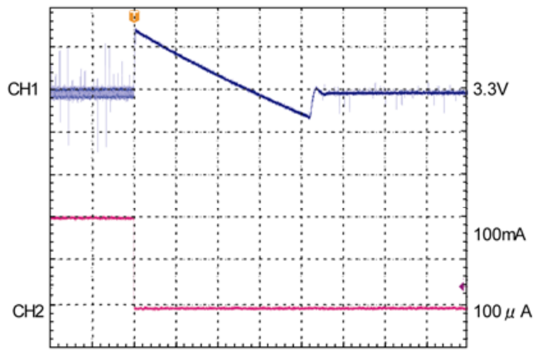
● PWM Control

FOSC=180kHz, $V_{OUT1}$=3.3V
VIN=2.0V, IOUT1=100 μ A→ 100mA




200 μ sec/div
CH1:$V_{OUT1}$ , AC-COUPLED, 50mV/div
CH2:$I_{OUT1}$ , 50mA/div

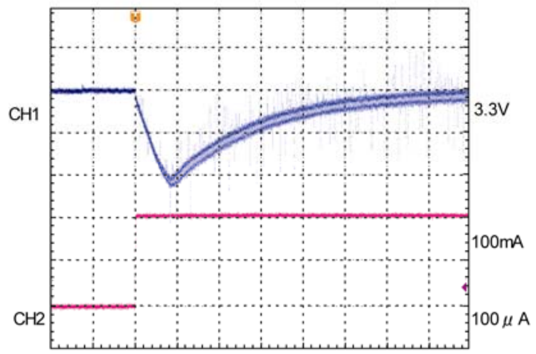
FOSC=180kHz, $V_{OUT1}$=3.3V
VIN=2.0V, IOUT1=100mA→ 100 μ A




10msec/div
CH1:$V_{OUT1}$ , AC-COUPLED, 50mV/div
CH2:$I_{OUT1}$ , 50mA/div

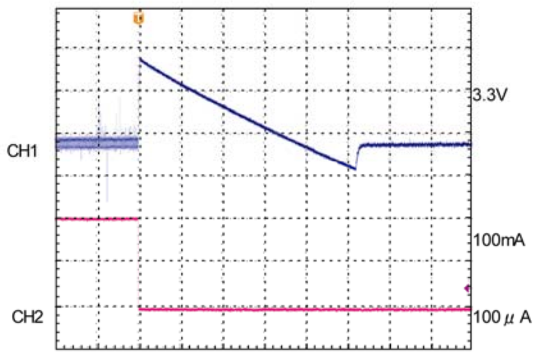
● PWM/PFM Switching Control

FOSC=180kHz, $V_{OUT1}$=3.3V
VIN=2.0V, IOUT1=100 μ A→ 100mA




200 μ sec/div
CH1:$V_{OUT1}$ , AC-COUPLED, 50mV/div
CH2:$I_{OUT1}$ , 50mA/div

FOSC=180kHz, $V_{OUT1}$=3.3V
VIN=2.0V, IOUT1=100mA→ 100 μ A




10msec/div
CH1:$V_{OUT1}$ , AC-COUPLED, 50mV/div
CH2:$I_{OUT1}$ , 50mA/div

## ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

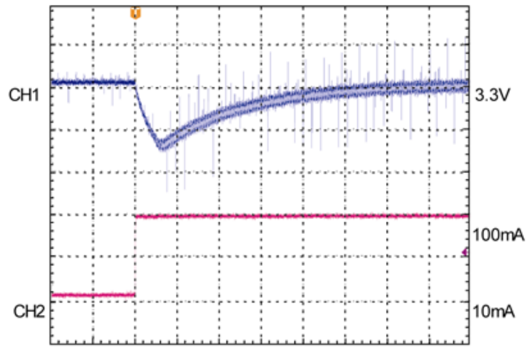
< 1 ch. Step-Up DC/DC Controller > (Continued)

(25) Load Transient Response (Continued) (Tantalum capacitor use)

< $V_{OUT1}$ = 3.3V, $V_{IN}$ = 2.0V, $I_{OUT1}$ =10mA ⇔ 100mA >

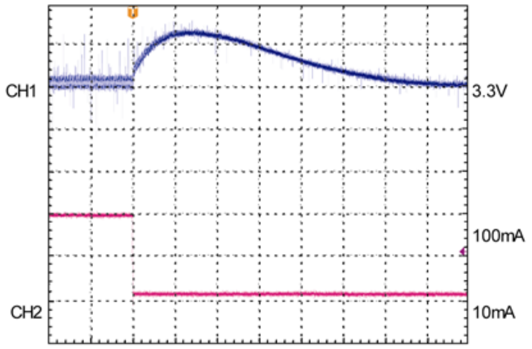
● PWM Control

FOSC=180kHz, VOUT1=3.3V
VIN=2.0V, IOUT1=10mA→ 100mA




200μ sec/div
CH1:VOUT1 , AC-COUPLED, 50mV/div
CH2:IOUT1 , 50mA/div

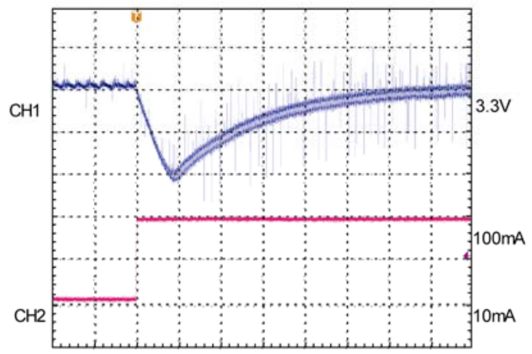
FOSC=180kHz, VOUT1=3.3V
VIN=2.0V, IOUT1=100mA→ 10mA




200μ sec/div
CH1:VOUT1 , AC-COUPLED, 50mV/div
CH2:IOUT1 , 50mA/div

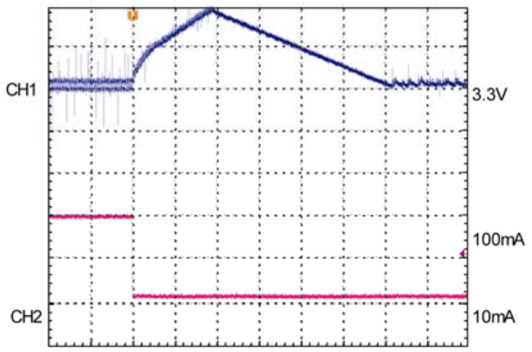
● PWM/PFM Switching Control

FOSC=180kHz, VOUT1=3.3V
VIN=2.0V, IOUT1=10mA→ 100mA




200μ sec/div
CH1:VOUT1 , AC-COUPLED, 50mV/div
CH2:IOUT1 , 50mA/div

FOSC=180kHz, VOUT1=3.3V
VIN=2.0V, IOUT1=100mA→ 10mA




200μ sec/div
CH1:VOUT1 , AC-COUPLED, 50mV/div
CH2:IOUT1 , 50mA/div

# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

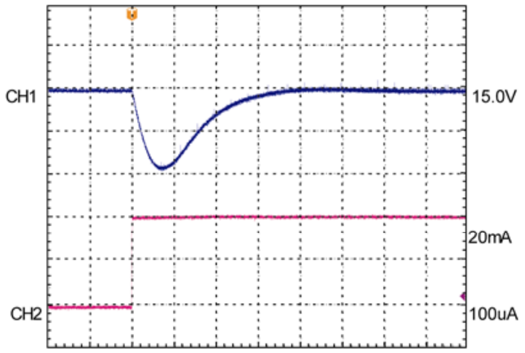
< 1 ch. Step-Up DC/DC Controller > (Continued)

(25) Load Transient Response (Continued) (Ceramic capacitor use when coil current is discontinuous. )

< VOUT1 = 15.0V, VIN = 3.3V, IOUT1 =100 μ A ⇔ 20mA >

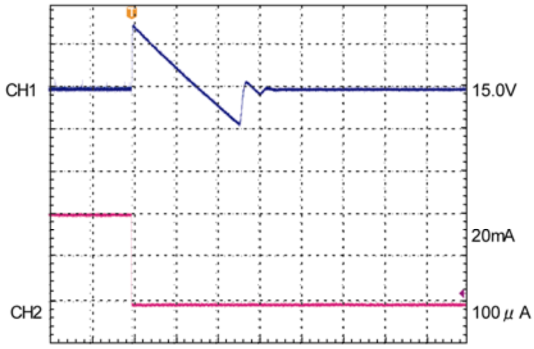
● PWM Control

FOSC=180kHz, VOUT1=15.0V
VIN=3.3V, IOUT1=100 μ A→ 20mA




400 μ sec/div
CH1:VOUT1 , AC-COUPLED, 200mV/div
CH2:IOUT1 , 10mA/div

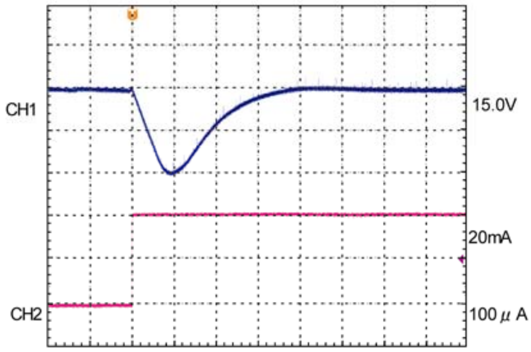
FOSC=180kHz, VOUT1=15.0V
VIN=3.3V, IOUT1=20mA→ 100 μ A




10msec/div
CH1:VOUT1 , AC-COUPLED, 200mV/div
CH2:IOUT1 , 10mA/div

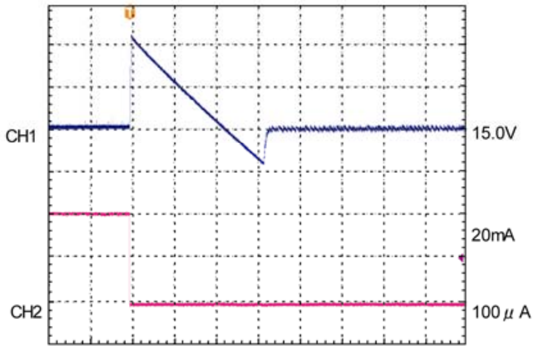
● PWM/PFM Switching Control

FOSC=180kHz, VOUT1=15.0V
VIN=3.3V, IOUT1=100 μ A→ 20mA




400 μ sec/div
CH1:VOUT1 , AC-COUPLED, 200mV/div
CH2:IOUT1 , 10mA/div

FOSC=180kHz, VOUT1=15.0V
VIN=3.3V, IOUT1=20mA→ 100 μ A




10msec/div
CH1:VOUT1 , AC-COUPLED, 200mV/div
CH2:IOUT1 , 10mA/div

## ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

< 1 ch. Step-Up DC/DC Controller > (Continued)

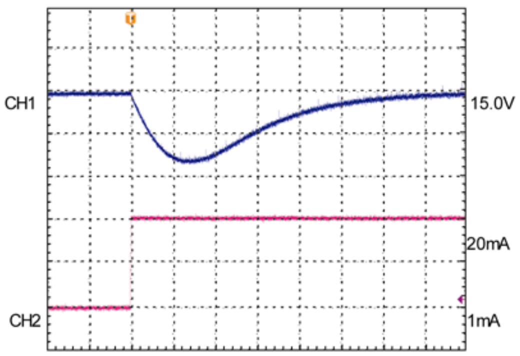
(25) Load Transient Response (Continued)

(Ceramic capacitor use when coil current is discontinuous. )

< $V_{OUT1}$ = 15.0V, $V_{IN}$ = 3.3V, $I_{OUT1}$ =1mA ⇔ 20mA >

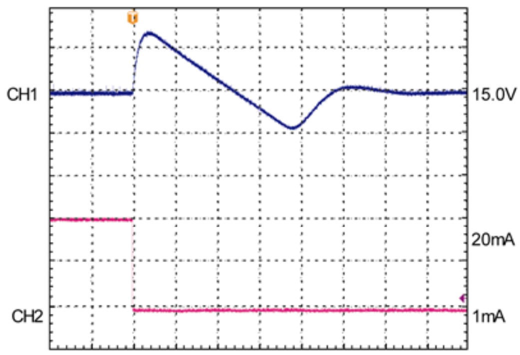
● PWM Control

FOSC=180kHz, VOUT1=15.0V
VIN=3.3V, IOUT1=1mA→ 20mA




200 µ sec/div
CH1:$V_{OUT1}$ , AC-COUPLED, 200mV/div
CH2:$I_{OUT1}$ , 10mA/div

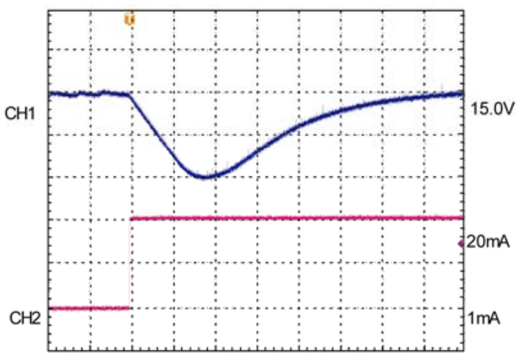
FOSC=180kHz, VOUT1=15.0V
VIN=3.3V, IOUT1=20mA→ 1mA




1msec/div
CH1:$V_{OUT1}$ , AC-COUPLED, 200mV/div
CH2:$I_{OUT1}$ , 10mA/div

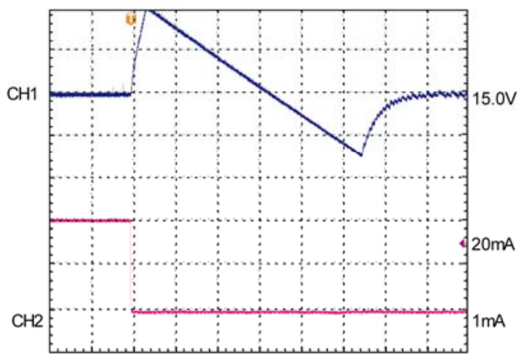
● PWM/PFM Switching Control

FOSC=180kHz, VOUT1=15.0V
VIN=3.3V, IOUT1=1mA→ 20mA




200 µ sec/div
CH1:$V_{OUT1}$ , AC-COUPLED, 20mV/div
CH2:$I_{OUT1}$ , 10mA/div

FOSC=180kHz, VOUT1=15.0V
VIN=3.3V, IOUT1=20mA→ 1mA




1msec/div
CH1:$V_{OUT1}$ , AC-COUPLED, 200mV/div
CH2:$I_{OUT1}$ , 10mA/div

# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

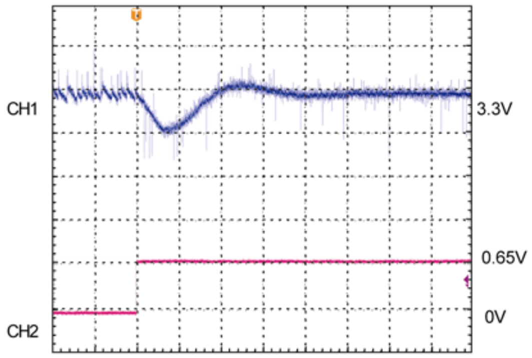
< 1 ch. Step-Up DC/DC Controller > (Continued)

(25) Load Transient Response (Continued)

(Ceramic capacitor use when coil current is discontinuous. )

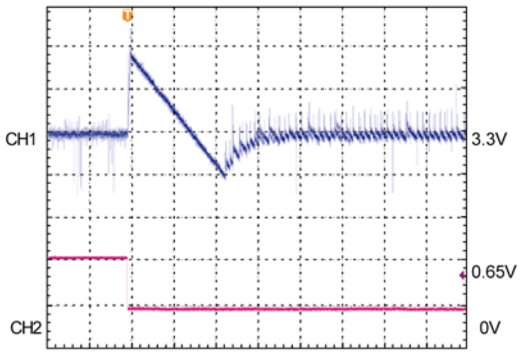
< PWM Control ⇔ PWM / PFM Switching Control >

FOSC=180kHz, $V_{OUT1}$=3.3V
VIN=2.0V, IOUT1=1mA PWM1 'L' → 'H'




1msec/div
CH1:$V_{OUT1}$ , AC-COUPLED ,10mV/div
CH2:PWM1 , 0.5V/div

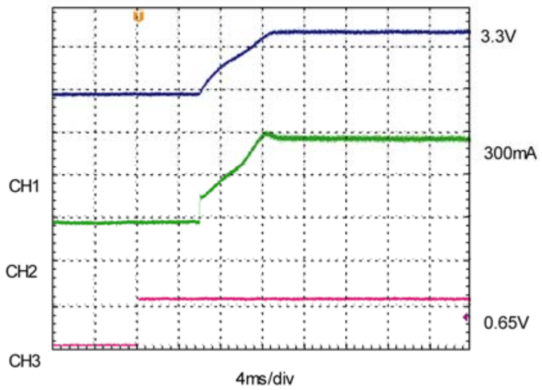
FOSC=180kHz, $V_{OUT1}$=3.3V
VIN=2.0V, IOUT1=1mA PWM1 'H'→'L'




1msec/div
CH1:VOUT1, AC-COUPLED ,10mV/div
CH2:PWM1, 0.5V/div

<Soft-start Wave Form>

FOSC=180kHz, $V_{OUT1}$=3.3V
VIN=2.0V, IOUT1=100mA EN1 'L'→'H',CIN=47 μ F




4ms/div
CH1:$V_{OUT1}$, 1.0V/div
CH2:$I_{IN1}$, 100mA/div
CH3:EN1, 0.5V/div

* EN2=GND

## ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

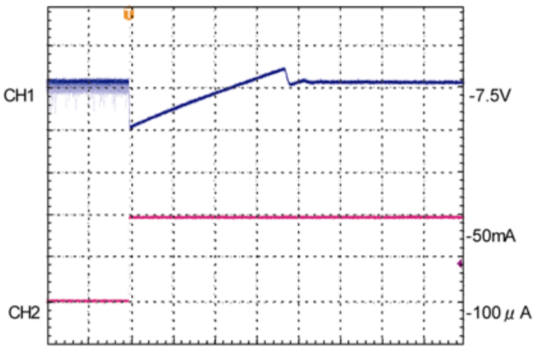
< 2 ch. Inverting DC/DC Controller >

(25) Load Transient Response (Continued) (Tantalum capacitor use)

< $V_{OUT2}$ = -7.5V, $V_{IN}$ = 3.3V, $I_{OUT2}$ =100uA ⇔ -50mA >

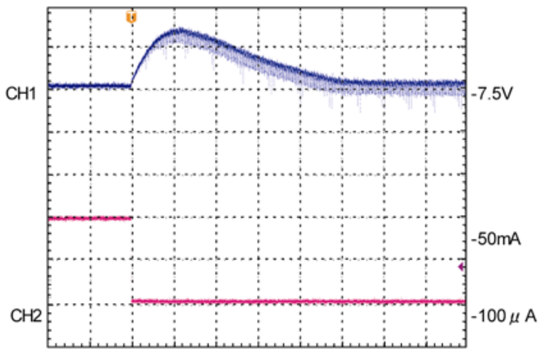
● PWM Control

FOSC=180kHz, VOUT2=-7.5V
VIN=3.3V, IOUT2=-100 μ A→ -50mA




10msec/div
CH1:VOUT2 , AC-COUPLED, 50mV/div
CH2:IOUT2 , 50mA/div

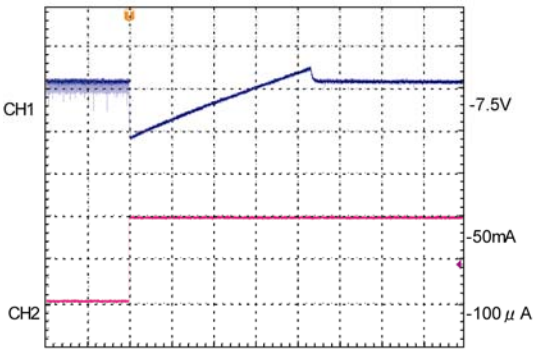
FOSC=180kHz, VOUT2=-7.5V
VIN=3.3V, IOUT2=-50mA→ -100 μ A




200 μ sec/div
CH1:VOUT2 , AC-COUPLED, 50mV/div
CH2:IOUT2 , 50mA/div

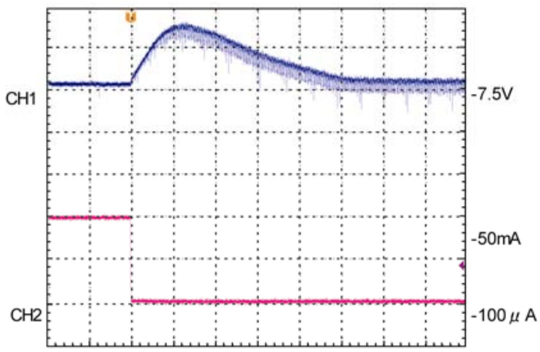
● PWM/PFM Switching Control

FOSC=180kHz, VOUT2=-7.5V
VIN=3.3V, IOUT2=-100 μ A→ -50mA




10msec/div
CH1:VOUT2 , AC-COUPLED, 50mV/div
CH2:IOUT2 , 50mA/div

FOSC=180kHz, VOUT2=-7.5V
VIN=3.3V, IOUT2=-50mA→ -100 μ A




200 μ sec/div
CH1:VOUT2 , AC-COUPLED, 50mV/div
CH2:IOUT2 , 50mA/div

# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

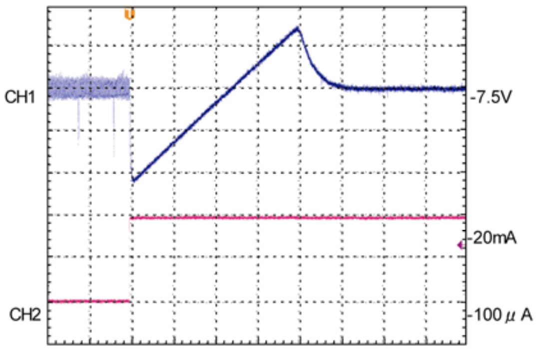
< 2 ch. Inverting DC/DC Controller > (Continued)

(25) Load Transient Response (Continued) (Ceramic capacitor Use when coil current is discontinuous. )

< $V_{OUT2}$ = -7.5V, $V_{IN}$ = 3.3V, $I_{OUT2}$ =100uA ⇔ - 20mA >

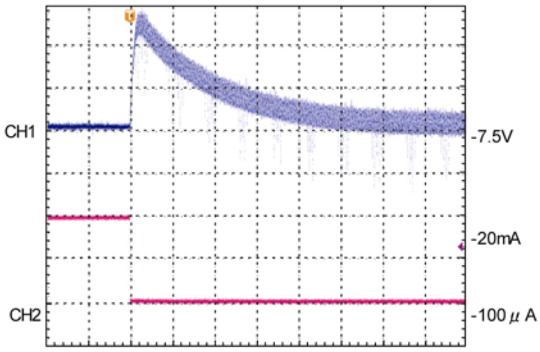
● PWM Control

FOSC=180kHz, $V_{OUT2}$=-7.5V
VIN=3.3V, IOUT2=-100 μ A→ -20mA




1msec/div
CH1:$V_{OUT2}$ , AC-COUPLED, 20mV/div
CH2:$I_{OUT2}$ , 10mA/div

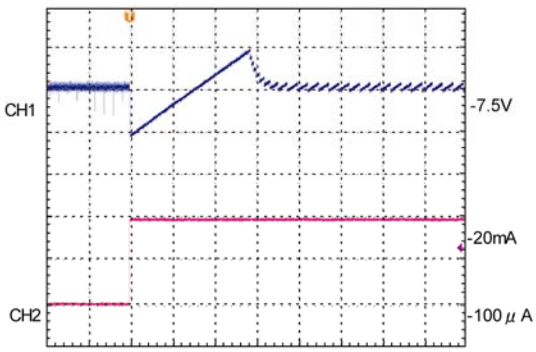
FOSC=180kHz, $V_{OUT2}$=-7.5V
VIN=3.3V, IOUT2=-20mA→ -100 μ A




200 μ sec/div
CH1:$V_{OUT2}$ , AC-COUPLED, 20mV/div
CH2:$I_{OUT2}$ , 10mA/div

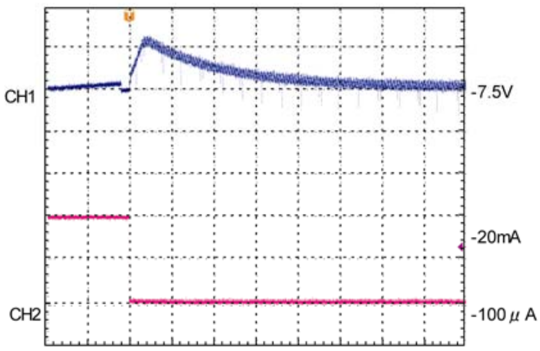
● PWM/PFM Switching Control

FOSC=180kHz, $V_{OUT2}$=-7.5V
VIN=3.3V, IOUT2=-100 μ A→ -20mA




2msec/div
CH1:$V_{OUT2}$ , AC-COUPLED, 50mV/div
CH2:$I_{OUT2}$ , 10mA/div

FOSC=180kHz, $V_{OUT2}$=-7.5V
VIN=3.3V, IOUT2=-20mA→ -100 μ A




200 μ sec/div
CH1:$V_{OUT2}$ , AC-COUPLED, 50mV/div
CH2:$I_{OUT2}$ , 10mA/div

## ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

< 2 ch. Inverting DC/DC Controller > (Continued)

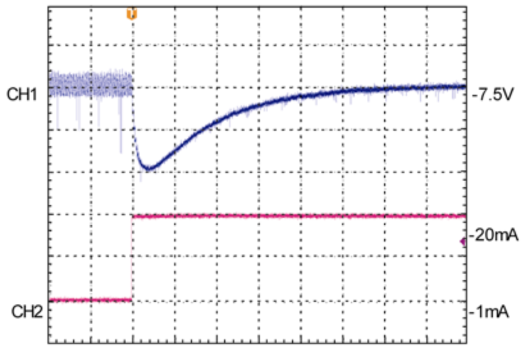
(25) Load Transient Response (Continued)

(Ceramic capacitor use when coil current is discontinuous. )

< $V_{OUT2}$ = -7.5V, $V_{IN}$ = 3.3V, $I_{OUT2}$ =1mA ⇔ - 20mA >

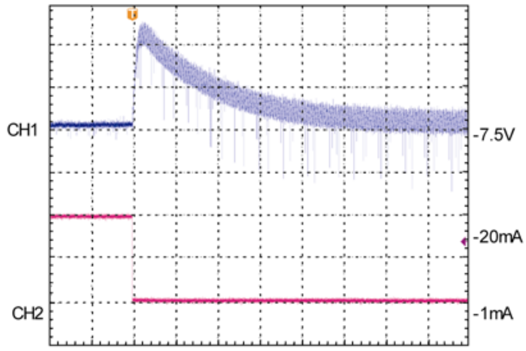
● PWM Control

FOSC=180kHz, VOUT2=-7.5V
VIN=3.3V, IOUT2=-1mA→ -20mA




200 μ sec/div
CH1:VOUT2 , AC-COUPLED, 20mV/div
CH2:IOUT2 , 10mA/div

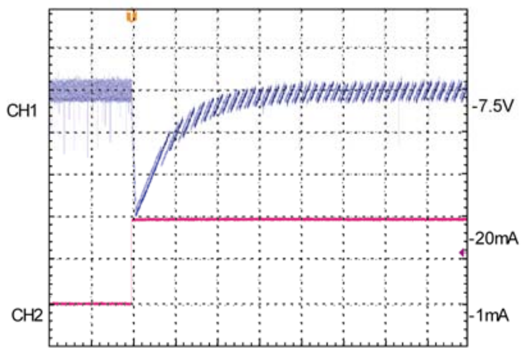
FOSC=180kHz, VOUT2=-7.5V
VIN=3.3V, IOUT2=-20mA→ -1mA




200 μ sec/div
CH1:VOUT2 , AC-COUPLED, 20mV/div
CH2:IOUT2 , 10mA/div

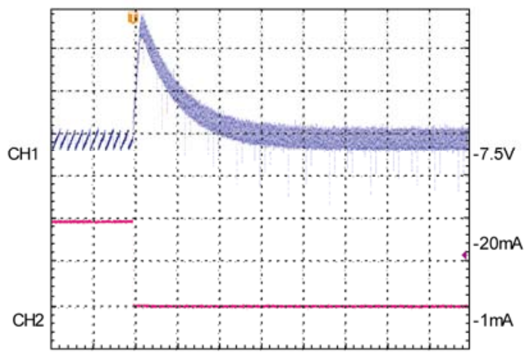
● PWM/PFM Switching Control

FOSC=180kHz, VOUT2=-7.5V
VIN=3.3V, IOUT2=-1mA→ -20mA




400 μ sec/div
CH1:VOUT2 , AC-COUPLED, 20mV/div
CH2:IOUT2 , 10mA/div

FOSC=180kHz, VOUT2=-7.5V
VIN=3.3V, IOUT2=-20mA→ -1mA




400 μ sec/div
CH1:VOUT2 , AC-COUPLED, 20mV/div
CH2:IOUT2 , 10mA/div

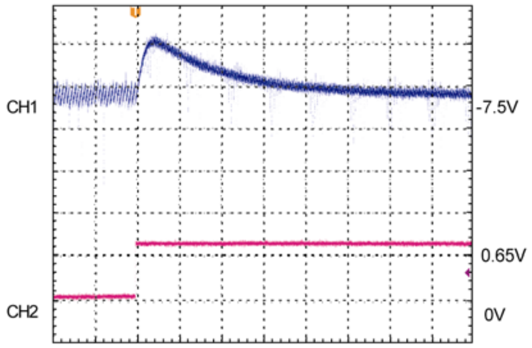
# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

< 2 ch. Inverting DC/DC Controller > (Continued)

(25) Load Transient Response (Continued) (Ceramic capacitor use when coil current is discontinuous. )

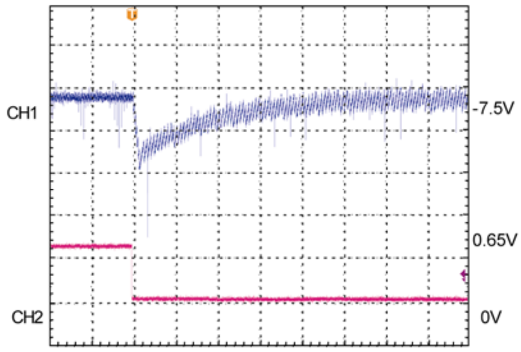
< PWM Control ⇔ PWM / PFM Switching Control >

FOSC=180kHz, VOUT2= - 7.5V
VIN=3.3V, IOUT2=-5mA PWM2 'L'→'H'




200 $\mu$ sec/div
CH1:VOUT2 , AC-COUPLED ,20mV/div
CH2:PWM2 , 0.5V/div

FOSC=180kHz, VOUT2=-7.5V
VIN=3.3V, IOUT2=-5mA PWM2 'H'→'L'




200 $\mu$ sec/div
CH1:VOUT2, AC-COUPLED ,20mV/div
CH2:PWM2, 0.5V/div

## ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

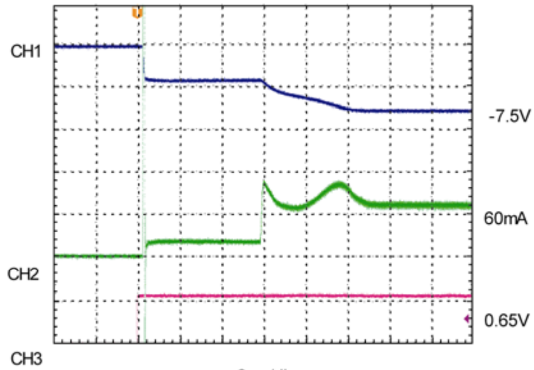
< 2 ch. Inverting DC/DC Controller > (Continued)

(25) Load Transient Response (Continued)

(Ceramic capacitor use when coil current is discontinuous. )

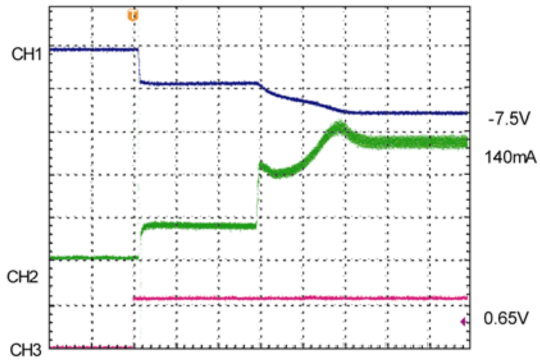
< Soft-Start Wave Form >

FOSC=180kHz, VOUT2=-7.5V
VIN=3.3V, IOUT2=-20mA EN1, 2 'L'→'H', CIN=10$\mu$F



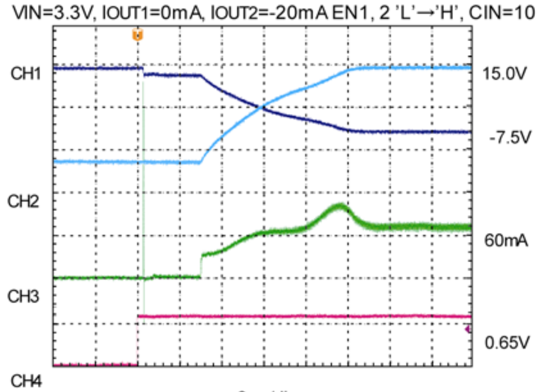

2ms/div
CH1:VOUT2 , 5.0V/div, CH2:IIN2, 50mA/div
CH3:EN1, 2 , 0.5V/div

FOSC=180kHz, VOUT2=-7.5V
VIN=3.3V, IOUT2=-50mA EN1, 2 'L'→'H', CIN=10$\mu$F



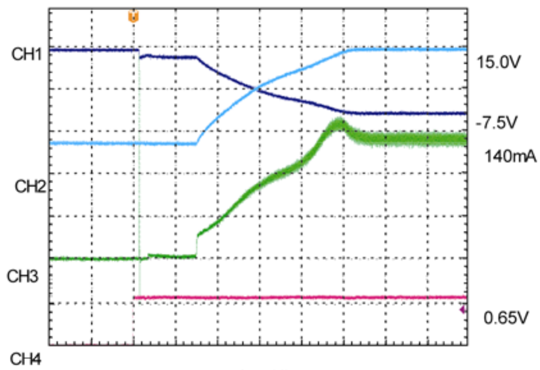

2ms/div
CH1:VOUT2 , 5.0V/div, CH2:IIN2, 50mA/div
CH3:EN1, 2 , 0.5V/div

FOSC=180kHz, VOUT2=-7.5V
VIN=3.3V, IOUT1=0mA, IOUT2=-20mA EN1, 2 'L'→'H', CIN=10$\mu$F



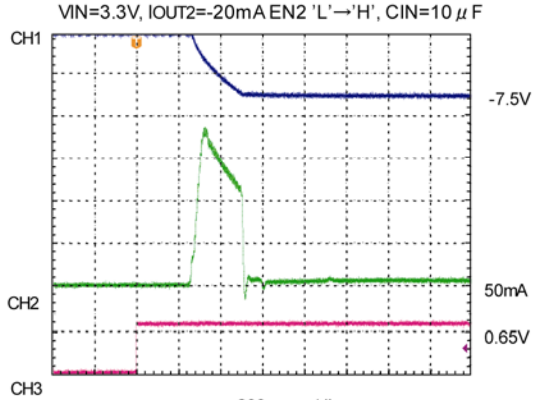

2ms/div
CH1:VOUT2 , 5.0V/div, CH2:VOUT1 , 5.0V/div,
CH3:IIN2, 50mA/div, CH4:EN1, 2 , 0.5V/div

FOSC=180kHz, VOUT2=-7.5V
VIN=3.3V, IOUT1=0mA, IOUT2=-50mA EN1, 2 'L'→'H', CIN=10$\mu$F



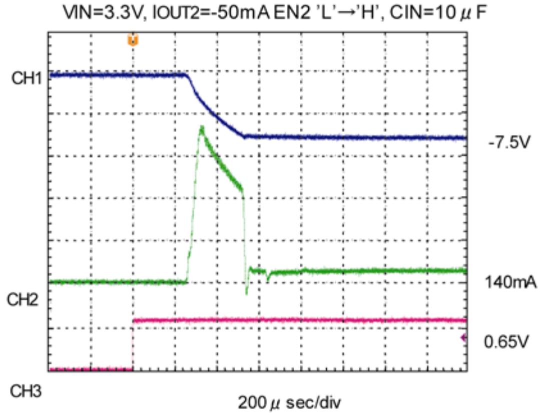

2ms/div
CH1:VOUT2 , 5.0V/div, CH2:VOUT1 , 5.0V/div
CH3:IIN2, 50mA/div, CH4:EN1, 2 , 0.5V/div

FOSC=180kHz, VOUT2=-7.5V
VIN=3.3V, IOUT2=-20mA EN2 'L'→'H', CIN=10$\mu$F




200$\mu$ sec/div
CH1:VOUT2 , 5.0V/div, CH2:IIN2, 500mA/div
CH3:EN2 , 0.5V/div

FOSC=180kHz, VOUT2=-7.5V
VIN=3.3V, IOUT2=-50mA EN2 'L'→'H', CIN=10$\mu$F



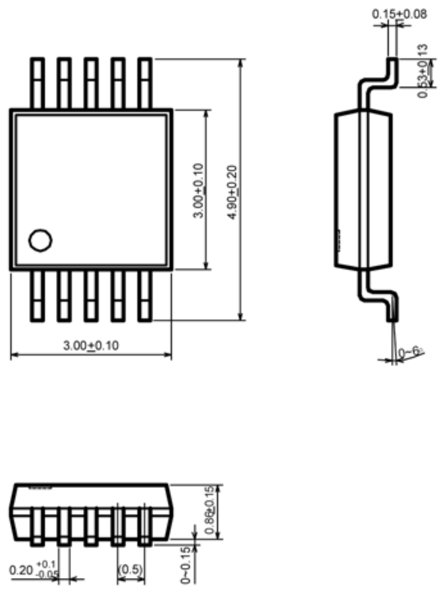

200$\mu$ sec/div
CH1:VOUT2 , 5.0V/div, CH2:IIN2, 500mA/div
CH3:EN2 , 0.5V/div

* EN1=GND

# ■PACKAGING INFORMATION

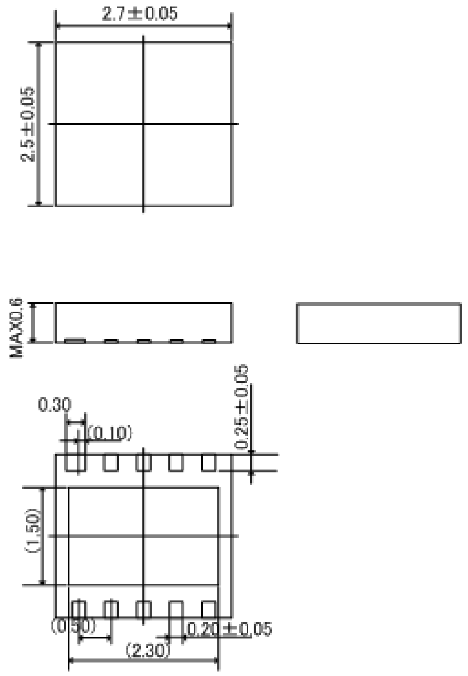
●MSOP-10

Unit:mm

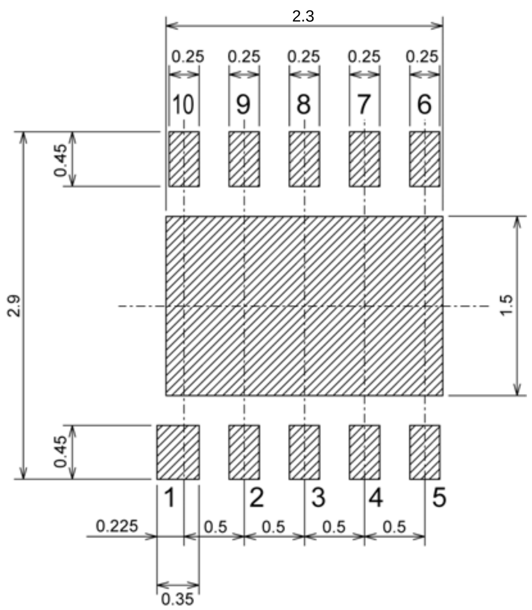



●USP-10

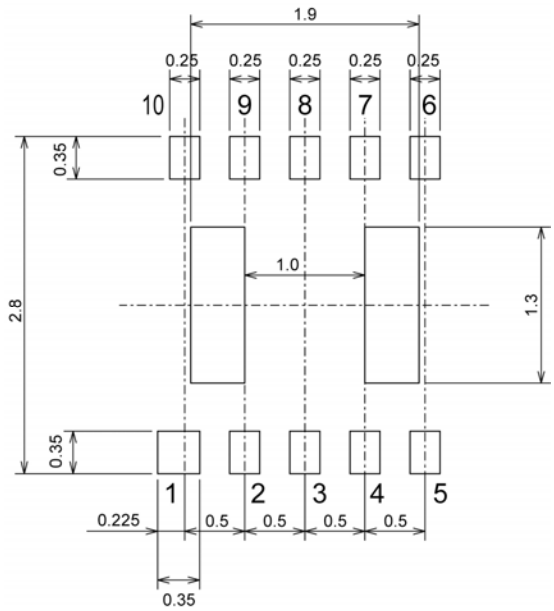
Unit:mm




●USP-10 Reference Pattern Layout

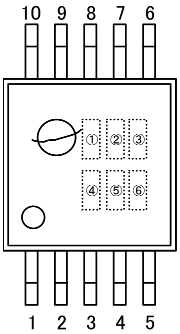



●USP-10 Reference Metal Mask Design

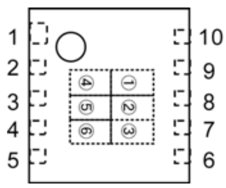


## ■MARKING RULE

●MSOP-10, USP-10




MSOP-10
(TOP VIEW)




USP-10
(TOP VIEW)

① represents product series

| MARK | PRODUCT SERIES |
|---|---|
| 1 | XC9504B09xxx |

② represents type of DC/DC controller

| MARK | PRODUCT SERIES |
|---|---|
| B | XC9504B09xxx |

③,④ represents FB voltage

| MARK | | VOLTAGE (V) | PRODUCT SERIES |
|---|---|---|---|
| ③ | ④ | | |
| 0 | 9 | 0.9 | XC9504B09xxx |

⑤ represents oscillation frequency

| MARK | OSCILLATION FREQUENCY (kHz) | PRODUCT SERIES |
|---|---|---|
| 2 | 180 | XC9504B092xx |
| 3 | 300 | XC9504B093xx |
| 5 | 500 | XC9504B095xx |

⑥ represents production lot number
0 to 9, A to Z repeated (G, I, J, O, Q, W excluded)
Note: No character inversion used.

# OCEAN CHIPS
## Океан Электроники
### Поставка электронных компонентов

Компания «Океан Электроники» предлагает заключение долгосрочных отношений при поставках импортных электронных компонентов на взаимовыгодных условиях!

Наши преимущества:

- Поставка оригинальных импортных электронных компонентов напрямую с производств Америки, Европы и Азии, а так же с крупнейших складов мира;
- Широкая линейка поставок активных и пассивных импортных электронных компонентов (более 30 млн. наименований);
- Поставка сложных, дефицитных, либо снятых с производства позиций;
- Оперативные сроки поставки под заказ (от 5 рабочих дней);
- Экспресс доставка в любую точку России;
- Помощь Конструкторского Отдела и консультации квалифицированных инженеров;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Поставка электронных компонентов под контролем ВП;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- При необходимости вся продукция военного и аэрокосмического назначения проходит испытания и сертификацию в лаборатории (по согласованию с заказчиком);
- Поставка специализированных компонентов военного и аэрокосмического уровня качества (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Actel, Aeroflex, Peregrine, VPT, Syfer, Eurofarad, Texas Instruments, MS Kennedy, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

Компания «Океан Электроники» является официальным дистрибьютором и эксклюзивным представителем в России одного из крупнейших производителей разъемов военного и аэрокосмического назначения **«JONHON»**, а так же официальным дистрибьютором и эксклюзивным представителем в России производителя высокотехнологичных и надежных решений для передачи СВЧ сигналов **«FORSTAR»**.

AVIC JONHON

**«JONHON»** (основан в 1970 г.)

Разъемы специального, военного и аэрокосмического назначения:

(Применяются в военной, авиационной, аэрокосмической, морской, железнодорожной, горно- и нефтедобывающей отраслях промышленности)

**«FORSTAR»** (основан в 1998 г.)

ВЧ соединители, коаксиальные кабели, кабельные сборки и микроволновые компоненты:

(Применяются в телекоммуникациях гражданского и специального назначения, в средствах связи, РЛС, а так же военной, авиационной и аэрокосмической отраслях промышленности).

FORSTAR®

Телефон: 8 (812) 309-75-97 (многоканальный)
Факс: 8 (812) 320-03-32
Электронная почта: ocean@oceanchips.ru
Web: http://oceanchips.ru/
Адрес: 198099, г. Санкт-Петербург, ул. Калинина, д. 2, корп. 4, лит. А