

# XC6401 Series

Dual LDO Regulators, Low ESR Cap. Compatible

November 7, 2003 Ver. 4

Preliminary

- **Low Power Consumption** : 25  $\mu$ A (TYP)
- **Dropout Voltage** : 30mV @ 30mA  
: 100mV @ 100mA
- **Output Voltage Range** : 0.8 V to 5.0 V
- **Output Current** : More than 150 mA (300mA limit)
- **High Ripple Rejection Rate** : 70 dB @ 1kHz
- **Low Output Noise**
- **Low ESR capacitor compatible**

## ■ APPLICATIONS

- Mobile phones (PDC, GSM, CDMA, IMT2000 etc.)
- Cordless phones and radio communication equipment
- Portable games
- Cameras, Video recorders
- Portable AV equipment
- PDAs

## ■ GENERAL DESCRIPTION

The XC6401 series are highly accurate, Dual, low noise, CMOS LDO voltage regulators. Performance features of the series includes low output noise, high ripple rejection ratio, low dropout and very fast turn-on times.

The XC6401 includes a reference voltage source, error amplifiers, driver transistors, current limiters and phase compensators internally. The XC6401's current limiters' foldback circuit also operates as a short protect for the output current limiter.

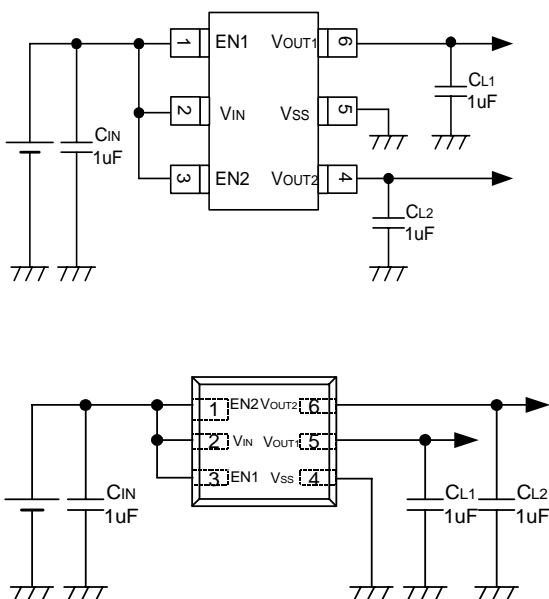
The output voltage for each regulator is set independently by laser trimming. Voltages are selectable in 50mV steps within a range of 0.8V to 5.0V. The XC6401 series is also fully compatible with low ESR ceramic capacitors, reducing cost and improving output stability. This high level of output stability is maintained even during frequent load fluctuations, due to the excellent transient response performance and high PSRR achieved across a broad range of frequencies.

The EN function allows the output of each regulator to be turned off independently, resulting in greatly reduced power consumption. The XC6401 series is available in the SOT-26W or USP-6B 'chip-scale' package.

## ■ FEATURES

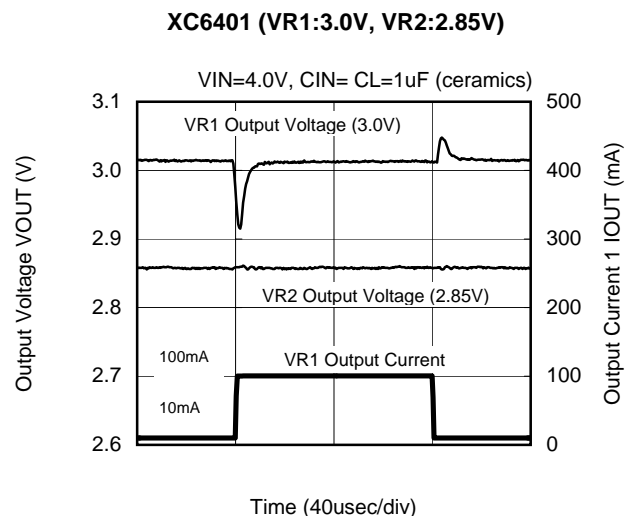
Maximum Output Current	: 150mA or more (300mA limit)
Dropout Voltage	: 100mV (IOUT=100mA)
Operating Voltage Range	: 1.5V ~ 6.0V
Output Voltage Range	: 0.8V ~ 5.0V (50mV Step)
Highly Accurate	: $\pm$ 2% (VOUT>1.5V) : $\pm$ 30mV (VOUT $\leq$ 1.5V)
Low Power Consumption	: 25 mA (TYP.)
Standby Current	: Less than 0.1 $\mu$ A (TYP.)
High Ripple Rejection	: 70dB (1kHz)
Operating Temperature Range	: -40°C ~ +85°C
Low ESR Capacitor Compatible	: Ceramic capacitor
Ultra Small Packages	: SOT-26W USP-6B

## ■ TYPICAL APPLICATION CIRCUITS



## ■ TYPICAL PERFORMANCE CHARACTERISTICS

○ Cross Talk

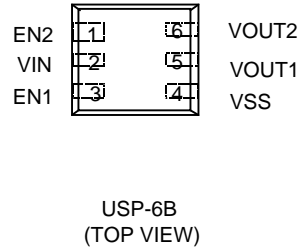
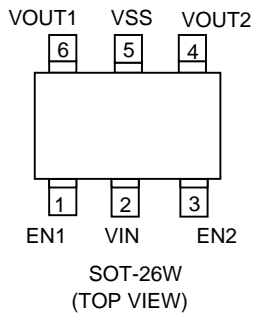


# XC6401 Series

Dual LDO Regulators, Low ESR Cap. Compatible

Preliminary

## ■ PIN CONFIGURATION



## ■ PIN ASSIGNMENT

PIN NUMBER		PIN NAME	FUNCTION
SOT-26W	USP-6B		
1	3	EN1	ON/OFF Control 1
2	2	VIN	Power Input
3	1	EN2	ON/OFF Control 2
4	6	VOUT2	Output 2
5	4	VSS	Ground
6	5	VOUT1	Output 1

\* A Pin number 1 is under the marking of the leftmost of 4 digits.

## ■ PRODUCT CLASSIFICATION

### ● SELECTION GUIDE

The following options for the Regulator 1, 2, the EN pin logic, internal pull-up / down are available.

### ● ORDERING INFORMATION

XC6401①②③④⑤⑥

DESIGNATOR	SYMBOL	DESCRIPTION	DESIGNATOR	SYMBOL	DESCRIPTION
①		Regulator 1, EN type	③④	01 ~	Internally set sequential number relating output voltage of each regulators  Regulator 1 Output Voltage Range : 0.8 ~ 5.0 V Regulator 2 Output Voltage Range : 0.8 ~ 5.0 V Both 1 and 2 can be set 50 mV steps
	E	Active 'High' (Pull-down resistor built in)			
	F	Active 'High' (No pull-down, resistor built in)			
	G	Active 'Low' (Pull-down resistor built in)			
	H	Active 'Low' (No pull-down, resistor built in)			
②		Regulator 2, EN type	⑤	D	USP-6B
	E	Active 'High' (Pull-down resistor built in)		M	SOT-26W
	F	Active 'High' (No pull-down, resistor built in)	⑥		Device Orientation
	G	Active 'Low' (Pull-down resistor built in)		R	Embossed Tape: Standard Feed
	H	Active 'Low' (No pull-down, resistor built in)		L	Embossed Tape: Reverse Feed

# XC6401 Series

Dual LDO Regulators, Low ESR Cap. Compatible

Preliminary

## ■ ABSOLUTE MAXIMUM RATINGS

Ta = 25°C

PARAMETER	SYMBOL	RATINGS	UNITS
Input Voltage	VIN	6.5	V
Output Current	IOUT1 + IOUT2	700	mA
Output Voltage	VOUT	VSS -0.3 ~ VIN +0.3	V
EN Pin Voltage	VEN	VSS -0.3 ~ VIN +0.3	V
Power Dissipation	SOT-26W	Pd	mW
	USP-6B		
Operating Ambient Temperature	Topr	-40 ~ +85	°C
Storage Temperature	Tstg	-55 ~ +125	°C

## ■ ELECTRICAL CHARACTERISTICS

### XC6401FFxx

#### Regulator 1, Regulator 2

Ta=25°C

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS	CIRCUIT
Output Voltage (Note 7)	VOUT (E)	VIN=VOUT (T) + 1.0V IOUT=30mA	× 0.98	VOUT(T)	× 1.02	V	1
Maximum Output Current	IOUTMAX	VIN=VOUT (T) + 1.0V	150			mA	1
Load Regulation	ΔVOUT	1mA≤IOUT≤100mA		15	60	mV	1
Dropout Voltage	Vdif1	IOUT=30mA		E-1		mV	1
	Vdif2	IOUT=100mA		E-2		mV	
Supply Current	ISS	VIN=VEN=VOUT (T) + 1.0V, IOUT=0mA		25	45	μA	2
Standby Current	ISTB	VIN=VOUT (T) + 1.0V, VEN=VSS		0.01	0.10	μA	3
Line Regulation	ΔVOUT / ΔVIN · VOUT	VOUT(T)+1.0V≤VIN≤6.0V IOUT=30mA		0.01	0.20	% / V	1
Input Voltage	VIN		1.5		6.0	V	
Output Voltage Temperature Characteristics	ΔVOUT / ΔTopr · VOUT	IOUT=30mA -40°C≤Topr≤85°C		±100		ppm/ °C	1
Ripple Rejection Rate	PSRR	IOUT=30mA, f=1kHz		70		dB	5
Current Limiter	Ilim	VIN=VOUT (T) + 1.0V, VEN=VIN		300		mA	1
Short-circuit Current	Ishort	VIN=VOUT (T) + 1.0V, VEN=VIN		30		mA	1
EN "High" Voltage	VENH		1.60		VIN	V	4
EN "Low" Voltage	VENL				0.25	V	4
EN "High" Current	IENH	VIN=VEN=VOUT (T) + 1.0V	-0.10		0.10	μA	4
EN "Low" Current	IENL	VIN=VEN=VOUT (T) + 1.0V, VEN=VSS	-0.10		0.10	μA	4

#### NOTE

(NOTE 1) VOUT(T)=Specified Output Voltage

(NOTE 2) VOUT(E)=Effective Output Voltage

(I.e. the output voltage when "VOUT(T)+1.0V" is provided at the VIN pin while maintaining a certain IOUT value).

(NOTE 3)  $V_{dif} = \{V_{IN1}^{(NOTE5)} - V_{OUT1}^{(NOTE4)}\}$

(NOTE 4) VOUT1=A voltage equal to 98% of the Output Voltage whenever an amply stabilized IOUT {VOUT(T)+1.0V} is input.

(NOTE 5) VIN1=The Input Voltage when VOUT1 appears as Input Voltage is gradually decreased.

(NOTE 6) Unless otherwise stated, VIN=VOUT(T)+1.0V

(NOTE 7) If VOUT (T) ≤ 1.45V, MIN VOUT (T) - 30mV

MAX VOUT (T) + 30mV

# XC6401 Series

Dual LDO Regulators, Low ESR Cap. Compatible

Preliminary

## ■ DROPOUT VOLTAGE

SETTING OUTPUT VOLTAGE (V)	OUTPUT VOLTAGE (V)		DROPOUT VOLTAGE 1 E-1 (mV)		DROPOUT VOLTAGE 2 E-2 (mV)	
	VOUT		Vdif 1		Vdif 2	
VOUT (T)	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.
0.80	0.770	0.830	300	700	400	800
0.85	0.820	0.880				
0.90	0.870	0.930	200	600	350	700
0.95	0.920	0.980				
1.00	0.970	1.030	100	500	270	600
1.05	1.020	1.080				
1.10	1.070	1.130	80	400	240	500
1.15	1.120	1.180				
1.20	1.170	1.230	65	300	200	400
1.25	1.220	1.280				
1.30	1.270	1.330	60	200	180	300
1.35	1.320	1.380				
1.40	1.370	1.430	55	100	165	250
1.45	1.420	1.480				
1.50	1.470	1.530	50	75	150	200
1.55	1.519	1.581				
1.60	1.568	1.632				
1.65	1.617	1.683				
1.70	1.666	1.734				
1.75	1.715	1.785				
1.80	1.764	1.836	45	65	140	180
1.85	1.813	1.887				
1.90	1.862	1.938				
1.95	1.911	1.989	40	60	120	170
2.00	1.960	2.040				
2.05	2.009	2.091				
2.10	2.058	2.142				
2.15	2.107	2.193				
2.20	2.156	2.244				
2.25	2.205	2.295				
2.30	2.254	2.346				
2.35	2.303	2.397	35	55	110	160
2.40	2.352	2.448				
2.45	2.401	2.499				
2.50	2.450	2.550				
2.55	2.499	2.601				
2.60	2.548	2.652				
2.65	2.597	2.703				
2.70	2.646	2.754				
2.75	2.695	2.805				
2.80	2.744	2.856				
2.85	2.793	2.907				
2.90	2.842	2.958				
2.95	2.891	3.009				

# XC6401 Series

Dual LDO Regulators, Low ESR Cap. Compatible

Preliminary

## ■ DROPOUT VOLTAGE

SETTING OUTPUT VOLTAGE (V)	OUTPUT VOLTAGE (V)		DROPOUT VOLTAGE 1 E-1 (mV)		DROPOUT VOLTAGE 2 E-2 (mV)	
	VOUT		Vdif 1		Vdif 2	
VOUT (T)	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.
3.00	2.940	3.060	30	45	100	150
3.05	2.989	3.111				
3.10	3.038	3.162				
3.15	3.087	3.213				
3.20	3.136	3.264				
3.25	3.185	3.315				
3.30	3.234	3.366				
3.35	3.283	3.417				
3.40	3.332	3.468				
3.45	3.381	3.519				
3.50	3.430	3.570				
3.55	3.479	3.621				
3.60	3.528	3.672				
3.65	3.577	3.723				
3.70	3.626	3.774				
3.75	3.675	3.825				
3.80	3.724	3.876				
3.85	3.773	3.927				
3.90	3.822	3.978				
3.95	3.871	4.029				
4.00	3.920	4.080				
4.05	3.969	4.131				
4.10	4.018	4.182				
4.15	4.067	4.233				
4.20	4.116	4.284				
4.25	4.165	4.335				
4.30	4.214	4.386				
4.35	4.263	4.437				
4.40	4.312	4.488				
4.45	4.361	4.539				
4.50	4.410	4.590				
4.55	4.459	4.641				
4.60	4.508	4.692				
4.65	4.557	4.743				
4.70	4.606	4.794				
4.75	4.655	4.845				
4.80	4.704	4.896				
4.85	4.753	4.947				
4.90	4.802	4.998				
4.95	4.851	5.049				
5.00	4.900	5.100				

# XC6401 Series

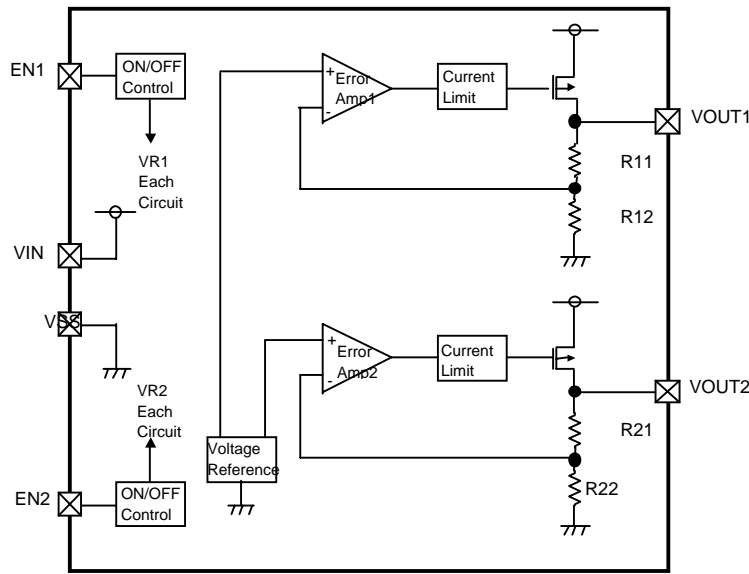
Dual LDO Regulators, Low ESR Cap. Compatible

Preliminary

## ■ OPERATIONAL EXPLANATION

### Output voltage control with the XC6401 series:

The voltage divided by resistors R1 & R2 is compared with the internal reference voltage by the error amplifier. The P-Channel MOSFETs, which are connected to the VOUT1 and VOUT2 pins, are then driven by the subsequent output signal. The output voltages at the VOUT1 and VOUT2 pins are controlled and stabilized by a system of negative feedback. The current limit circuit and short protect circuit operate in relation to the level of output current. Further, the IC's internal circuitry can be shutdown via the EN pin's signal.



### Low ESR Capacitors

With the XC6401 series, a stable output voltage is achievable even if used with low ESR capacitors as a phase compensation circuit is built-in. In order to ensure the effectiveness of the phase compensation, we suggest that output capacitors (CL1, CL2) is connected as close as possible to the output pins (VOUT1 and VOUT2) and the VSS pin. Please use an output capacitor with a capacitance value of at least 1 $\mu$ F. Also, please connect an input capacitor (CIN) of 0.1 $\mu$ F between the VIN pin and the VSS pin in order to ensure a stable power input.

### Current Limiter, Short-Circuit Protection

The XC6401 series includes a combination of a fixed current limiter circuit & a foldback circuit which aid the operations of the current limiter and circuit protection. When the load current reaches the current limit level, the fixed current limiter circuit operates and output voltage drops. As a result of this drop in output voltage, the foldback circuit operates, output voltage drops further and output current decreases. When the output pin is shorted, a current of about 30mA flows.

### EN Pins

The IC's internal circuitry can be shutdown via the signal from the EN1 and EN2 pins with the XC6401 series. In shutdown mode, output at the VOUT1 and VOUT2 pins will be pulled down to the VSS level via R11 & R12 and R21 & R22. The operational logic of the IC's EN1 and EN2 pins are selectable (please refer to the selection guide on page 2). Note that as the standard XC6401FF type's regulator 1 and 2 are both 'High Active/No Pull Down', operations will become unstable with the EN1 or EN2 pins open. Although the EN1 and EN2 pins are equal to an inverter input with CMOS hysteresis, with either the pull-up or pull-down options, the EN1 and EN2 pins input current will increase when the IC is in operation. We suggest that you use this IC with either a VIN voltage or a VSS voltage input at the EN1 and EN2 pins. If this IC is used with the correct specifications for the EN1 and EN2 pins, the operational logic is fixed and the IC will operate normally. However, supply current may increase as a result of through current in the IC's internal circuitry.

## ■ NOTE ON USE

- 1 Please use this IC within the stated absolute maximum ratings.  
The IC is liable to malfunction should the ratings be exceeded.
- 2 Where wiring impedance is high, operations may become unstable due to noise and/or phase lag depending on output current. Please keep the resistance low between VIN and VSS wiring in particular.
- 3 Please wire the input capacitor (CIN) and the output capacitors (CL1, CL2) as close to the IC as possible.

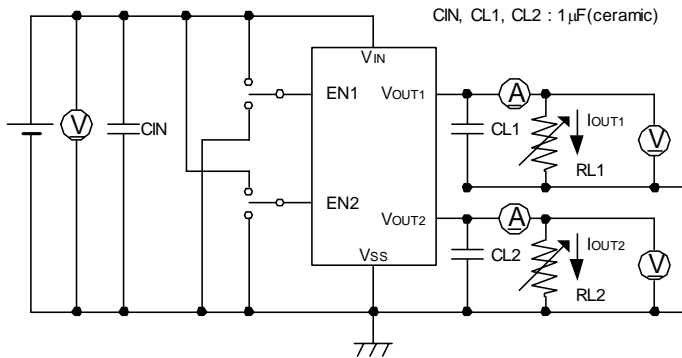
# XC6401 Series

Dual LDO Regulators, Low ESR Cap. Compatible

Preliminary

## TEST CIRCUITS

Circuit ①

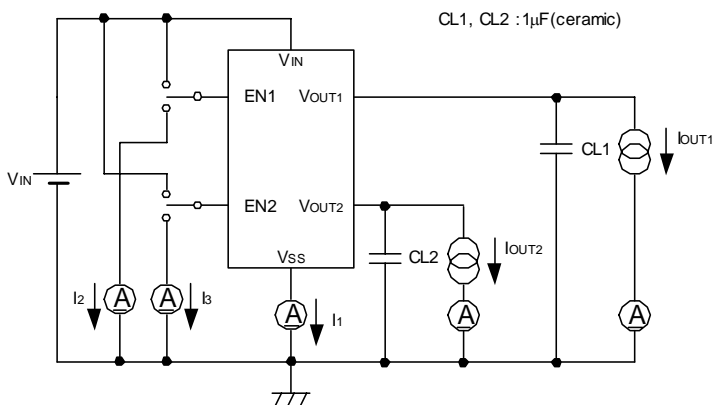


**EN1/EN2 :**

Active 'High' = EN=VIN

Active 'Low' = EN=VSS

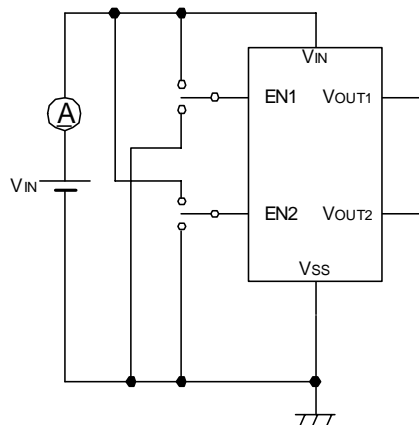
Circuit ②



**EN1/EN2 :**

- Active 'High' (Pull-down resistor built-in)  
VR1 Supply Current  $ISS1=I1$  (Note:EN1=ON, EN2=OFF)  
VR2 Supply Current  $ISS2=I1$  (Note:EN1=OFF, EN2=ON)
- Active 'High' (Pull-down, no resistor built-in)  
VR1 Supply Current  $ISS1=I1$  (Note:EN1=ON, EN2=OFF)  
VR2 Supply Current  $ISS2=I1$  (Note:EN1=OFF, EN2=ON)
- Active 'Low' (Pull-up resistor built-in)  
VR1 Supply Current  $ISS1=I1+I2$  (Note:EN1=ON, EN2=OFF)  
VR2 Supply Current  $ISS2=I1+I3$  (Note:EN1=OFF, EN2=ON)
- Active 'Low' (Pull-up, no resistor built-in)  
VR1 Supply Current  $ISS1=I1$  (Note:EN1=ON, EN2=OFF)  
VR2 Supply Current  $ISS2=I1$  (Note:EN1=OFF, EN2=ON)

Circuit ③



**EN1/EN2 :**

Active 'High' = EN=VSS

Active 'Low' = EN=VIN

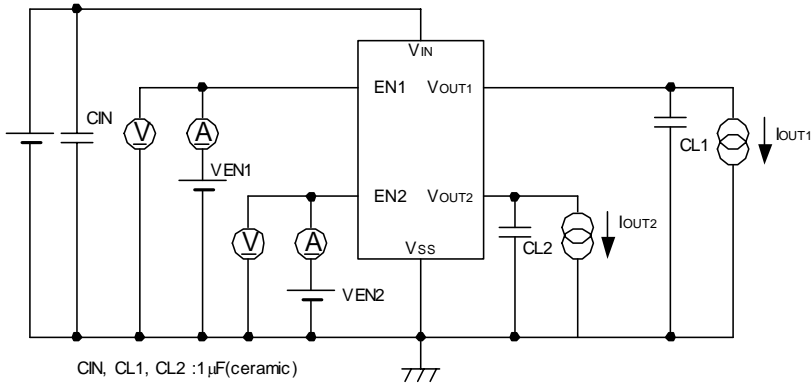
# XC6401 Series

Dual LDO Regulators, Low ESR Cap. Compatible

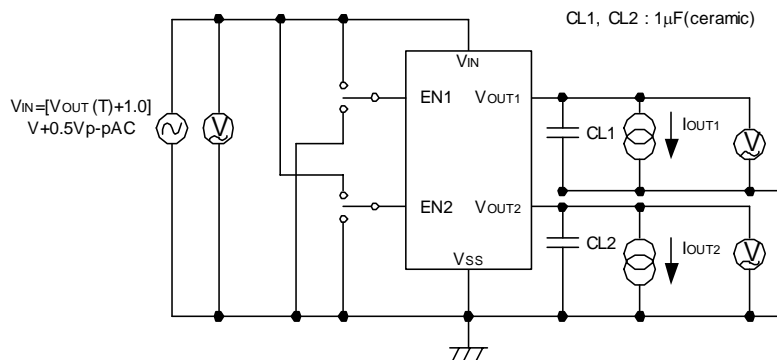
Preliminary

## ■ TEST CIRCUITS (Continued)

Circuit ④



Circuit ⑤



**EN1/EN2 :**

Active 'High' = EN=VIN

Active 'Low' = EN=VSS



# XC6401 Series

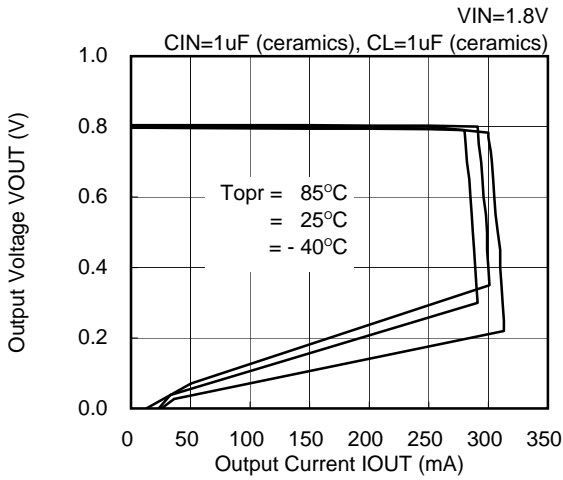
Dual LDO Regulators, Low ESR Cap. Compatible

Preliminary

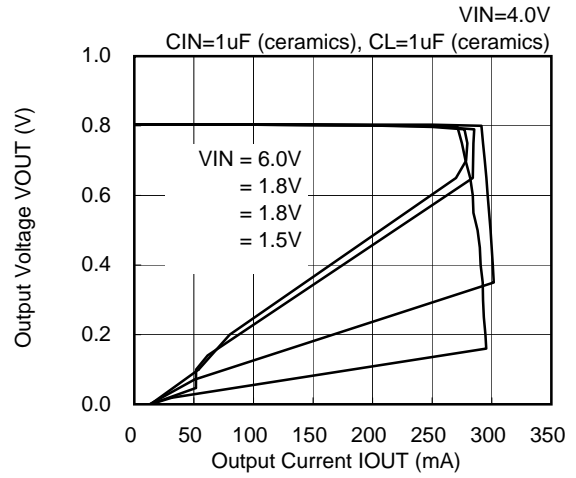
## TYPICAL PERFORMANCE CHARACTERISTICS

(1) Output Voltage vs. Output Current

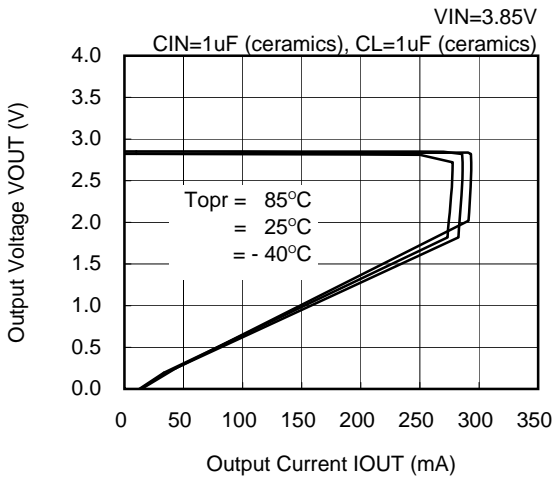
**XC6401 (0.8V)**



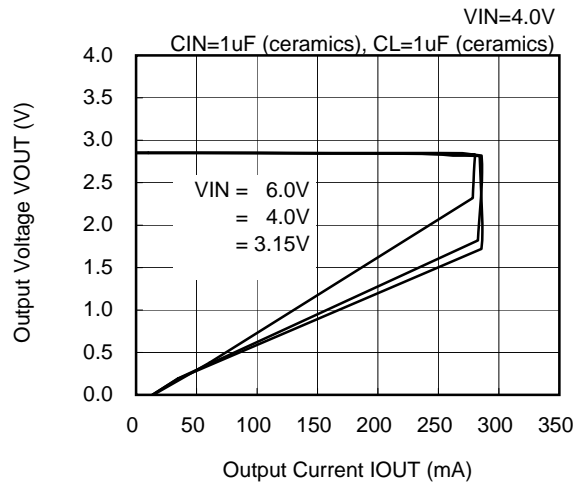
**XC6401(0.8V)**



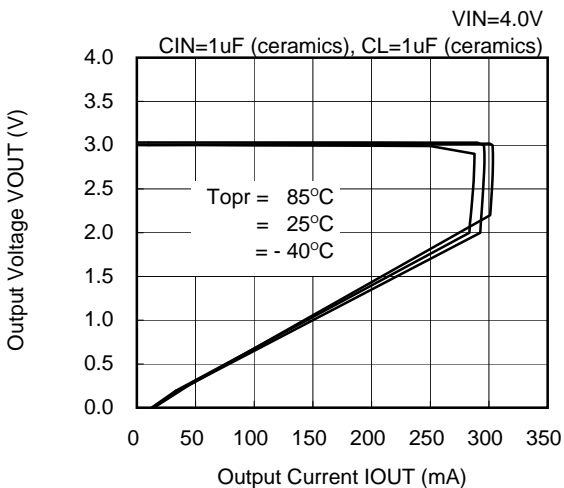
**XC6401(2.85V)**



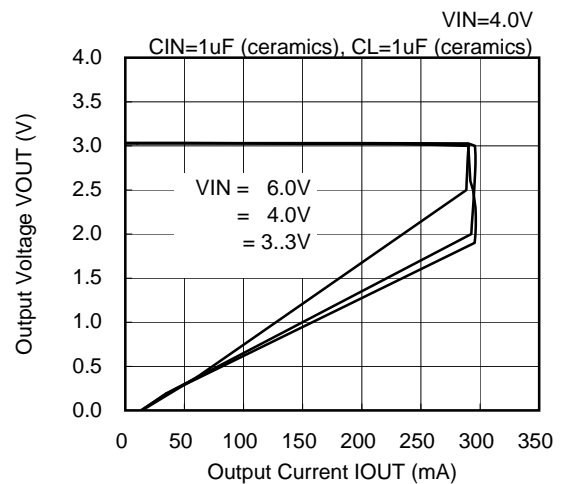
**XC6401(2.85V)**



**XC6401(3.0V)**



**XC6401(3.0V)**

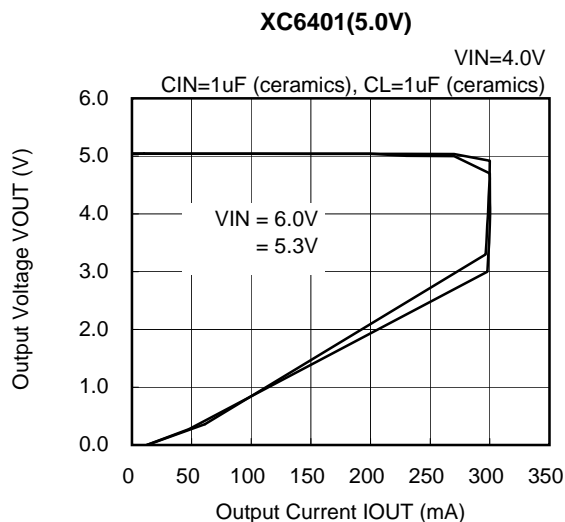
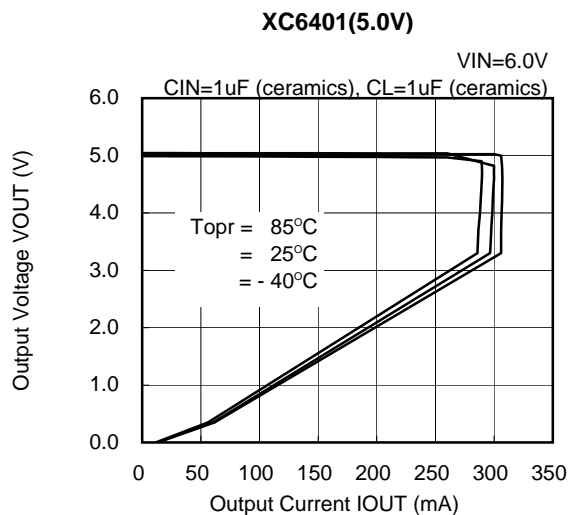


# XC6401 Series

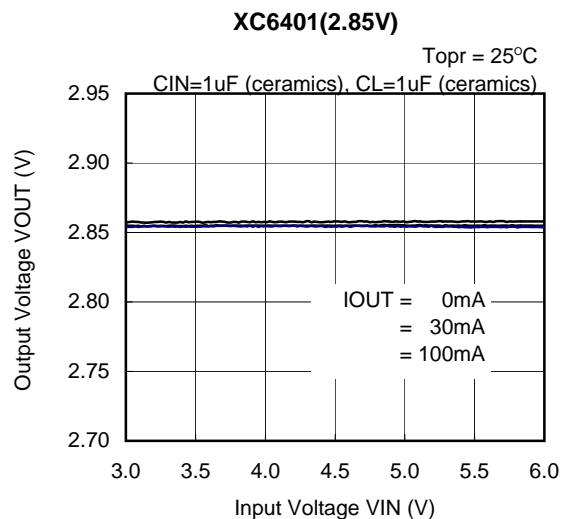
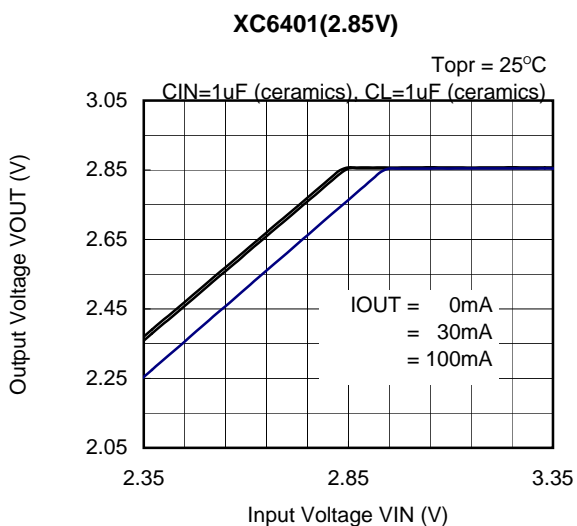
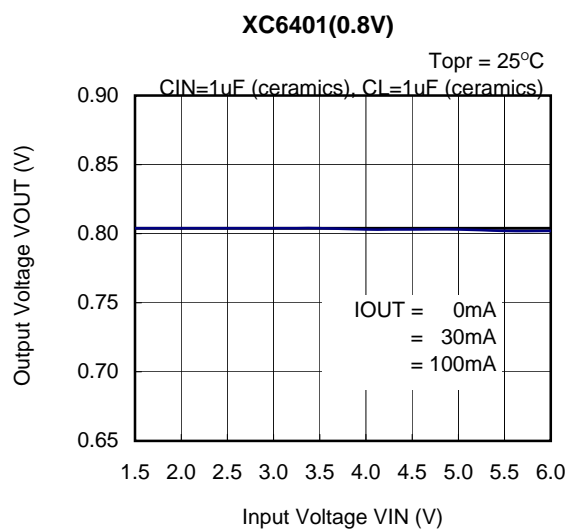
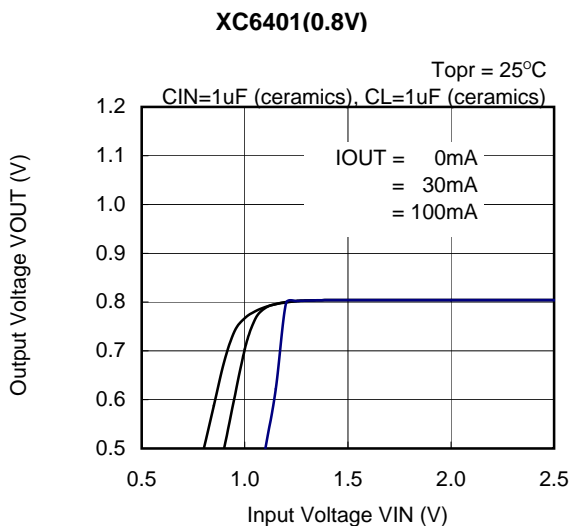
Dual LDO Regulators, Low ESR Cap. Compatible

Preliminary

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



## (2) Output Voltage vs. Input Voltage

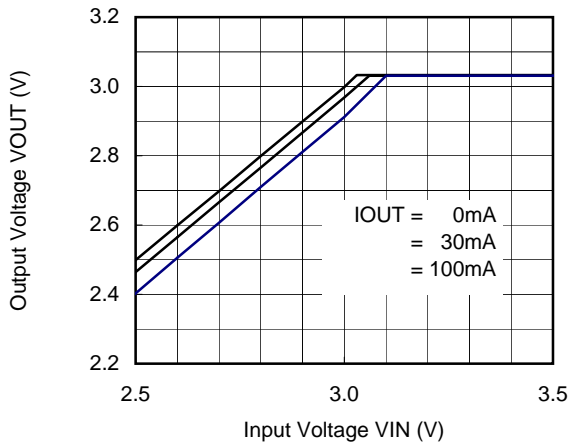


# XC6401 Series

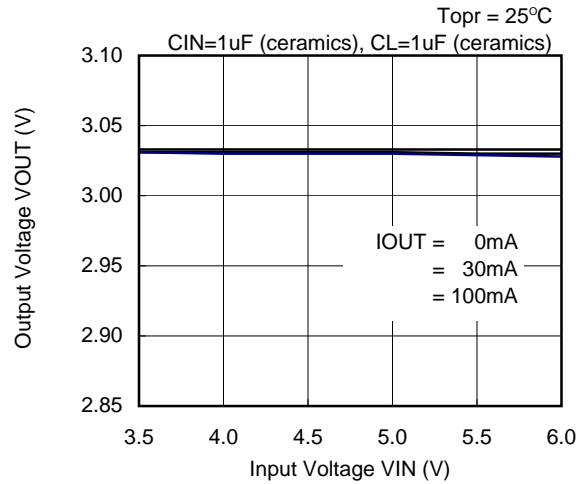
Dual LDO Regulators, Low ESR Cap. Compatible  
Preliminary

## (2) Output Voltage vs. Input Voltage (Continued)

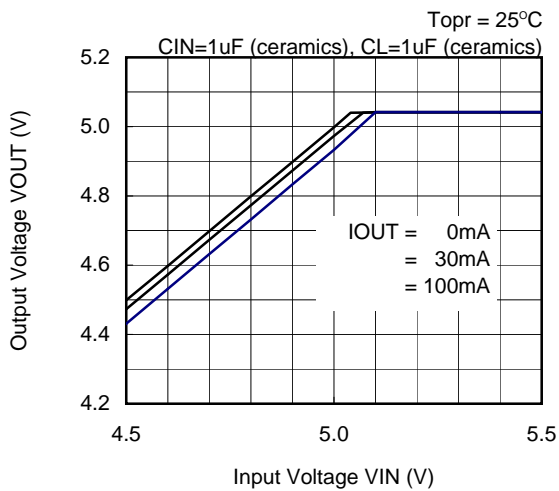
**XC6401(3.0V)**



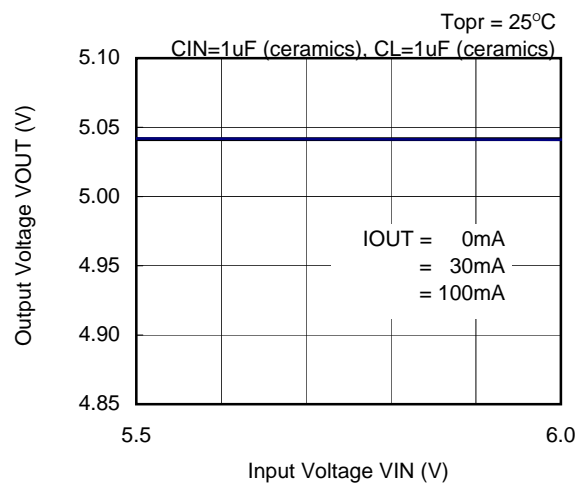
**XC6401(3.0V)**



**XC6401(5.0V)**

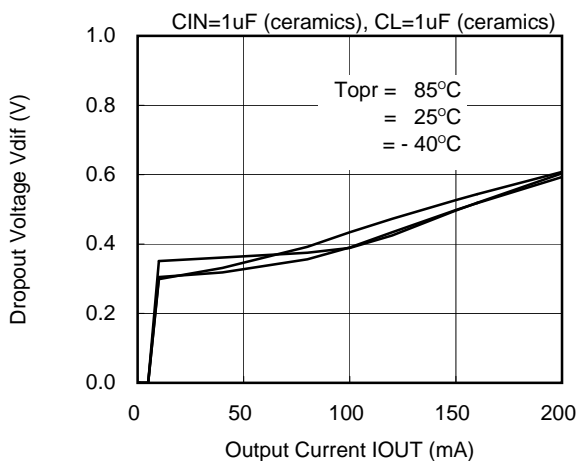


**XC6401(5.0V)**

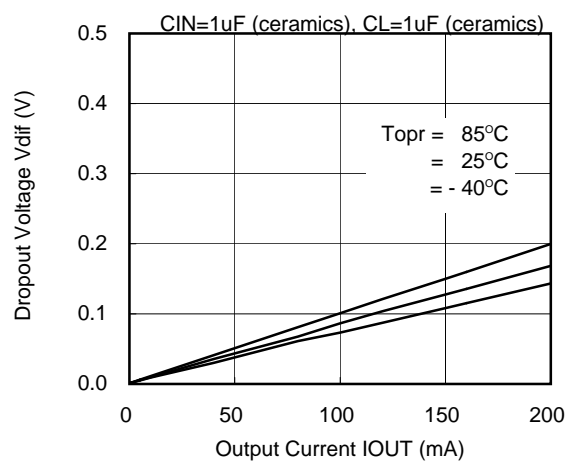


## (3) Dropout Voltage vs. Output Current

**XC6401(0.8V)**



**XC6401(2.85V)**

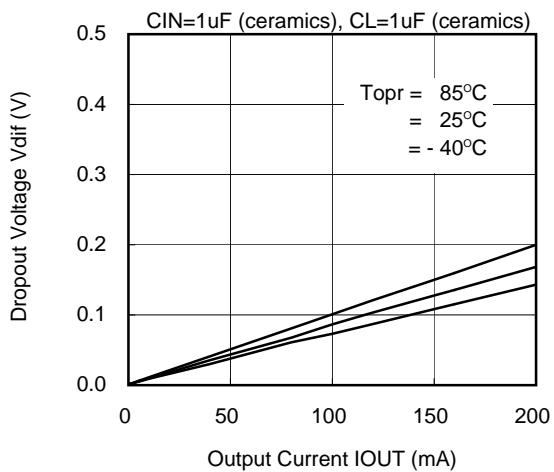


# XC6401 Series

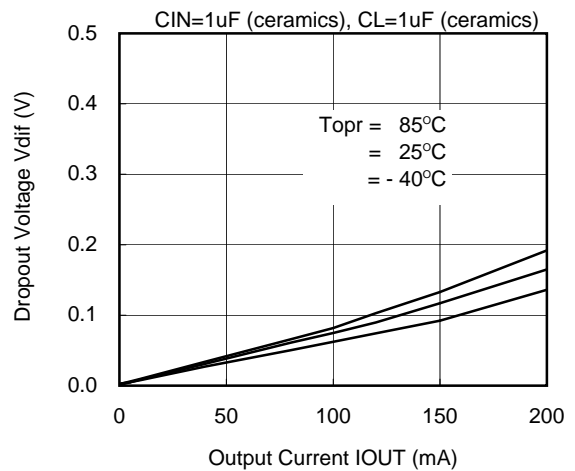
Dual LDO Regulators, Low ESR Cap. Compatible  
Preliminary

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

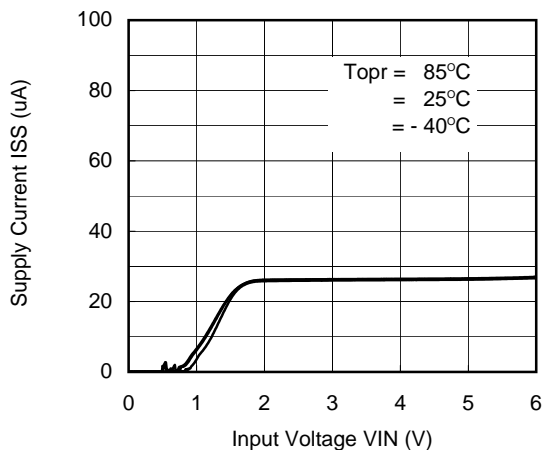
### XC6401(3.0V)



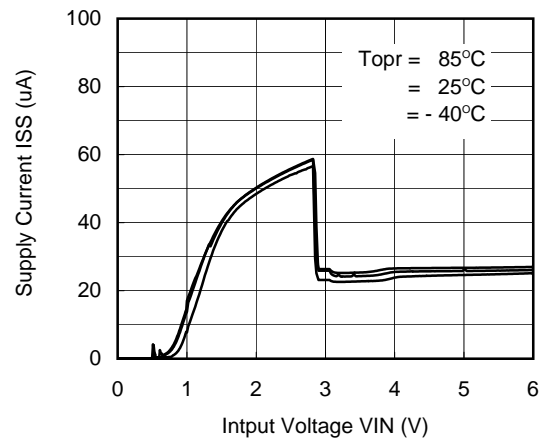
### XC6401(5.0V)



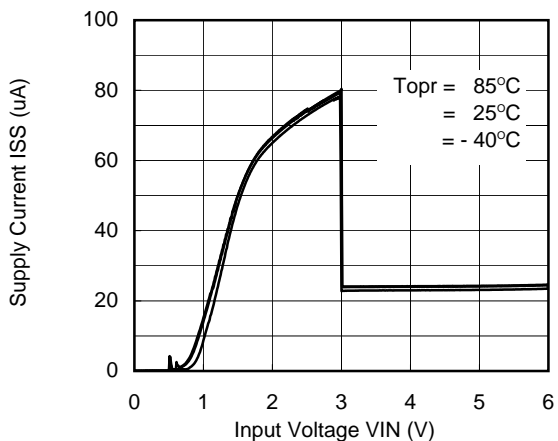
### XC6401(0.8V)



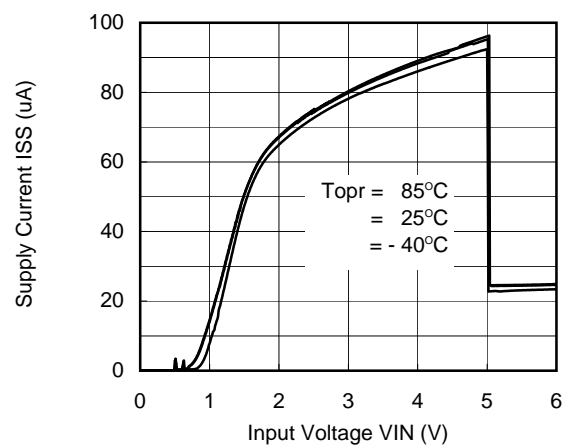
### XC6401(2.85V)



### XC6401(3.0V)



### XC6401(5.0V)

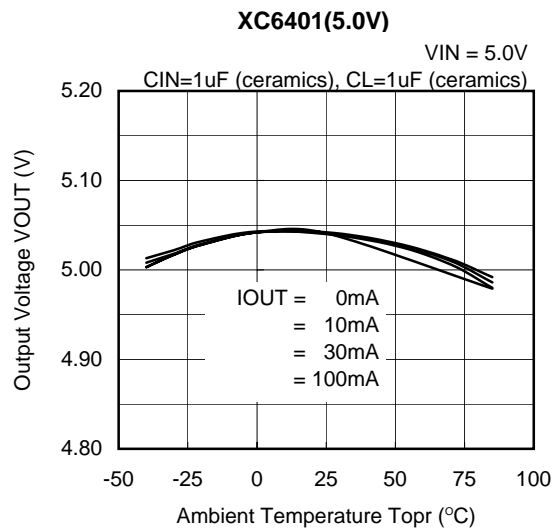
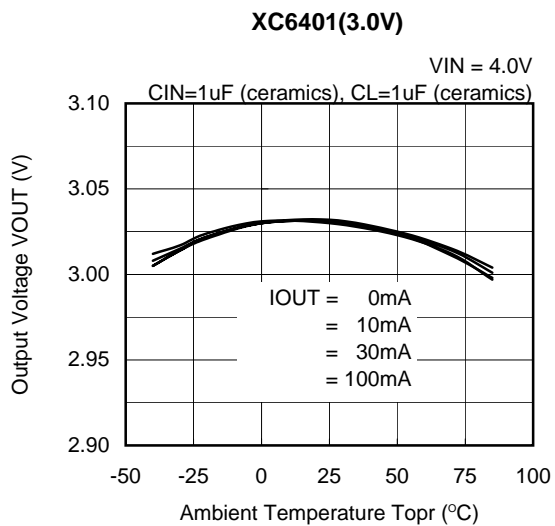
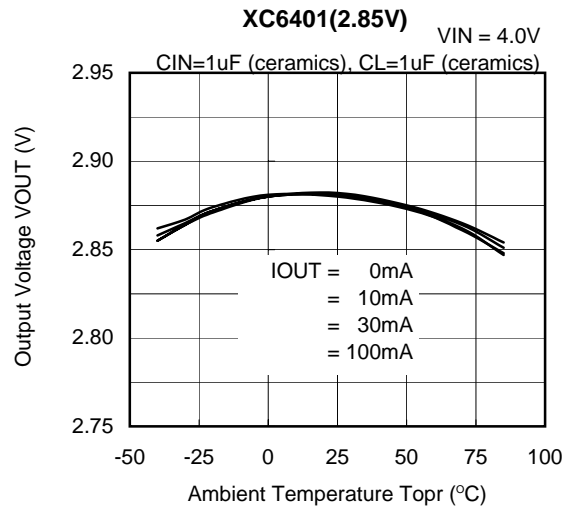
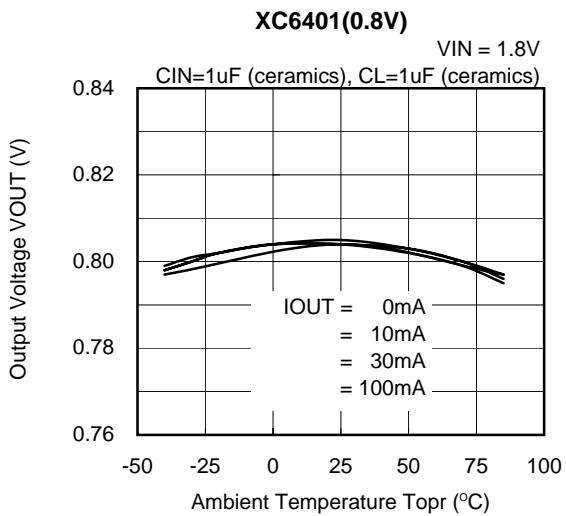


# XC6401 Series

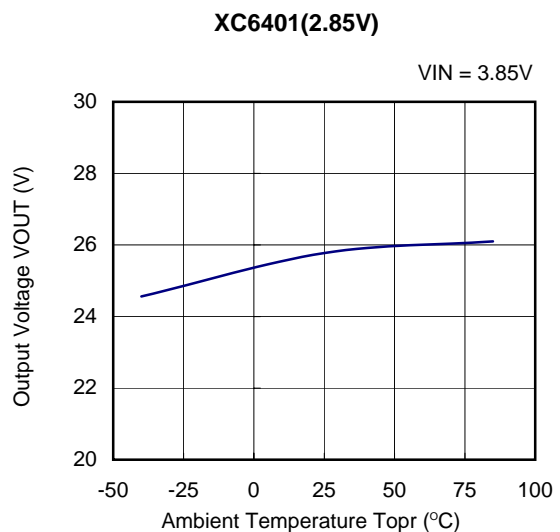
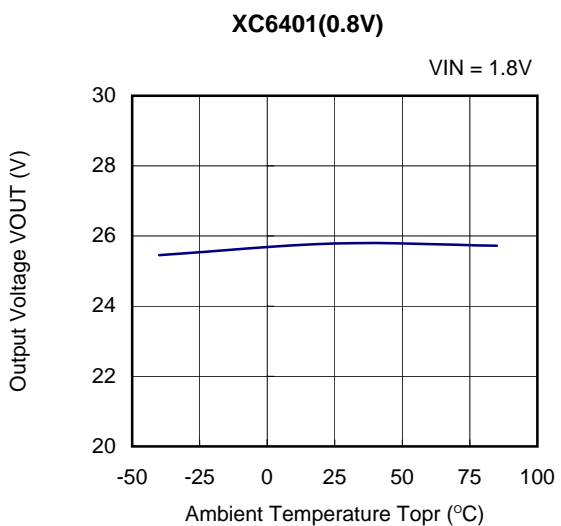
Dual LDO Regulators, Low ESR Cap. Compatible

Preliminary

## (5) Output Voltage vs. Ambient Temperature



## (6) Supply Current vs. Ambient Temperature

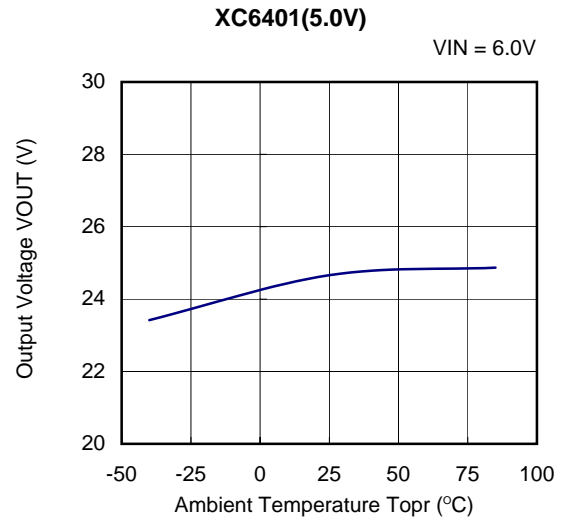
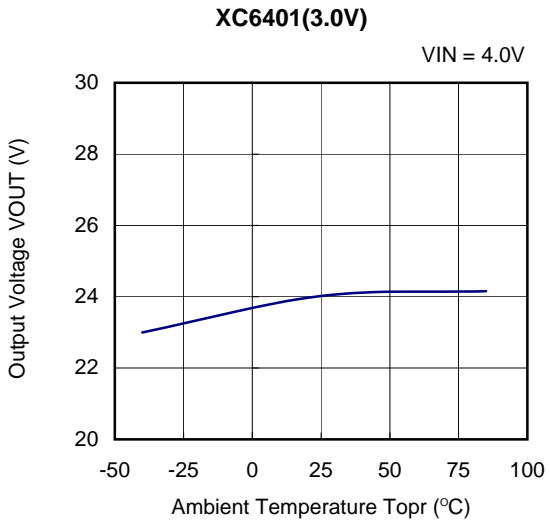


# XC6401 Series

Dual LDO Regulators, Low ESR Cap. Compatible

Preliminary

(6) Supply Current vs. Ambient Temperature (Continued)

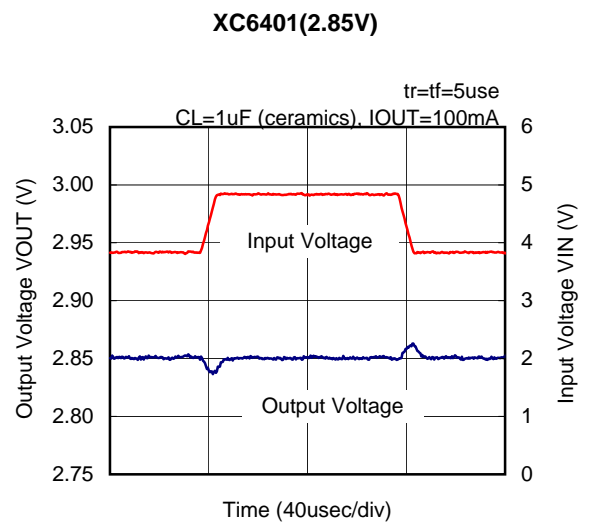
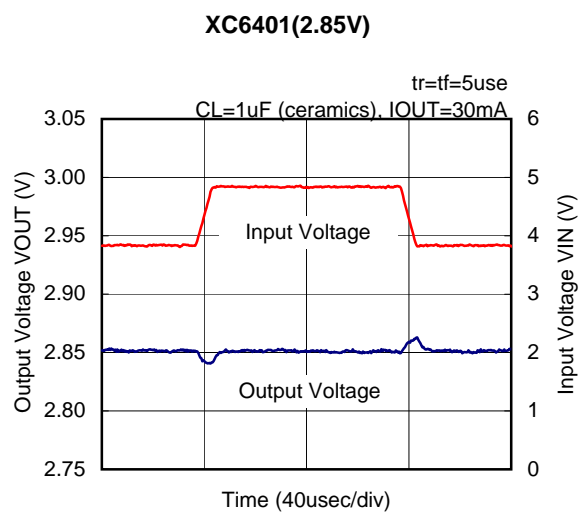
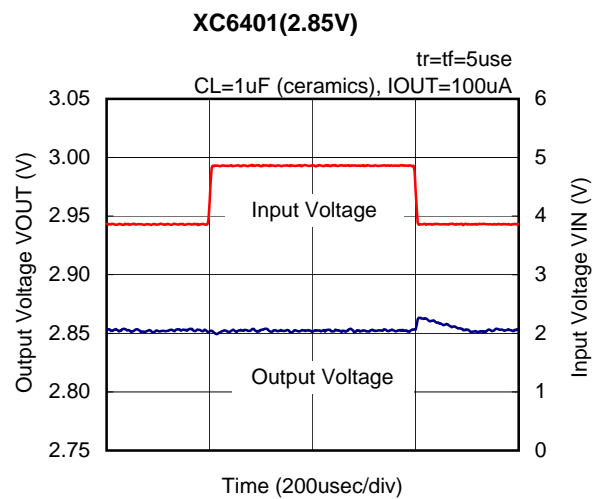
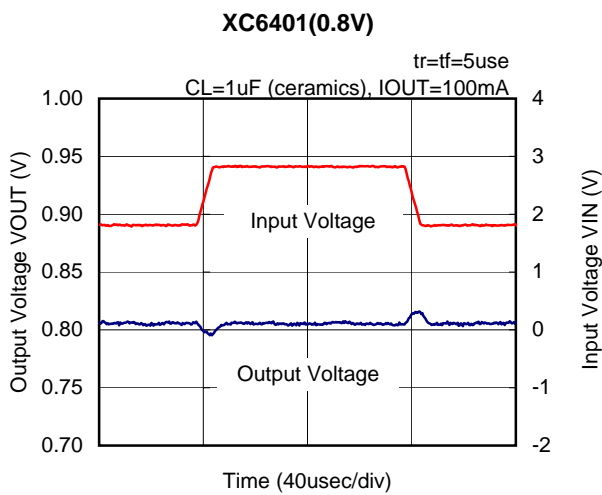
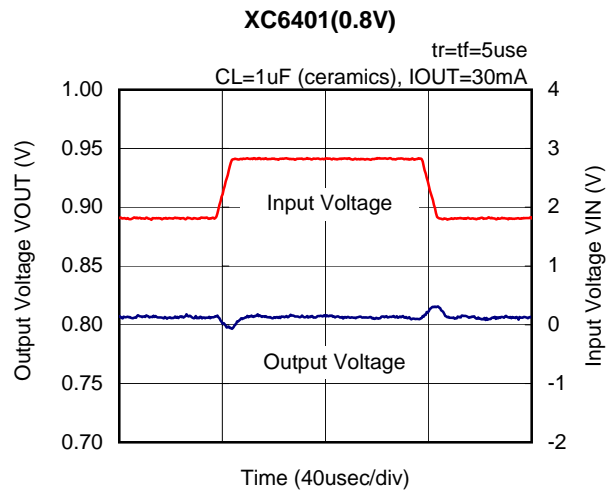
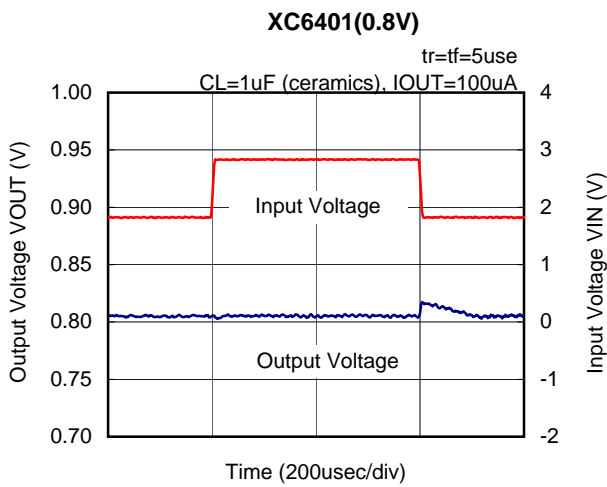


# XC6401 Series

Dual LDO Regulators, Low ESR Cap. Compatible

Preliminary

## (7) Input Transient Response

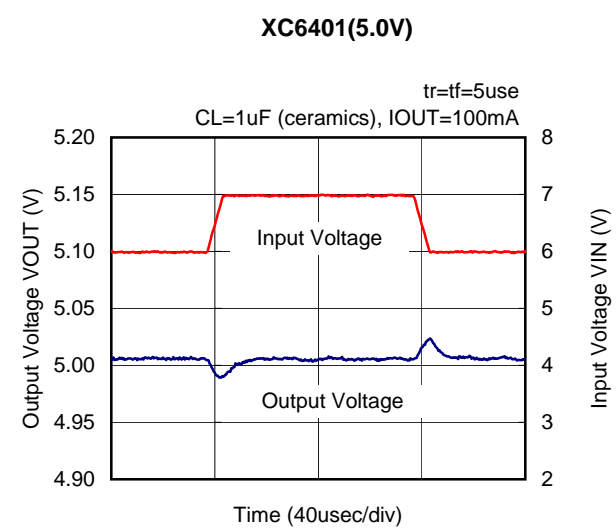
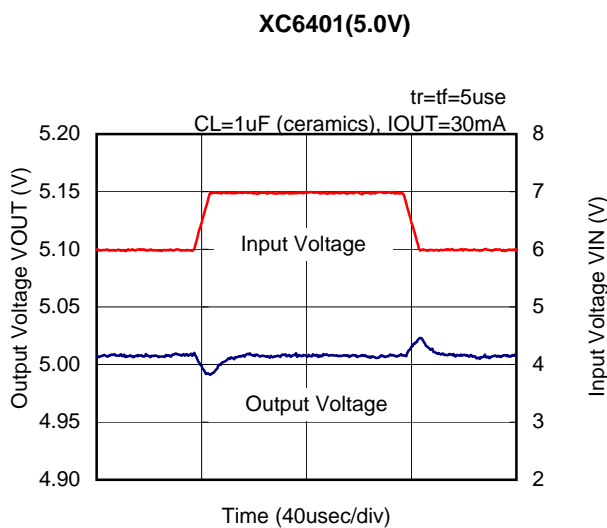
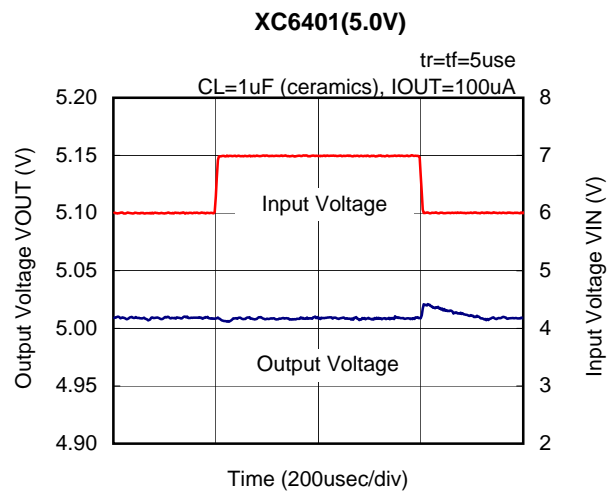
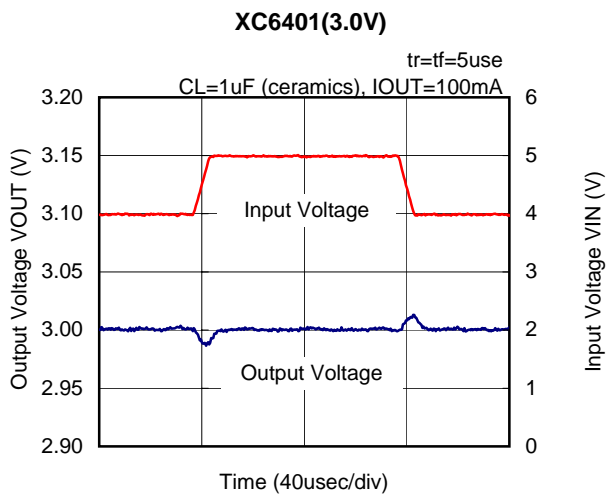
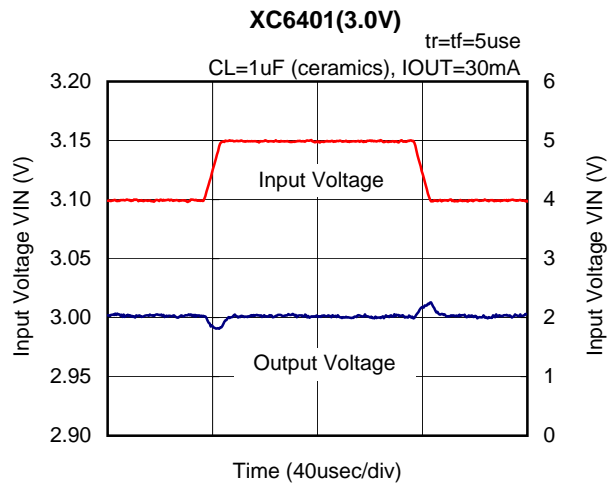
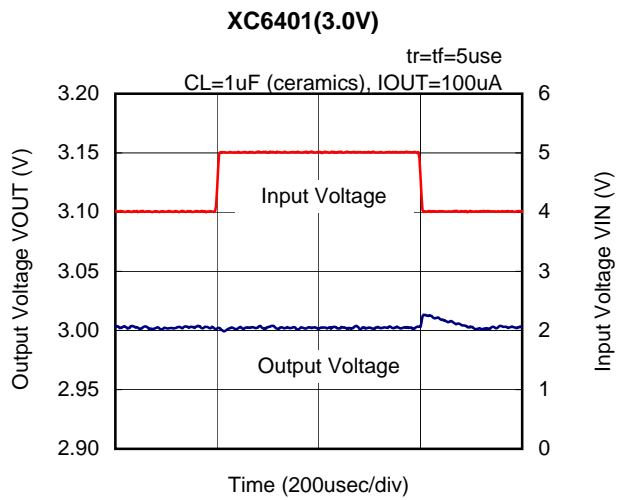


# XC6401 Series

Dual LDO Regulators, Low ESR Cap. Compatible

Preliminary

## (7) Input Transient Response (Continued)





# XC6401 Series

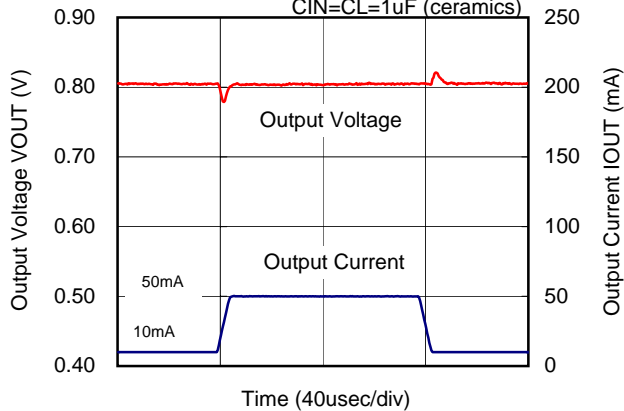
Dual LDO Regulators, Low ESR Cap. Compatible

Preliminary

## (8) Load Transient Response

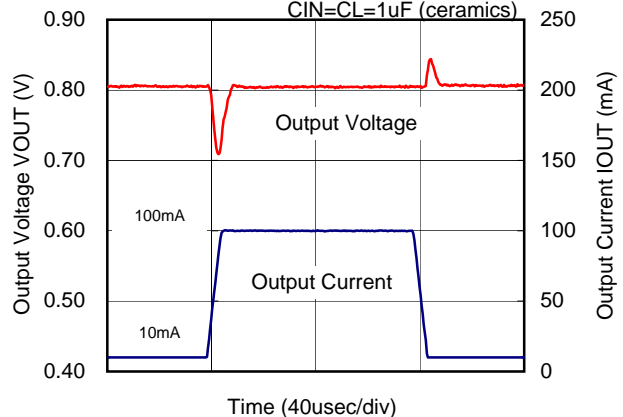
**XC6401(0.8V)**

VIN=1.8V, tr=tf=5use  
CIN=CL=1uF (ceramics)



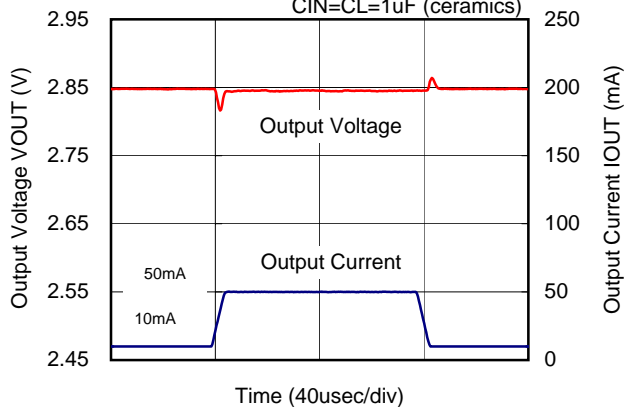
**XC6401(0.8V)**

VIN=1.8V, tr=tf=5use  
CIN=CL=1uF (ceramics)



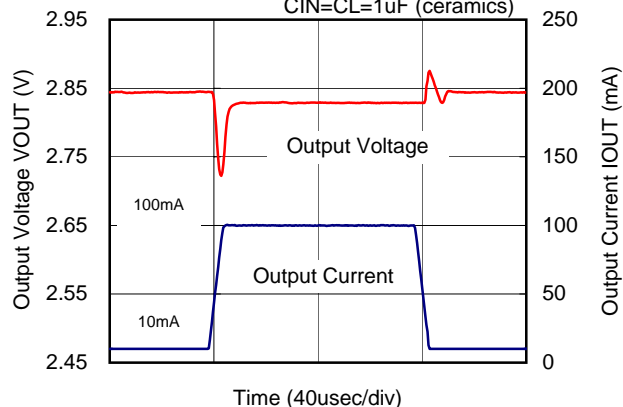
**XC6401(2.85V)**

VIN=4.0V, tr=tf=5use  
CIN=CL=1uF (ceramics)



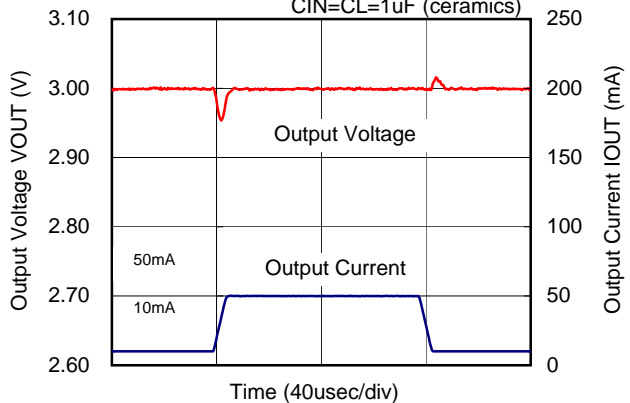
**XC6401(2.85V)**

VIN=4.0V, tr=tf=5use  
CIN=CL=1uF (ceramics)



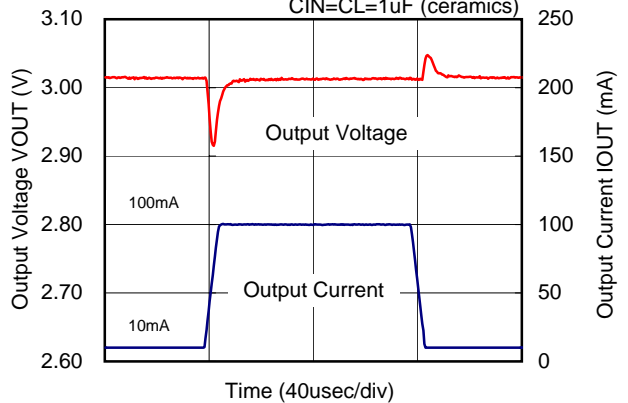
**XC6401(3.0V)**

VIN=4.0V, tr=tf=5use  
CIN=CL=1uF (ceramics)



**XC6401(3.0V)**

VIN=4.0V, tr=tf=5use  
CIN=CL=1uF (ceramics)

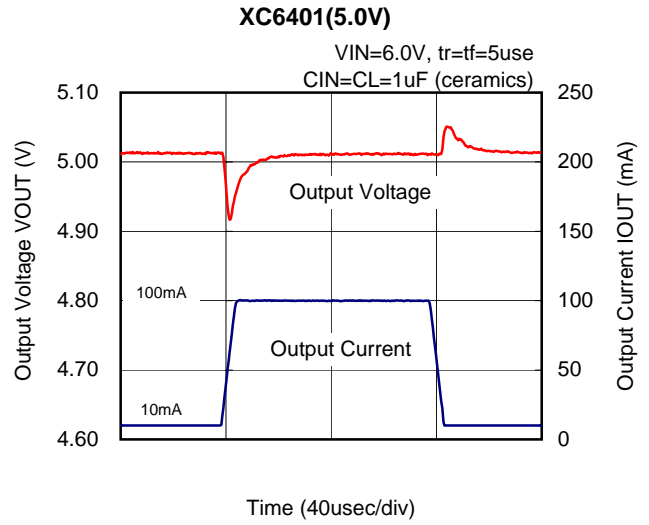
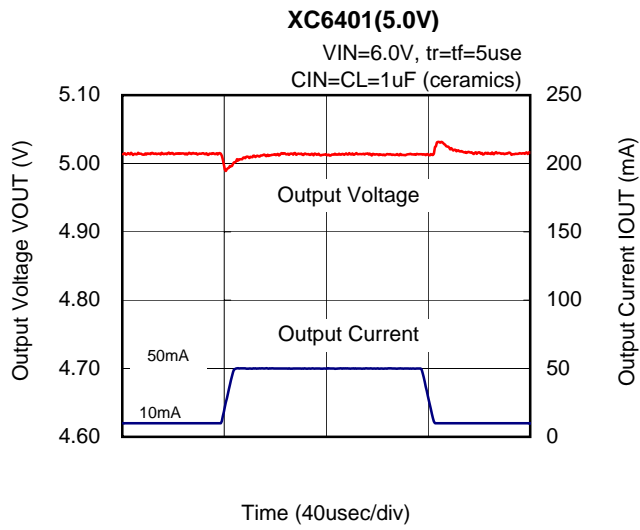


# XC6401 Series

Dual LDO Regulators, Low ESR Cap. Compatible

Preliminary

(8) Load Transient Response (Continued)



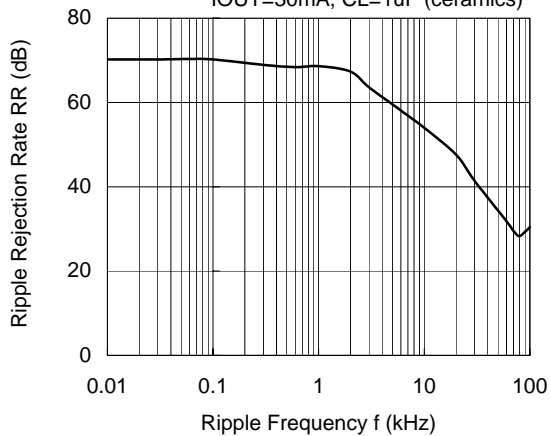
# XC6401 Series

Dual LDO Regulators, Low ESR Cap. Compatible  
Preliminary

## (9) Ripple Rejection Rate

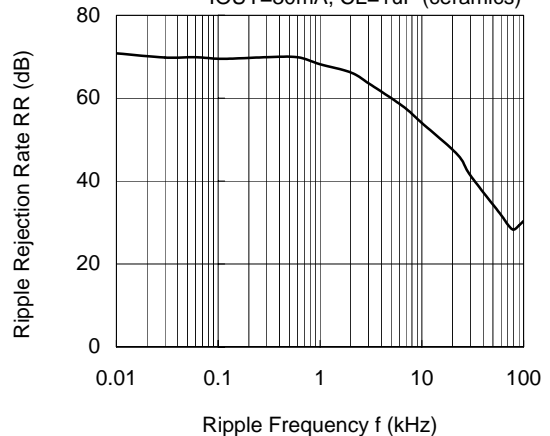
**XC6401(0.8V)**

VIN=1.8V DC+0.5Vp-pAC  
IOUT=30mA, CL=1uF (ceramics)



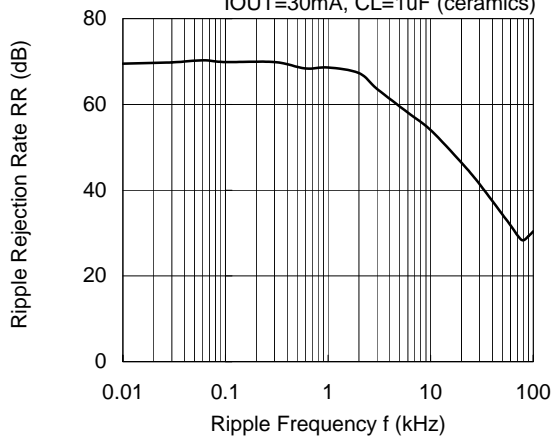
**XC6401(2.85V)**

VIN=3.85V DC+0.5Vp-pAC  
IOUT=30mA, CL=1uF (ceramics)



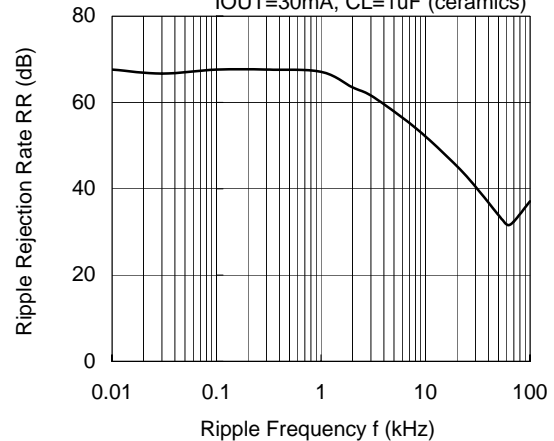
**XC6401(3.0V)**

VIN=4.0V DC+0.5Vp-pAC  
IOUT=30mA, CL=1uF (ceramics)



**XC6401(5.0V)**

VIN=5.75V DC+0.5Vp-pAC  
IOUT=30mA, CL=1uF (ceramics)



## (10) Cross Talk

**XC6401 (VR1:3.0V, VR2:2.85V)**

VIN=4.0V, CIN= CL=1uF (ceramics)

