

PWM Controlled, PWM/PFM Switchable Step-Down DC/DC Controllers

☆GreenOperation Compatible

■GENERAL DESCRIPTION

The XC6365/XC6366 series are multi-functional step-down DC/DC controllers which have 1A output current capability by using an externally connected transistor, coil, diode and capacitor.

Output voltage is programmable in 0.1V increments between 1.5V to 6.0V (V_{OUT}) ($\pm 2.5\%$ accuracy). Further, with 1.0V of standard voltage supply internal and using externally connected components, output voltage can be set up freely (FB). With a 300kHz switching frequency, the size of the external components can be reduced.

Control switches from PWM to PFM during light loads with the XC6366 (PWM/PFM switchable) and the series is highly efficient from light loads to large output currents.

Soft start time of XC6365/ XC6366A, B series is internally set to 10ms and XC6365/66C, D series regulate soft-start time by connecting resistors and capacitors externally.

During stand-by time (CE pin "Low"), current consumption is reduced to less than $0.5 \mu A$.

With UVLO internal, the external transistor will be forcibly switched off if used below the stipulated voltage.

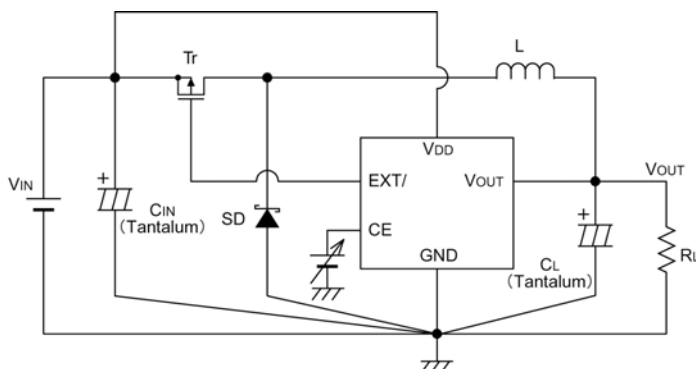
■APPLICATIONS

- E-book Reader / Electronic dictionaries
- Smart phones / Mobile phones
- Note PCs / Tablet PCs
- Digital audio equipments
- Multi-function power supplies

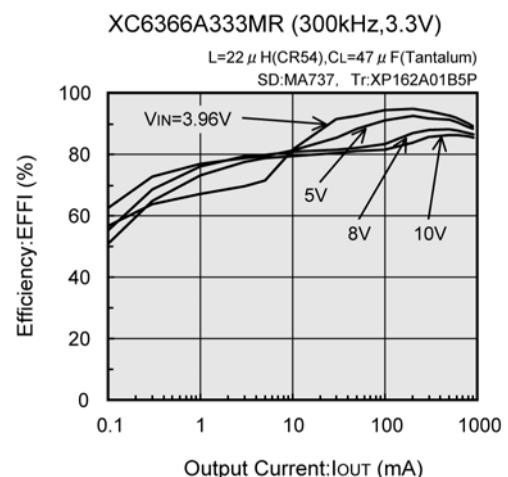
■FEATURES

- Input Voltage Range** : 2.2V ~ 10V (V_{OUT} type)
- Output Voltage Range** : 1.5V ~ 6.0V (0.1V increments) ($\pm 2.5\%$)
- Oscillation Frequency** : 300kHz ($\pm 15\%$)
Custom products for 180, 500kHz
- Output Current** : More than 1.0A ($V_{IN}=5.0V$, $V_{OUT}=3.0V$)
- High Efficiency** : 92% (TYP.)
- Stand-by Capability** : $I_{STB}=0.5 \mu A$ (MAX.)
- Selection** : Soft-start set-up external
Output voltage set-up internal (V_{OUT})
Output voltage set-up external (FB)
PWM/PFM Control (XC6366)
- Maximum Duty Cycle** : 100%
- Packages** : SOT-25, USP-6C
- Environmentally Friendly** : EU RoHS Compliant, Pb Free

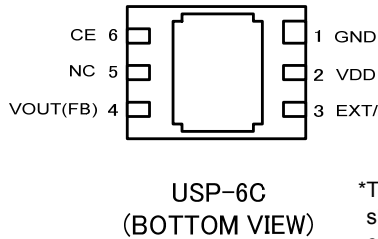
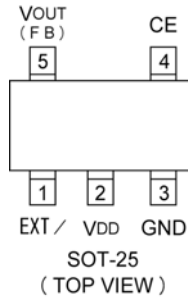
■TYPICAL APPLICATION CIRCUIT



■TYPICAL PERFORMANCE CHARACTERISTICS



PIN CONFIGURATION



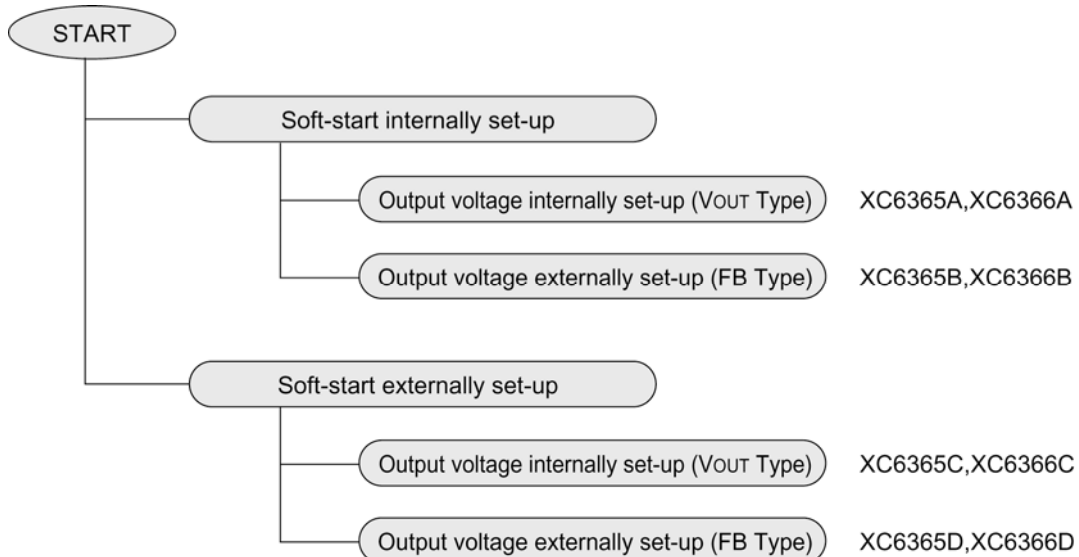
*The dissipation pad of the USP-6C package should be left open. If the circuit needs to be connected to other pin, it should be connected to the VDD (No.2) pin.

PIN ASSIGNMENT

PIN NUMBER		PIN NAME	FUNCTION
SOT-25	USP-6		
1	3	EXT/	External Transistor Connection
2	2	VDD	Power Supply
3	1	GND	Ground
4	6	CE	Chip Enable Soft-Start Capacitor Connection with Soft-Start Externally Set-Up Types (C, D)
5	4	VOUT (FB)	Output Voltage Monitor FB with Externally Set-Up Types (B, D)
-	5	NC	No Connection

PRODUCT CLASSIFICATION

● Selection Guide



■ PRODUCT CLASSIFICATION (Continued)

● Ordering Information

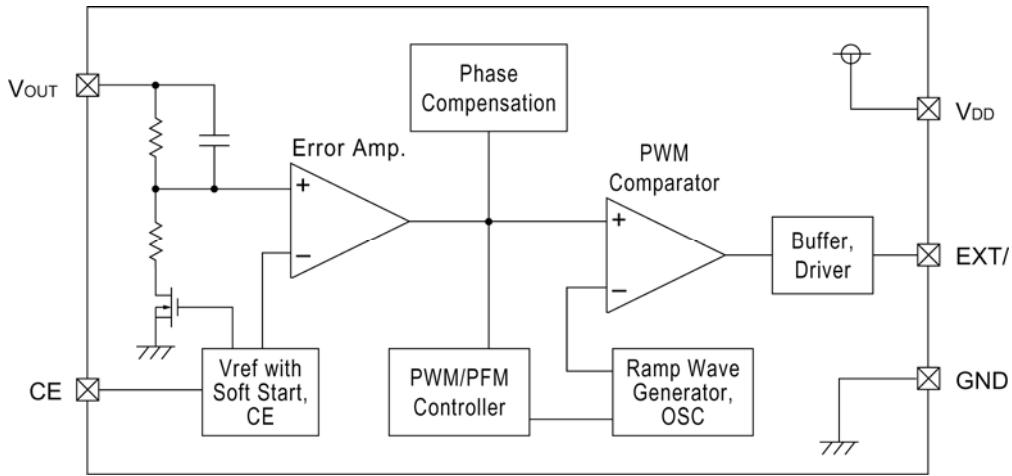
XC6365①②③④⑤⑥-⑦^(*) PWM control
 XC6366①②③④⑤⑥-⑦^(*) PWM/PFM switching control

DESIGNATOR	ITEM	SYMBOL	DESCRIPTION
①	Type of DC/DC Converter	A	V _{OUT} type: Internally set-up, soft-start internally set-up
		B	FB type: Externally set-up, soft-start internally set-up
		C	V _{OUT} type: Internally set-up, soft-start externally set-up
		D	FB type: Externally set-up, soft-start internally set-up
②③	Output Voltage	15~60	V _{OUT} type: 3.0V output → ②=3, ③=0
		10	FB type: 10 fixed → ②=1, ③=0 fixed
④	Oscillation Frequency	3	300kHz
		5	500kHz (custom)
		2	180kHz (custom)
⑤⑥-⑦	Packages (Order Unit)	MR	SOT-25 (3,000/Reel)
		MR-G	SOT-25 (3,000/Reel)
		ER	USP-6C (3,000/Reel)
		ER-G	USP-6C (3,000/Reel)

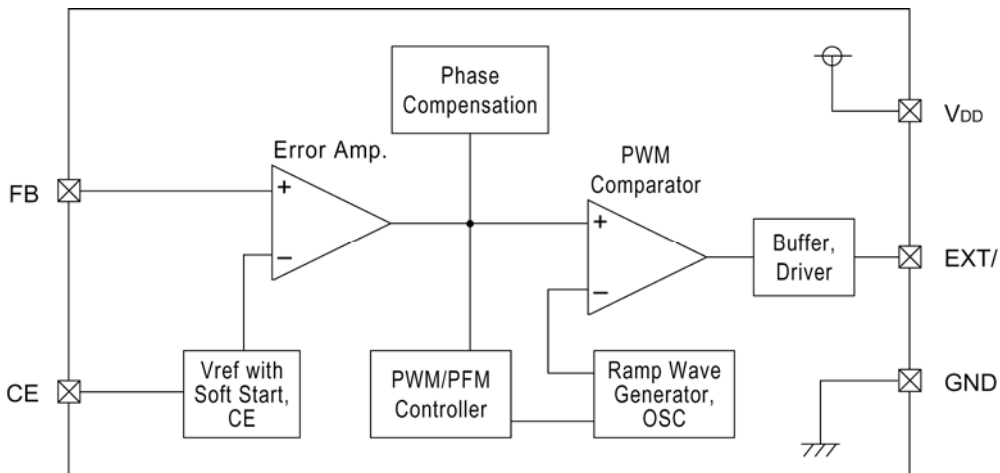
^(*) The “-G” suffix indicates that the products are Halogen and Antimony free as well as being fully EU RoHS compliant.

■ BLOCK DIAGRAMS

XC6365, XC6366 Series A, C type (V_{OUT})



XC6365, XC6366 Series B, D type (FB)



■ ABSOLUTE MAXIMUM RATINGS

Ta = 25°C

PARAMETER	SYMBOL	RATINGS	UNITS
V _{IN} Pin Voltage	V _{DD}	-0.3 ~ +12	V
V _{OUT} Pin Voltage	V _{OUT}	-0.3 ~ V _{IN} +0.3	V
FB Pin Voltage	V _{FB}	-0.3 ~ V _{IN} +0.3	V
CE Pin Voltage	V _{CE}	-0.3 ~ V _{IN} +0.3	V
EXT/ Pin Voltage	V _{EXT/}	-0.3 ~ V _{IN} +0.3	V
EXT/ Pin Current	I _{EXT/}	± 100	mA
Power Dissipation	SOT-25	150	mW
	USP-6C	100	
Operating Temperature Range	T _{opr}	-30 ~ +80	°C
Storage Temperature Range	T _{stg}	-40 ~ +125	°C

Note: Voltage is all ground standardized.

■ ELECTRICAL CHARACTERISTICS

XC6365A333MR, XC6366A333MR

(V_{OUT}=3.3V, f_{osc}=300kHz)

Ta=25°C

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Output Voltage	V _{OUT}		3.218	3.300	3.383	V
Maximum Input Voltage	V _{IN}		10.0	-	-	V
UVLO Voltage (Minimum Operating Voltage)	V _{UVLO}	Same as I _{DD1} , Voltage which EXT/pin voltage holding "H" level	0.9	-	2.2	V
Supply Current 1	I _{DD1}	No external components, CE=V _{DD} , V _{OUT} =0V	-	57	102	μA
Supply Current 2	I _{DD2}	XC6365	-	57	102	μA
		XC6366	-	15	27	μA
Stand-by Current	I _{STB}	No external components, CE=V _{OUT} =0V	-	-	0.5	μA
Oscillation Frequency	f _{osc}	Measuring of EXT/ waveform, V _{IN} =output voltage + 0.1V	255	300	345	kHz
Maximum Duty Ratio	MAXDTY		100	-	-	%
PFM Duty Ratio	PFMDTY	No load (XC6366 only)	15	25	35	%
CE "High" Voltage	V _{CEH}	No external components, V _{OUT} =0V, Voltage which EXT/pin voltage holding "L" level	0.65	-	-	V
CE "Low" Voltage	V _{CEL}	No external components, V _{OUT} =0V, Voltage which EXT/pin voltage holding "H" level	-	-	0.20	V
EXT "High" ON Resistance	R _{EXTBH}	Same as I _{DD2} , V _{EXT/} =V _{DD} -0.4V	-	16	22	μA
EXT "Low" ON Resistance	R _{EXTBL}	Same as I _{DD1} , V _{EXT/} =0.4V	-	14	19	μA
Efficiency	EFFI	Use of a XP162A12A6 transistor recommended	-	92	-	%
Soft-Start Time	t _{SS}	Connect R _{SS} , C _{SS} , CE, 0V → 3.0V (When V _{IN} ≤ 3.0V, V _{IN} =3.0V)	5	10	20	ms

Conditions: 1. Unless otherwise stated, connect external components. V_{IN}=V_{DD} = 5.0V, I_{OUT} = 220mA

2. XC6365/66C series external components: C_{SS}=0.033 μF, R_{SS}=470kΩ

■ ELECTRICAL CHARACTERISTICS (Continued)

XC6365A503MR, XC6366A503MR

(V_{OUT}=5.0V, f_{osc}=300kHz)

T_a=25°C

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Output Voltage	V _{OUT}		4.875	5.000	5.125	V
Maximum Input Voltage	V _{IN}		10.0	-	-	V
UVLO Voltage (Minimum Operating Voltage)	V _{UVLO}	Same as I _{DD1} , Voltage which EXT/pin voltage holding "H" level	0.9	-	2.2	V
Supply Current 1	I _{DD1}	No external components, CE=V _{DD} , V _{OUT} =0V	-	67	122	μA
Supply Current 2	I _{DD2}	XC6365	-	67	122	μA
		XC6366	-	16	29	μA
Stand-by Current	I _{STB}	No external components, CE=V _{OUT} =0V	-	-	0.5	μA
Oscillation Frequency	f _{osc}	Measuring of EXT/ waveform, V _{IN} =output voltage + 0.1V	255	300	345	kHz
Maximum Duty Ratio	MAXDTY		100	-	-	%
PFM Duty Ratio	PFMDTY	No load (XC6366 only)	15	25	35	%
CE "High" Voltage	V _{CEH}	No external components, V _{OUT} =0V, Voltage which EXT/pin voltage holding "L" level	0.65	-	-	V
CE "Low" Voltage	V _{CEL}	No external components, V _{OUT} =0V, Voltage which EXT/pin voltage holding "H" level	-	-	0.20	V
EXT "High" ON Resistance	R _{EXTBH}	Same as I _{DD2} , V _{EXT} =V _{IN} -0.4V	-	12	17	μA
EXT "Low" ON Resistance	R _{EXTBL}	Same as I _{DD1} , V _{EXT} =0.4V	-	10	14	μA
Efficiency	EFFI	Use of a XP162A12A6 transistor recommended	-	93	-	%
Soft-Start Time	t _{SS}	Connect R _{SS} , C _{SS} , CE, 0V → 3.0V (When V _{IN} ≤ 3.0V, V _{IN} =3.0V)	5	10	20	ms

- Conditions: 1. Unless otherwise stated, connect external components. V_{IN}=V_{DD} = 7.5V, I_{OUT} = 330mA
 2. XC6365/66C series external components: C_{SS}=0.033 μF, R_{SS}=470kΩ

■ ELECTRICAL CHARACTERISTICS (Continued)

XC6365B103MR, XC6366B103MR

(V_{OUT}=3.0V, f_{OSC}=300kHz)

T_a=25°C

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Output Voltage	V _{OUT}		2.925	3.000	3.075	V
Maximum Input Voltage	V _{IN}		10.0	-	-	V
UVLO Voltage (Minimum Operating Voltage)	V _{UVLO}	Same as I _{DD1} , Voltage which EXT/pin voltage holding "H" level	0.9	-	2.2	V
Supply Current 1	I _{DD1}	No external components, CE=V _{IN} , V _{OUT} =0V	-	55	100	μA
Supply Current 2	I _{DD2}	XC6365	-	55	100	μA
		XC6366	-	15	27	μA
Stand-by Current	I _{STB}	No external components, CE=FB=0V	-	-	0.5	μA
Oscillation Frequency	f _{OSC}	Measuring of EXT/ waveform, V _{IN} =output voltage + 0.1V	255	300	345	kHz
Maximum Duty Ratio	MAXDTY		100	-	-	%
PFM Duty Ratio	PFMDTY	No load (XC6366 only)	15	25	35	%
CE "High" Voltage	V _{CEH}	No external components, FB=0V, Voltage which EXT/pin voltage holding "L" level	0.65	-	-	V
CE "Low" Voltage	V _{CEL}	No external components, V _{OUT} =0V, Voltage which EXT/pin voltage holding "H" level	-	-	0.20	V
EXT "High" ON Resistance	R _{EXTBH}	Same as I _{DD2} , V _{EXT} =V _{IN} -0.4V	-	17	24	μA
EXT "Low" ON Resistance	R _{EXTBL}	Same as I _{DD1} , V _{EXT} =0.4V	-	15	20	μA
Efficiency	EFFI	Use of a XP162A12A6 transistor recommended	-	92	-	%
Soft-Start Time	t _{SS}	Connect R _{SS} , C _{SS} , CE, 0V → 3.0V (When V _{IN} ≤ 3.0V, V _{IN} =3.0V)	5	10	20	ms

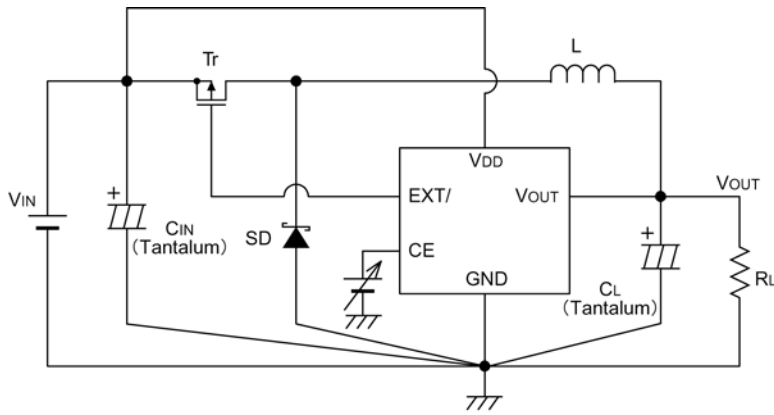
Conditions: 1. Unless otherwise stated, connect external components. V_{IN}=V_{DD} = 4.5V, I_{OUT} = 200mA

2. XC6365/66C series external components: C_{SS}=0.033 μF, R_{SS}=470kΩ

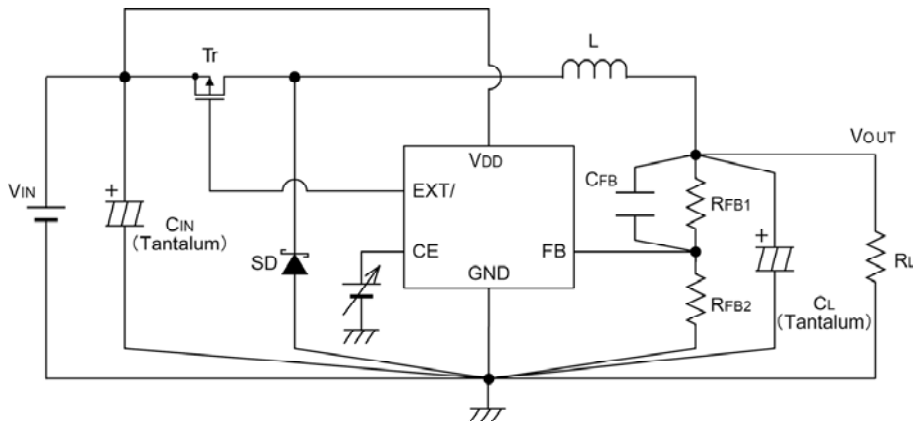
3. R_{FB1} = 400kΩ, R_{FB2} = 200kΩ, C_{FB} = 100ppF

TEST CIRCUITS

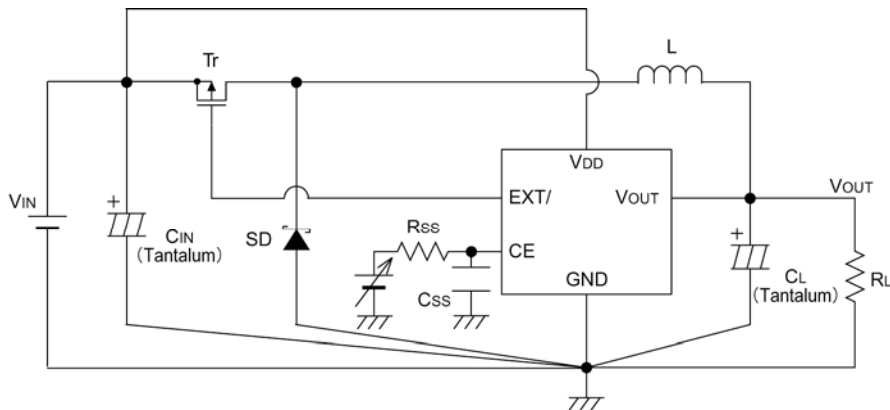
Circuit 1. XC6365A, XC6366A



Circuit 2. XC6365B, XC6366B

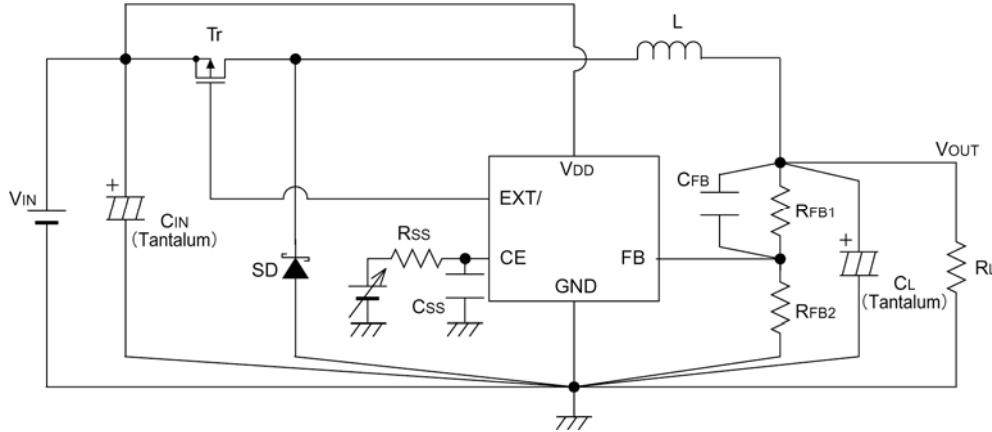


Circuit 3. XC6365C, XC6366C

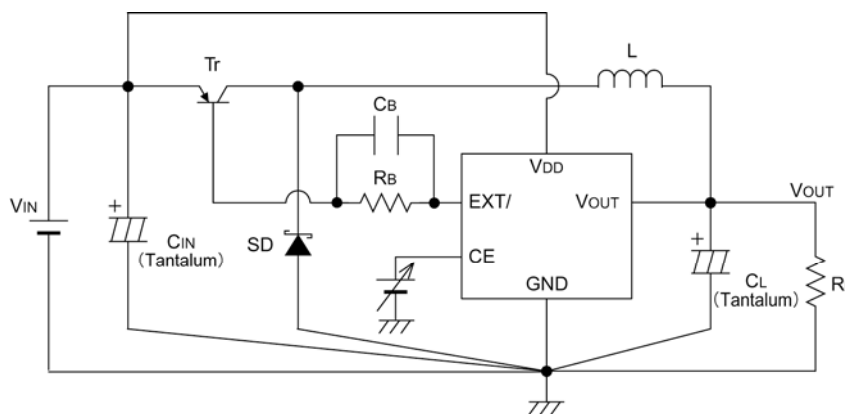


TEST CIRCUITS (Continued)

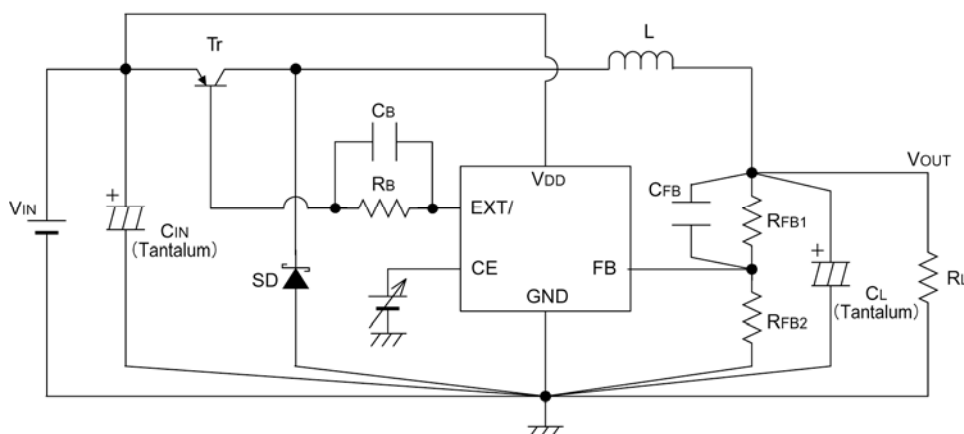
Circuit 4. XC6365D, XC6366D



Circuit 5. XC6365A, XC6366A (when used with a PNP transistor)

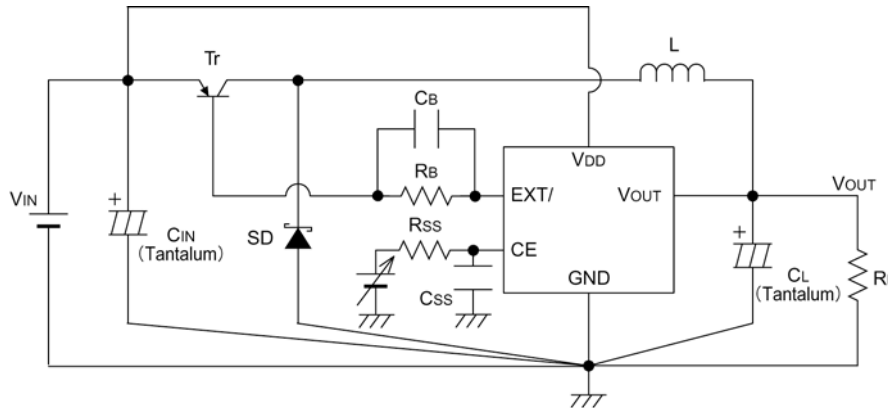


Circuit 6. XC6365B, XC6366B (when used with a PNP transistor)

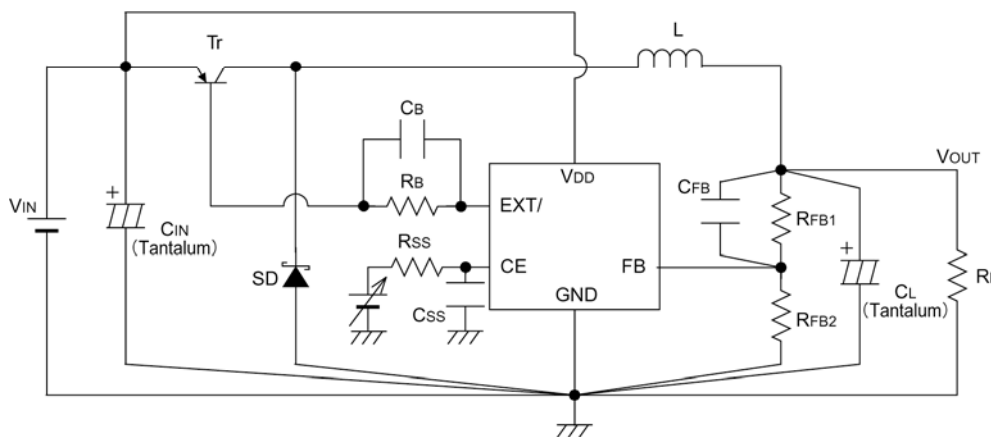


TEST CIRCUITS (Continued)

Circuit 7. XC6365C, XC6366C (when used with a PNP transistor)



Circuit 8. XC6365D, XC6366D (when used with a PNP transistor)



Recommended Components

- Tr : XP162A12A6PR (Torex P-channel Power MOSFET)
Please use a PNP transistor where $V_{IN} < 2.5V$
- L : 22 μH (CR54, SUMIDA, $f_{OSC}=300kHz$)
47 μH (CR75, SUMIDA, $f_{OSC}=180kHz$)
10 μH (CR54, SUMIDA, $f_{OSC}=500kHz$)
- SD : MA2Q735 (Schottky Diode, MATSUSHITA)
- CL : 10V, 47 μF (Tantalum capacitor, NICHICHEMI MCE)
- CIN : 16V 10 μF (Tantalum capacitor, NICHICHEMI MCE)

PNP Tr. Type

- Tr : 2SA1213 (TOSHIBA)
- Rb : 500 Ω (Adjust according to load and Tr. hFE levels)
- Cb : 2200pF (Ceramic Type)
Set up so that $Cb \leq 1 / (2\pi \times Rb \times f_{OSC} \times 0.7)$

C, D type (soft-start externally set-up)

- Css : 0.033 μF (Ceramic Capacitor)
- Rss : 470k Ω (C type), 330k Ω (D type)

B, D type (FB type)

- FBF : Set up so that $R_{FB1} / R_{FB2} = V_{OUT} - 1$
(V_{OUT} = setting output voltage),
 $R_{FB1} = R_{FB2} \leq 2M\Omega$
- CFB : Set up so that $f_{zfb} = 1 / (2\pi \times C_{FB} \times R_{FB1})$ is within the 0.5 to 20kHz range (10kHz conventional)
Adjustments necessary in respect of L, CL.
- e.g. : $V_{OUT} = 3.0V$
 $R_{FB1} = 400k\Omega$, $R_{FB2} = 200k\Omega$, $C_{FB} = 100pF$

■ NOTES ON USE

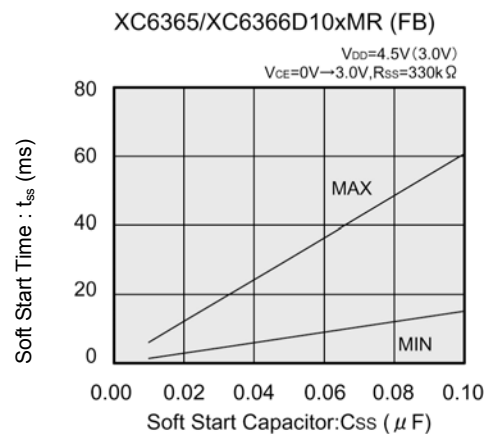
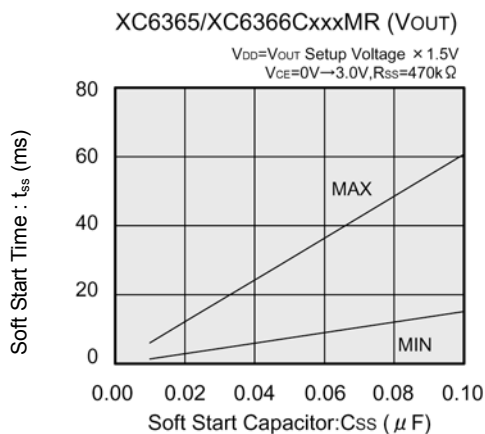
1. Take ample care to ensure that none of the IC's, nor the external component's, absolute maximum ratings are exceeded.
2. Be extremely careful when selecting parts and do not limit your reference to the specifications and characteristics for the DC/DC converter alone. The IC also depends, to a great extent, upon the external components.
3. Arrange the peripherals in the environs of the IC. In order to reduce wiring impedance, use short, thick wires. In particular, wire the load capacitor as close as possible and strengthen the ground wiring sufficiently.
4. Ground current during switching may cause the IC's operations to become unstable due to changes in ground voltage, so please strengthen the IC's GND pin surroundings.

● External Components

1. Setting soft start time

To set a longer soft start time, please use XC6365C or XC6365D series which soft start function is externally set up.

For the measurement of soft start time T_{SS} , the time is needed to be between the maximum and the minimum value indicated in the chart below. Please set a soft start capacitor C_{SS} according to the application.

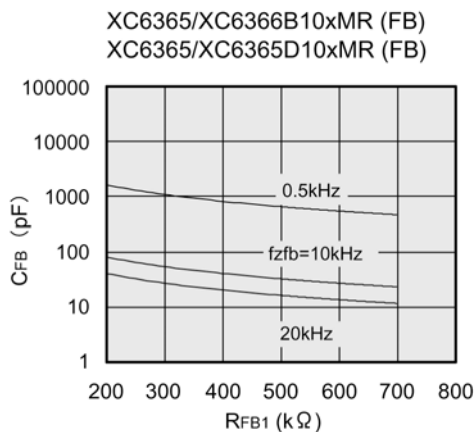


2. Setting R_{FB1} and C_{FB}

$$f_{zfb} = 1 \div (2 \pi \times C_{FB} \times R_{FB1})$$

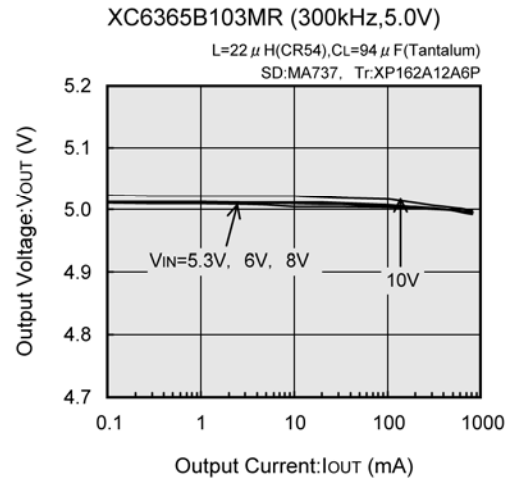
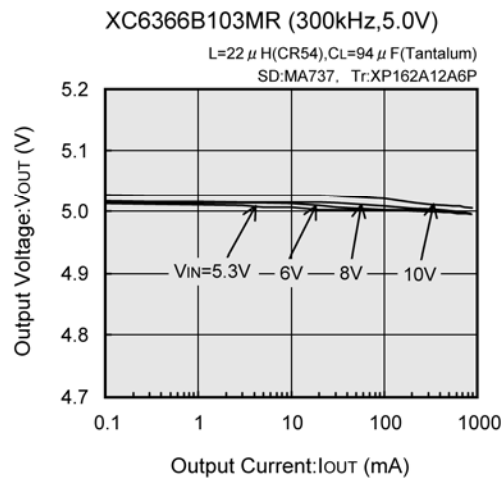
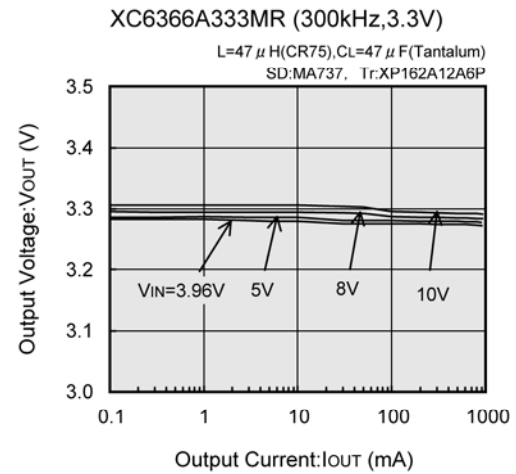
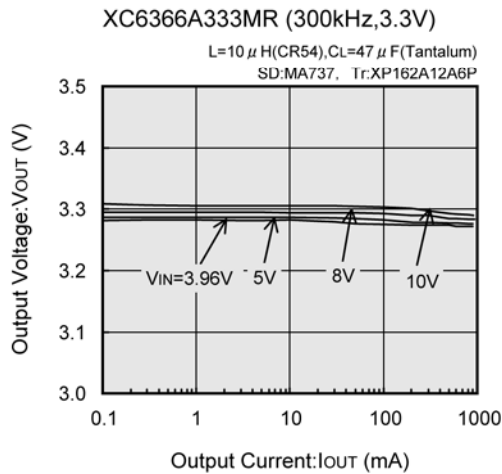
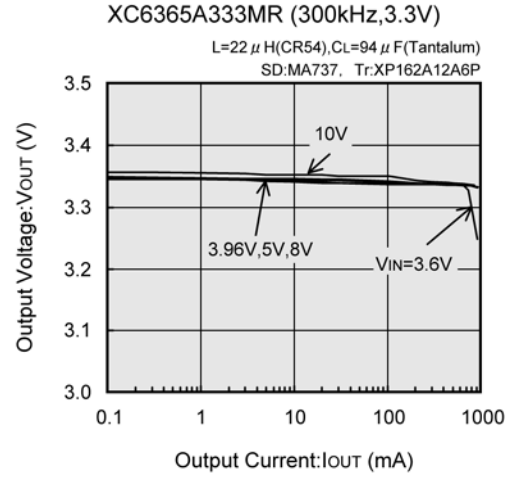
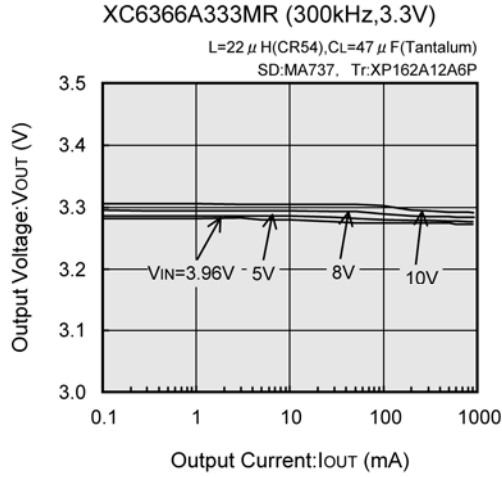
As the combination of R_{FB1} and C_{FB} enable to set f_{zfb} between 0.5kHz to 20kHz, within the realm of $f_{zfb}=0.5kHz$ to $f_{zfb}=20kHz$ as the chart below can be effective.

Under normal condition, please set the combination to configure around $f_{zfb}=10kHz$.



TYPICAL PERFORMANCE CHARACTERISTICS

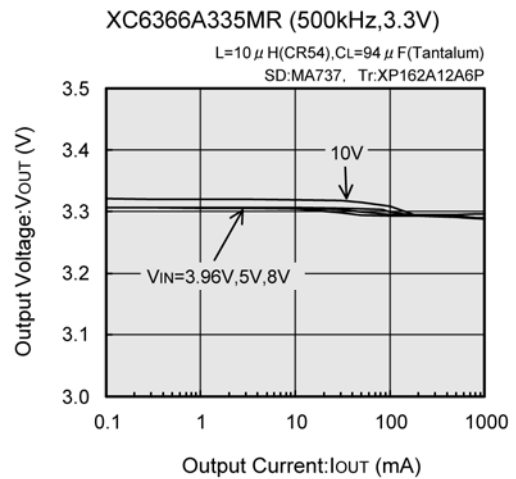
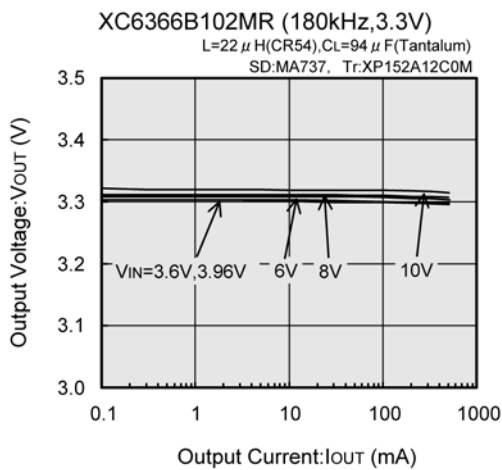
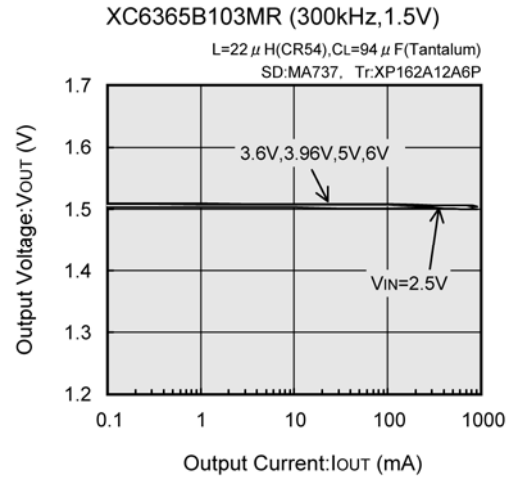
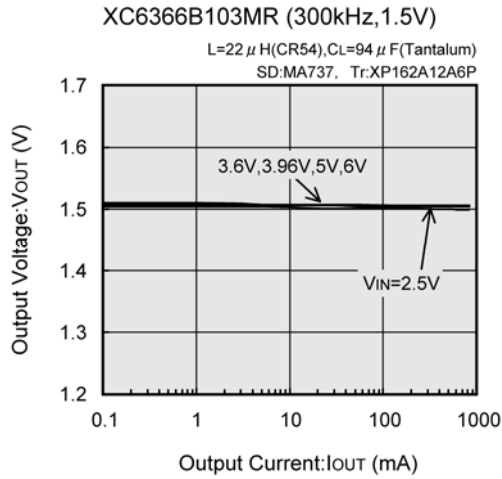
(1) Output Voltage vs. Output Current



Note: CIN=47 μ F(Tantalum)

■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

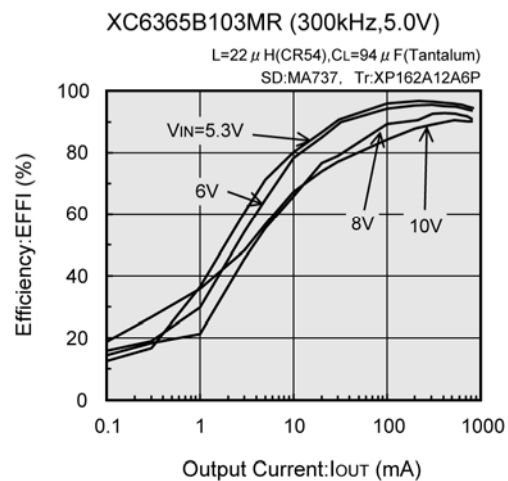
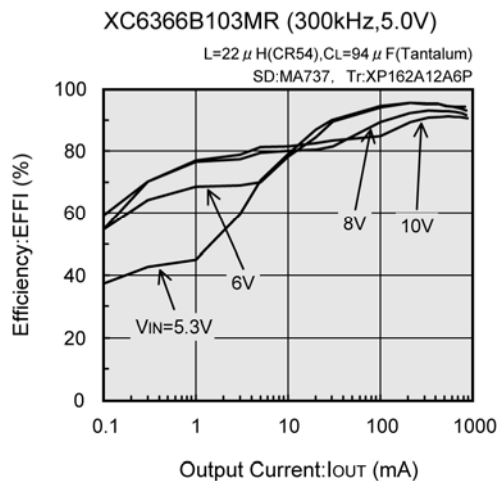
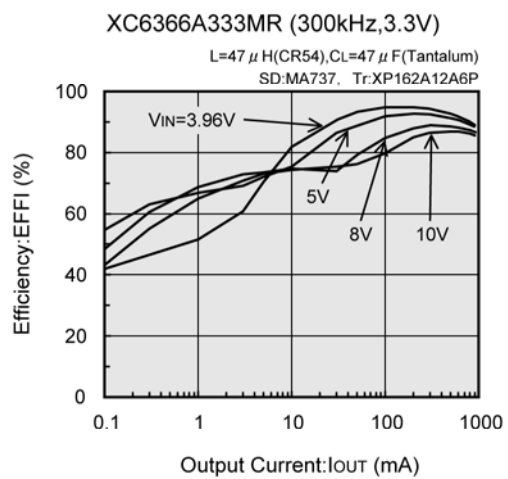
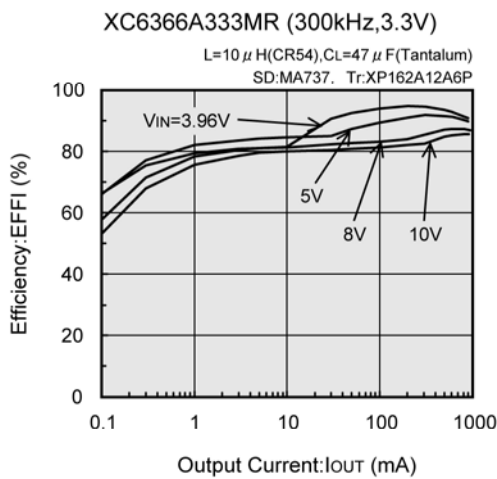
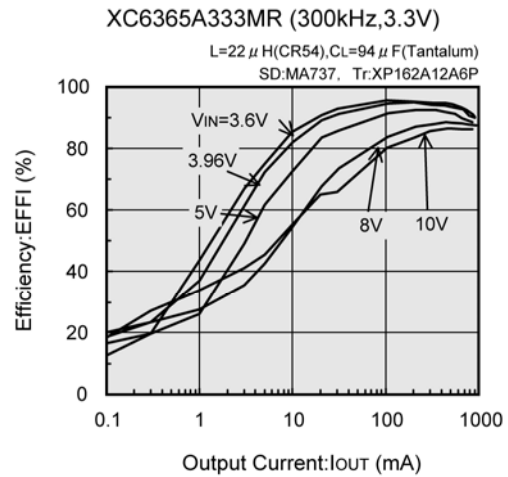
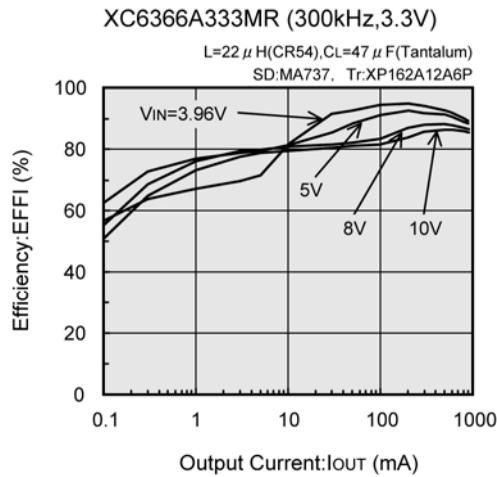
(1) Output Voltage vs. Output Current (Continued)



Note: CIN=47 μ F(Tantalum)

■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

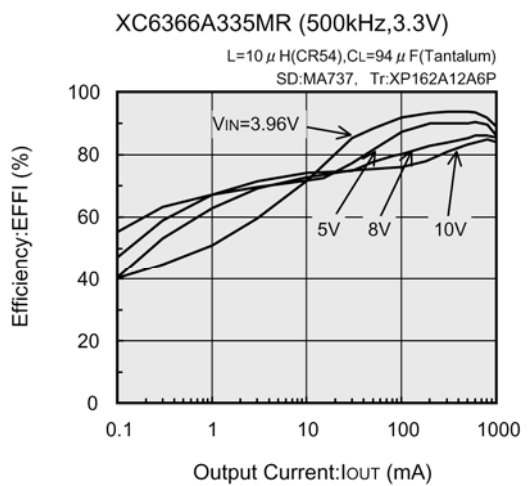
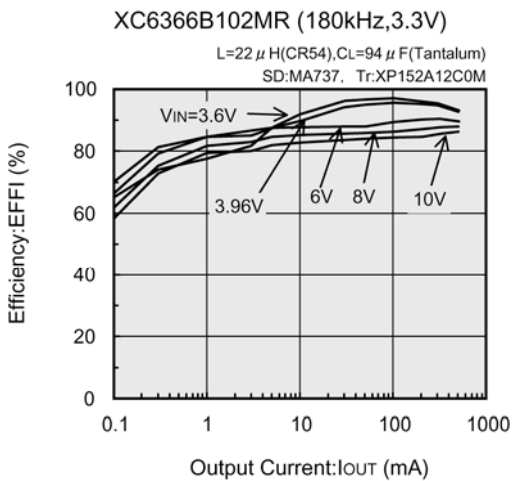
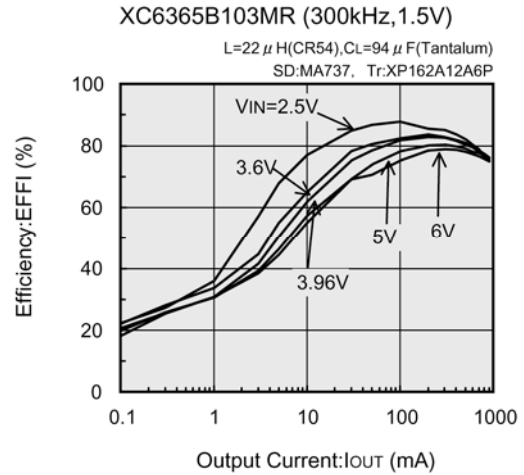
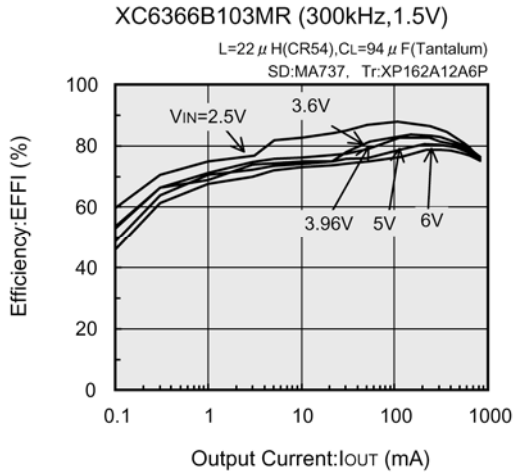
(2) Efficiency vs. Output Current



Note: CIN=47 μ F(Tantalum)

■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

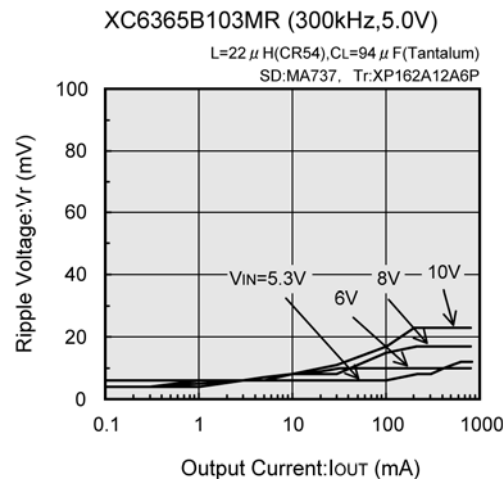
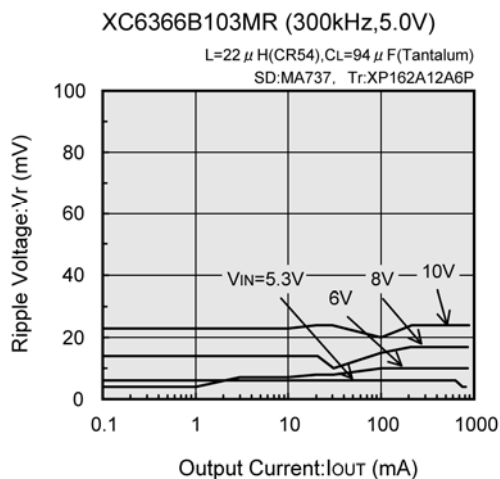
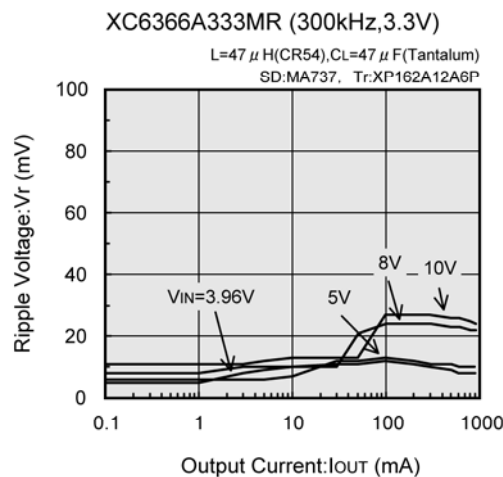
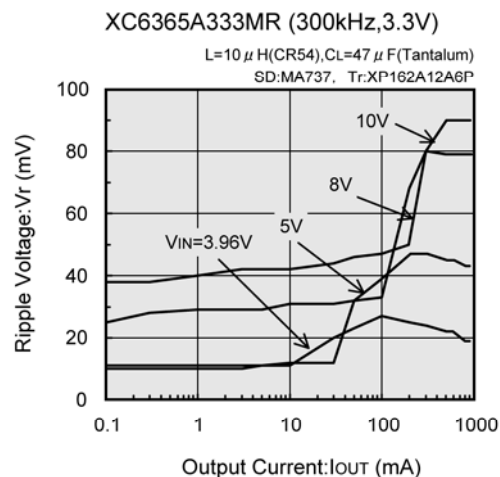
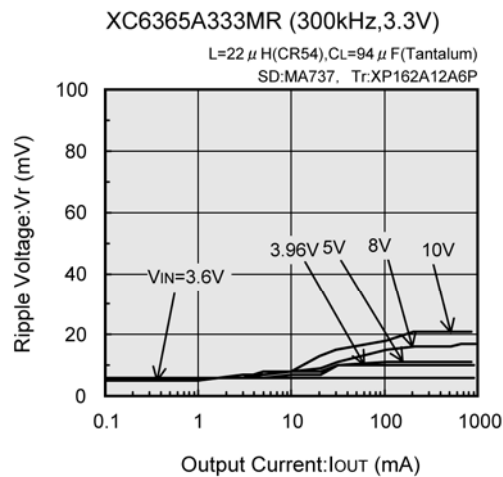
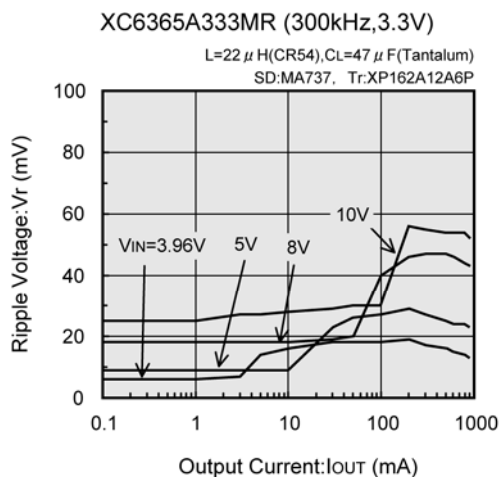
(2) Efficiency vs. Output Current (Continued)



Note: CIN=47 μ F(Tantalum)

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

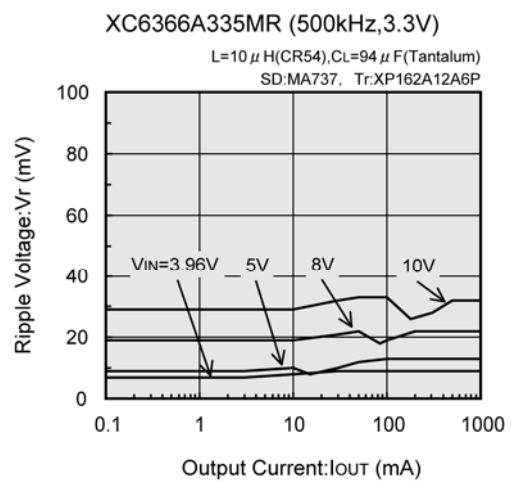
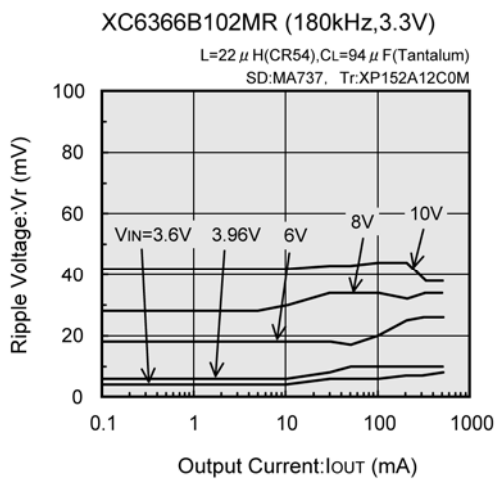
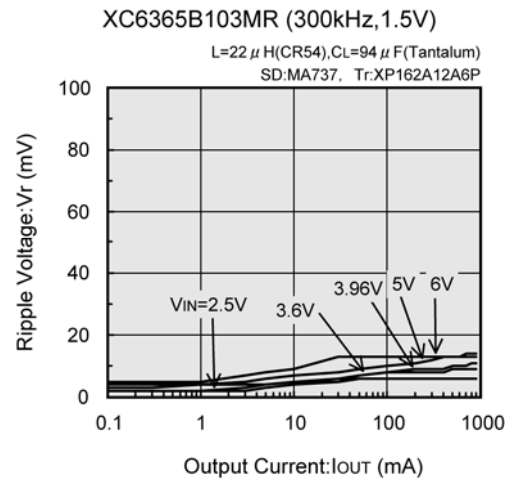
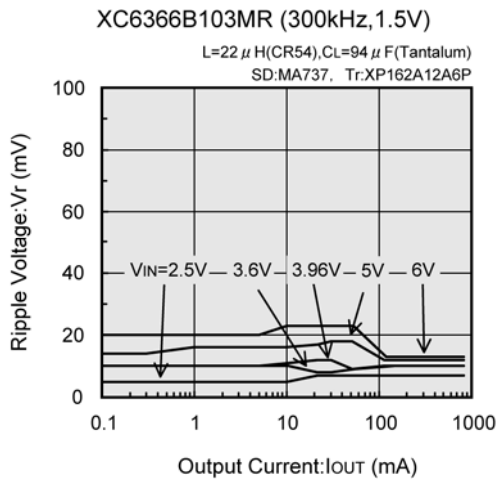
(3) Ripple Voltage vs. Output Current



Note: CIN=47 μ F(Tantalum)

■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

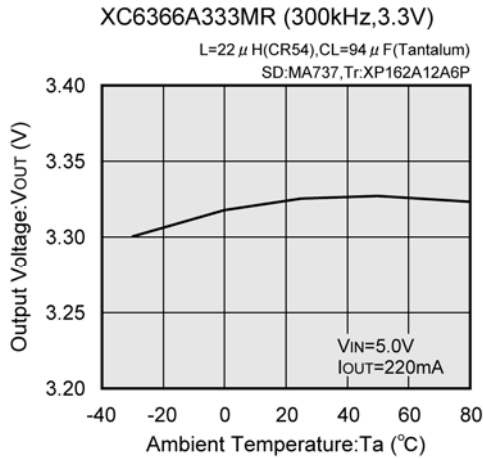
(3) Ripple Voltage vs. Output Current (Continued)



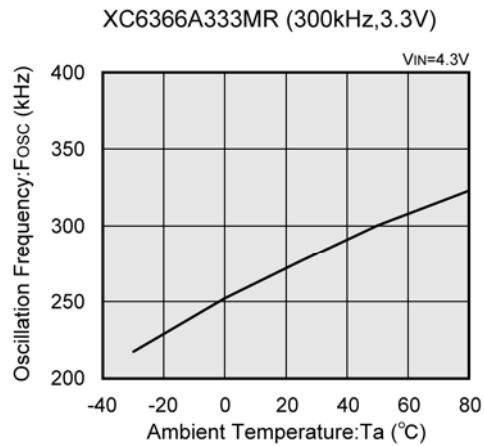
Note: CIN=47 μ F(Tantalum)

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

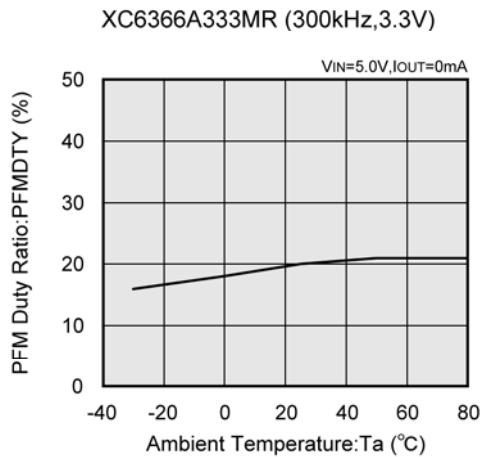
(4) Output Voltage vs. Ambient Temperature



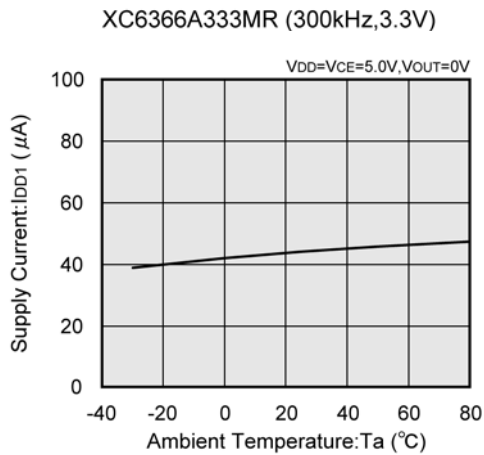
(5) Oscillation Frequency vs. Ambient Temperature



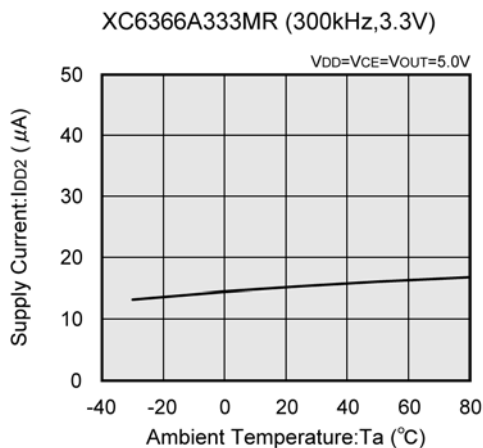
(6) PFM Duty Ratio vs. Ambient Temperature



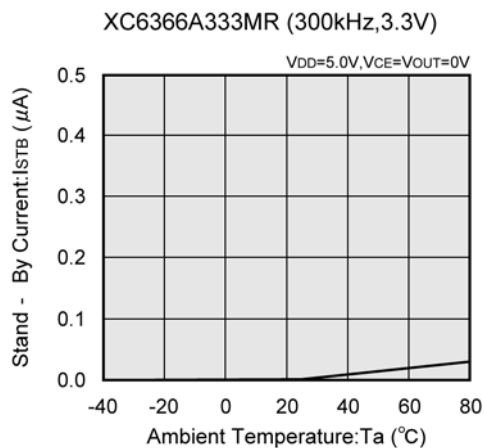
(7) Supply Current 1 vs. Ambient Temperature



(8) Supply Current 2 vs. Ambient Temperature

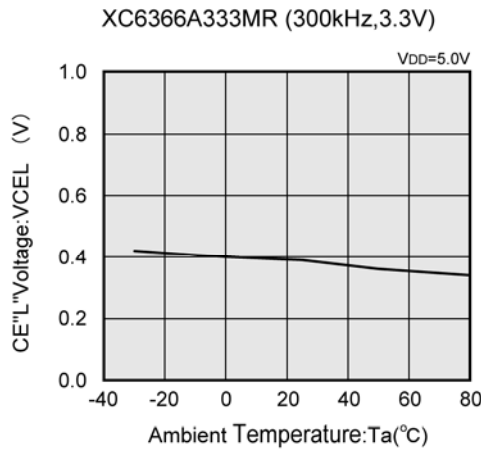


(9) Stand-By Current vs. Ambient Temperature

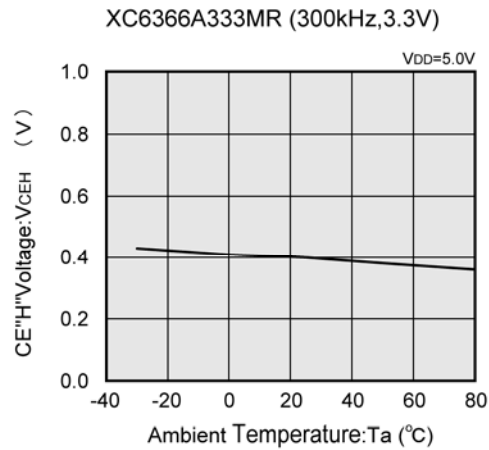


TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

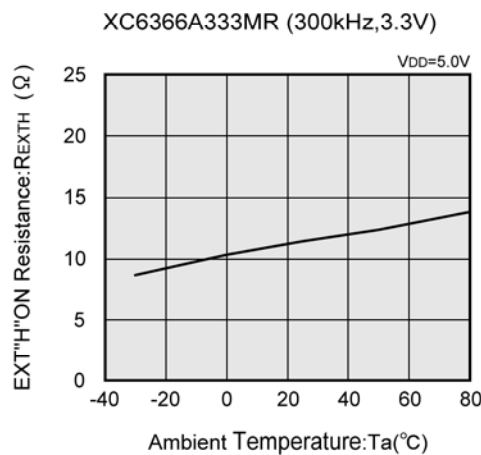
(10) CE "L" Voltage vs. Ambient Temperature



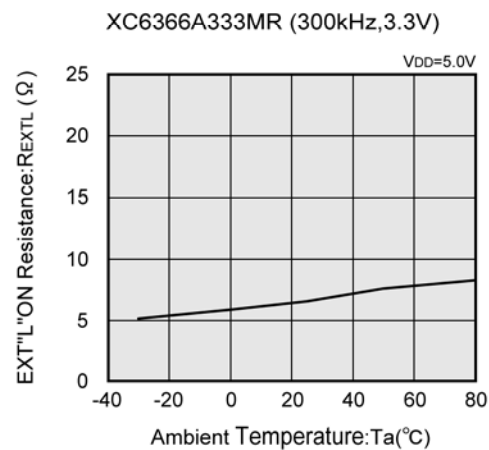
(11) CE "H" Voltage vs. Ambient Temperature



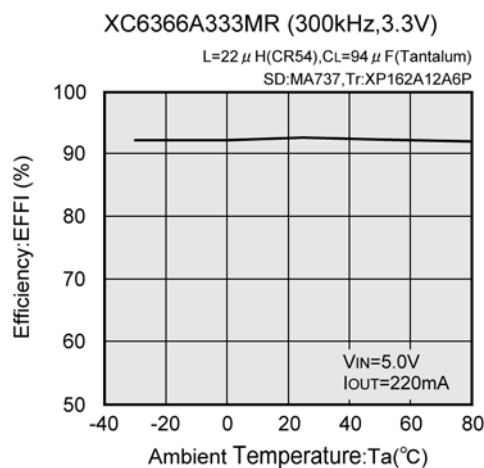
(12) EXT "H" ON Resistance vs. Ambient Temperature



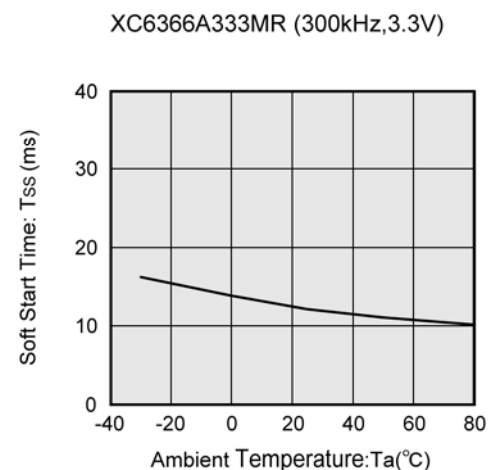
(13) EXT "L" ON Resistance vs. Ambient Temperature



(14) Efficiency vs. Ambient Temperature

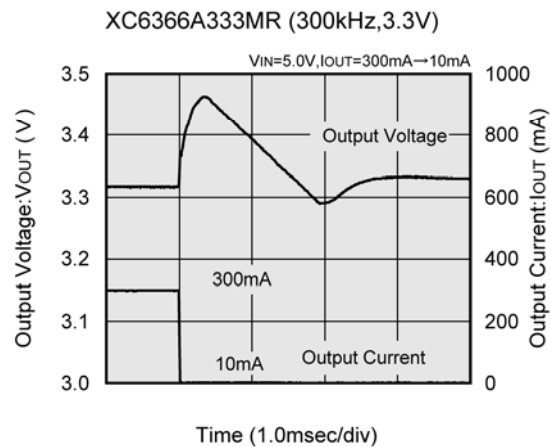
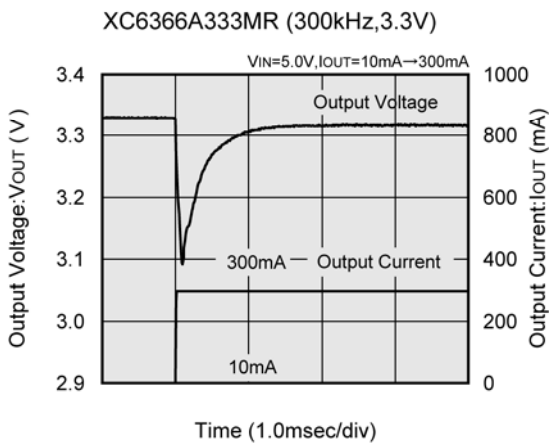
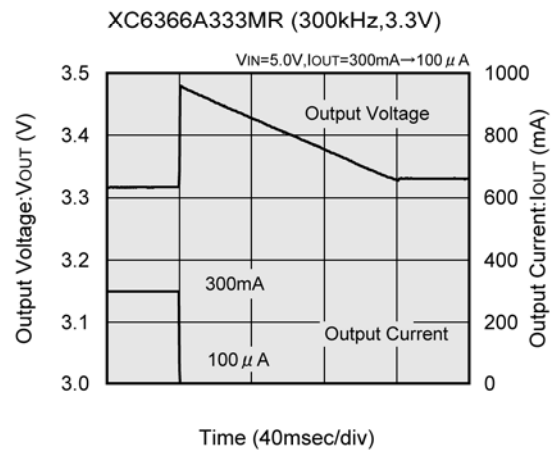
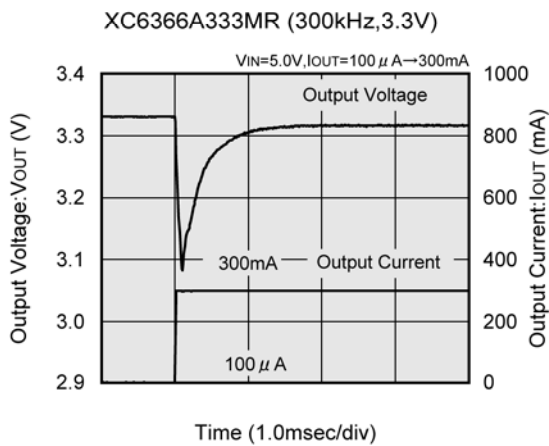
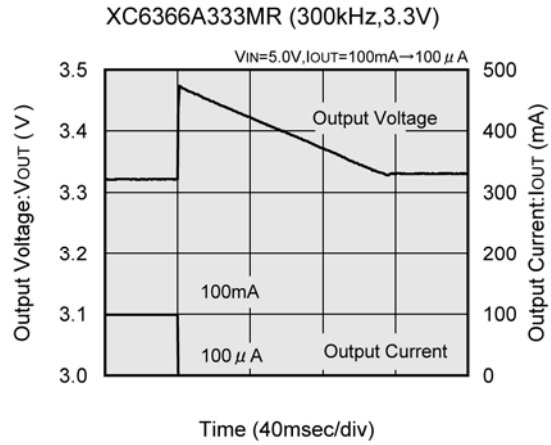
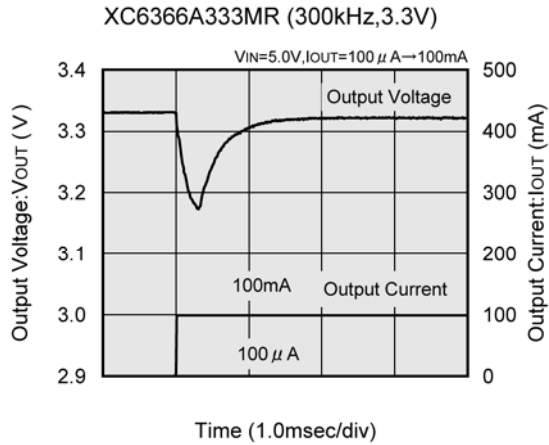


(15) Soft-Start Time vs. Ambient Temperature



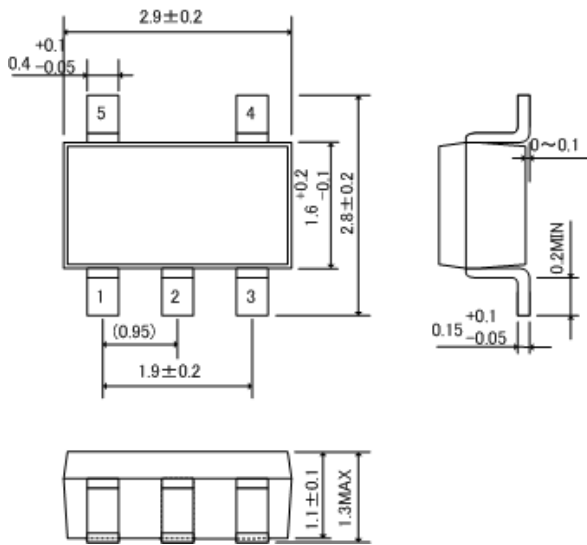
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(16) Load Transient Response

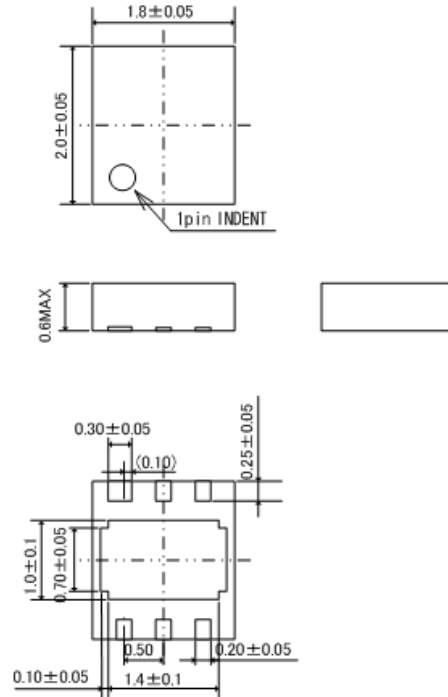


PACKAGING INFORMATION

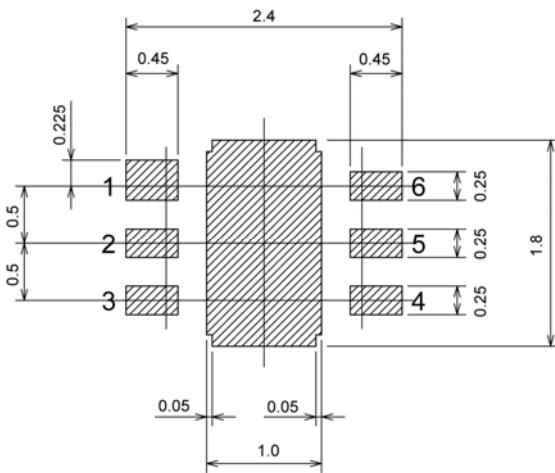
● SOT-25



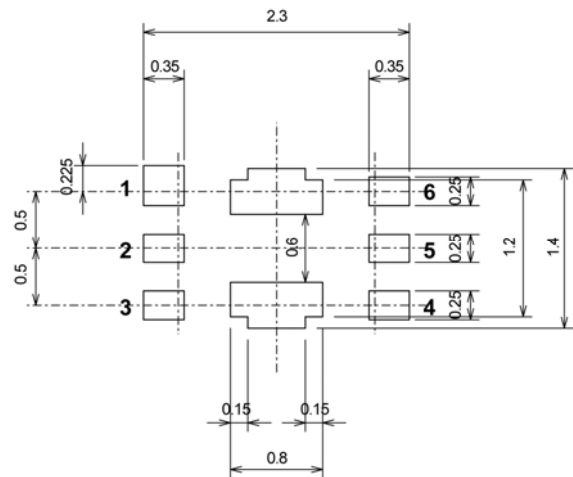
● USP-6C



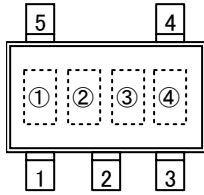
● USP-6C Reference Pattern Layout



● USP-6C Reference Metal Mask Design



MARKING RULE



SOT-25
(TOP VIEW)

① represents product classification

MARK	PRODUCT SERIES	MARK	PRODUCT SERIES
<u>A</u>	XC6365A	<u>K</u>	XC6366A
<u>B</u>	XC6365B	<u>L</u>	XC6366B
<u>C</u>	XC6365C	<u>M</u>	XC6366C
<u>D</u>	XC6365D	<u>N</u>	XC6366D

② represents integer of output voltage and oscillation frequency

OUTPUT VOLTAGE	OSCILLATION FREQUENCY (kHz)			
	100	180	300	500
1.x	<u>B</u>	<u>1</u>	<u>1</u>	<u>B</u>
2.x	<u>C</u>	<u>2</u>	<u>2</u>	<u>C</u>
3.x	<u>D</u>	<u>3</u>	<u>3</u>	<u>D</u>
4.x	<u>E</u>	<u>4</u>	<u>4</u>	<u>E</u>
5.x	<u>F</u>	<u>5</u>	<u>5</u>	<u>F</u>
6.x	<u>H</u>	<u>6</u>	<u>6</u>	<u>H</u>

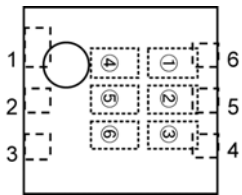
③ represents decimal number of output voltage and oscillation frequency

OUTPUT VOLTAGE	OSCILLATION FREQUENCY (kHz)			
	100	180	300	500
x.0	0	0	A	A
x.1	1	1	B	B
x.2	2	2	C	C
x.3	3	3	D	D
x.4	4	4	E	E
x.5	5	5	F	F
x.6	6	6	H	H
x.7	7	7	K	K
x.8	8	8	L	L
x.9	9	9	M	M

④ represents production lot number

0 to 9, A to Z repeated (G, I, J, O, Q, W excluded)

MARKING RULE (Continued)



USP-6C
(TOP VIEW)

① represents product series

MARK	PRODUCT SERIES
2	XC6365****E*
0	XC6366****E*

② represents product classification

MARK	PRODUCT SERIES
A	XC6365/66A***E*
B	XC6365/66B***E*
C	XC6365/66C***E*
D	XC6365/66D***E*

③④ represents output voltage

e.g.:

MARK		OUTPUT VOLTAGE (V)	PRODUCT SERIES
③	④		
3	3	3.3	XC6365/66*33*E*
5	0	5.0	XC6365/66*50*E*

⑤ represents oscillation frequency

MARK	OSCILLATION FREQUENCY	PRODUCT SERIES
2	180kHz	XC6365/66***2E*
3	300kHz	XC6365/66***3E*
5	500kHz	XC6365/66***5E*

⑥ represents production lot number

0 to 9, A to Z repeated (G, I, J, O, Q, W excluded)

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