XC6204E, F, G, H Series

High Speed LDO Regulators

Preliminary

Output On/Off Control

Feb. 7, 2003 Ver. 2

- **CMOS Low Power Consumption**
- **Dropout Voltage :**
  60mV @ 30mA, 200mV @ 100mA
- **Maximum Output Current : 300mA**
  300mA (VOUT≥2.0V, VIN=VOUT+1V)
  (VOUT<2.0V, VIN=3.0V)
- **Highly Accurate : ± 2% (±1% as semi-custom)**
- **Output Voltage Range : 1.8V ~ 6.0V**
- **Low ESR capacitor compatible**

■ Applications

- Mobile phones
- Cordless phones
- Cameras, video recorders
- Portable games
- Portable AV equipment
- Reference voltage
- Battery powered equipment

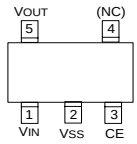
■ General Description

The XC6204 series are highly accurate, low noise, CMOS LDO Voltage Regulators. Offering low output noise, high ripple rejection ratio, low dropout and very fast turn-on times, the XC6204 series is ideal for today's cutting edge mobile phone and Bluetooth applications.
Internally the XC6204 includes a reference voltage source, error amplifiers, driver transistors, current limiters and phase compensators. The XC6204'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 1.8V to 6.0V. The XC6204 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 CE function allows the output of each regulator to be turned off independently, resulting in greatly reduced power consumption.
The XC6204 series is available in the SOT-25, SOT-89 or USP-6B 'chip-scale' package. Measuring only 2.0mm x 1.8mm the USP-6B is perfect for applications where PCB area is critical.

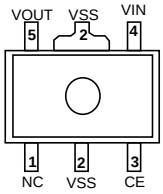
■ Features

Maximum Output Current : 300mA (E to H Series)
(VOUT≥2.0V, VIN=VOUT+1V)
(VOUT<2.0V, VIN=3.0V)
Dropout Voltage : 200mV (IOUT = 100mA)
Maximum Operating Voltage : 10V
Output Voltage Range : 1.8V ~ 6.0V in 50mV increments
Highly Accurate : ± 2%, (± 1% as semi-custom)
Low Power Consumption : TYP 70μA
Standby Current : less than 0.1μA
High Ripple Rejection : 70dB (10 kHz)
Low Output Noise : 30μVrms
Operating Temperature Range : -40°C ~ +85°C
Low ESR Capacitor Compatible : Ceramic capacitor

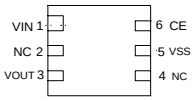
■ Pin Configuration



SOT-25
(SOT-23-5)
[TOP VIEW]



SOT-89
[TOP VIEW]



USP-6B
[TOP VIEW]

■ Pin Assignment

PIN NUMBER			PIN NAME	FUNCTION
SOT-25	SOT-89	USP-6B		
1	4	1	VIN	Input
2	2	5	VSS	Ground
3	3	6	CE	ON/OFF Control
4	1	2, 4	NC	No Connection
5	5	3	VOUT	Output

■ Selection Guide

The following options for the CE pin logic and internal pull-up/down are available:

Active 'High' + no pull-down resistor built-in (standard)
Active 'High' + 300kΩ pull-down resistor built-in <between CE-VSS> (semi-custom)
Active 'Low' + no pull-up resistor built-in (semi-custom)
Active 'Low' + 300kΩ pull-up resistor built-in <between VIN-CE> (semi-custom)

Note: *With the pull-up resistor or pull-down resistor built-in types, the supply current during operation will increase by VIN / 300kΩ (TYP.)

■ Ordering Information

XC6204①②③④⑤⑥

DESIGNATOR	SYMBOL	DESCRIPTION	DESIGNATOR	SYMBOL	DESCRIPTION
①		CE Pin Logic :	④	2	Output Voltage: 100mV increments, ±2% accuracy e.g. ②=2, ③=8, ④=2 ⇒ 2.80V
	E	Active 'High' (pull-down resistor built in)		A	Output Voltage : 50mV increments, ±2% accuracy e.g. ②=2, ③=8, ④=A ⇒ 2.85V
	F	Active 'High' (no pull-down resistor built in)			
	G	Active 'Low' (pull-up resistor built in)			
	H	Active 'Low' (no pull-up resistor built in)	⑤		Package Type :
② ③	Integer	Output Voltage : e.g. ②=3, ③=0 ⇒ 3.0V		M	SOT-25 (SOT-23-5)
				P	SOT-89
				D	USP - 6B
			⑥		Device Orientation :
				R	Embossed Tape : Standard Feed
				L	Embossed Tape : Reverse Feed

Preliminary

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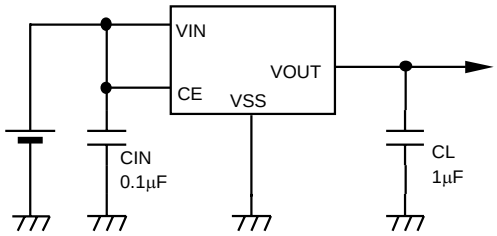
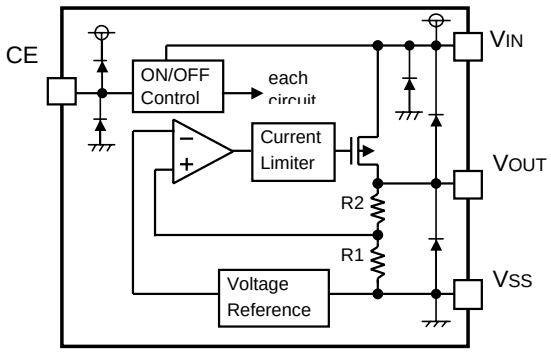
■ Typical Application



■ Block Diagram



* The Diode in the circuit is the protective Diode.

■ Absolute Maximum Ratings

PARAMETER		SYMBOL	RATINGS	UNITS
Input Voltage		VIN	12	V
Output Current		IOUT	500	mA
Output Voltage		VOUT	VSS -0.3 ~ VIN +0.3	V
CE Input Voltage		VCE	VSS -0.3 ~ VIN +0.3	V
Power Dissipation	SOT-23-5	Pd	250	mW
	SOT-89		500	
	USP-6B		100	
Operating Ambient Temperature		Topr	-40 ~ +85	°C
Storage Temperature		Tstg	-55 ~ +125	°C

* IOUT=Pd / Range of (VIN-VOUT)

■ Electrical Characteristics XC6204E, F Series

PARAMETER	SYMBOL	CONDITIONS	Ta=25°C			-40°C≤Ta≤85°C			UNITS	CIRCUIT
			MIN	TYP	MAX	MIN	TYP	MAX		
Output Voltage	VOUT (E)	IOUT=30mA	× 0.98	VOUT(T)	× 1.02	×0.97	VOUT(T)	×1.03	V	1
Maximum Output Current	IOUTMAX	* 1	300			300			mA	1
Load Regulation	ΔVOUT	1mA≤IOUT≤100mA		15	50		30	80	mV	1
Dropout Voltage	Vdif1	IOUT=30mA	E-1						mV	1
	Vdif2	IOUT=100mA	E-2						mV	
Supply Current (E series)	IDD	VIN=VCE=VOUT(T)+1.0V	50	80	120	50	90	145	µA	2
Supply Current (F series)		VIN=VCE=VOUT(T)+1.0V	40	70	100	40	80	120		
Standby Current	Istby	VIN=VOUT(T)+1.0V, VCE=VSS		0.01	0.10		0.05	1.00	µA	2
Line Regulation	ΔVOUT / ΔVIN・VOUT	VOUT(T)+1.0V≤VIN≤10V IOUT=30mA		0.01	0.20		0.05	0.30	% / V	1
Input Voltage	VIN		2		10	2		10	V	-
Output Voltage Temp. Characteristics	ΔVOUT / ΔTopr・VOUT	IOUT=30mA -40°C≤Topr≤85°C		100					ppm / °C	1
Output Noise	en	IOUT=10mA, 300Hz~50kHz		30					µVrms	3
Ripple Rejection Rate	PSRR	VIN=[VOUT(T)+1.0]V+1.0Vp-pAC IOUT=50mA, f=10kHz		70					dB	4
Current Limiter	Ilim	VIN=VOUT(T)+1.0V, VCE=VIN		380			380		mA	1
Short-circuit Current	Ishort	VIN=VOUT(T)+1.0V, VCE=VIN		50			60		mA	1
CE "High" Voltage	VCEH		1.6		VIN	1.7		VIN	V	1
CE "Low" Voltage	VCEL				0.25			0.20	V	1
CE "High" Current (E series)	ICEH	VIN=VCE=VOUT(T)+1.0V	-0.1		20	-0.15		25	µA	2
CE "High" Current (F series)	ICEH	VIN=VCE=VOUT(T)+1.0V	-0.1		0.10	-0.15		0.15	µA	2
CE "Low" Current	ICEL	VIN=VOUT(T)+1.0V, VCE=VSS	-0.1		0.10	-0.15		0.15	µA	2

Note

* 300mA (VOUT≥2.0V, VIN=VOUT+1V)
(VOUT<2.0V, VIN=3.0V)

(NOTE 1) Unless otherwise stated, VIN=VOUT(T)+1.0V

(NOTE 2) VOUT(T)=Specified Output Voltage

(NOTE 3) 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 4) Vdif={VIN1(NOTE6)-VOUT1(NOTE5)}

(NOTE 5) VOUT1=A voltage equal to 98% of the Output Voltage whenever an amply stabilized IOUT {VOUT(T)+1.0V} is input.

(NOTE 6) VIN1=The Input Voltage when VOUT1 appears as Input Voltage is gradually decreased.

(NOTE 7) The values for -40°C≤Ta≤85°C are designed values.

■ **Electrical Characteristics** XC6204G, H Series

PARAMETER	SYMBOL	CONDITIONS	Ta=25°C			-40°C≤Ta≤85°C			UNITS	CIRCUIT
			MIN	TYP	MAX	MIN	TYP	MAX		
Output Voltage	VOUT (E)	IOUT=30mA	× 0.98	VOUT(T)	× 1.02	×0.97	VOUT(T)	×1.03	V	1
Maximum Output Current	IOUTMAX	*1	300			300			mA	1
Load Regulation	ΔVOUT	1mA≤IOUT≤100mA		15	50		30	80	mV	1
Dropout Voltage	Vdif1	IOUT=30mA	E-1						mV	1
	Vdif2	IOUT=100mA	E-2						mV	
Supply Current (G series)	IDD	VIN=VOUT(T)+1.0V, VCE=VSS	50	80	120	50	90	145	μA	2
Supply Current (H series)		VIN=VOUT(T)+1.0V, VCE=VSS	40	70	100	40	80	120		
Standby Current	Istby	VIN=VCE=VOUT(T)+1.0V		0.01	0.10		0.05	1.00	μA	2
Line Regulation	ΔVOUT / ΔVIN・VOUT	VOUT(T)+1.0V≤VIN≤10V IOUT=30mA		0.01	0.20		0.05	0.30	% / V	1
Input Voltage	VIN		2		10	2		10	V	-
Output Voltage Temp. Characteristics	ΔVOUT / ΔTopr・VOUT	IOUT=30mA -40°C≤Topr≤85°C		100					ppm / °C	1
Output Noise	en	IOUT=10mA, 300Hz~50kHz		30					μVrms	3
Ripple Rejection Rate	PSRR	VIN=[VOUT(T)+1.0]V+1.0Vp-pAC IOUT=50mA, f=10kHz		70					dB	4
Current Limiter	Ilim	VIN=VOUT(T)+1.0V, VCE=VSS		380			380		mA	1
Short-circuit Current	Ishort	VIN=VOUT(T)+1.0V, VCE=VSS		50			60		mA	1
CE "High" Voltage	VCEH		1.6		VIN	1.7		VIN	V	1
CE "Low" Voltage	VCEL				0.25			0.20	V	1
CE "High" Current	ICEH	VIN=VCE=VOUT(T)+1.0V	-0.1		0.10	-0.15		0.15	μA	2
CE "Low" Current (G series)	ICEL	VIN=VOUT(T)+1.0V, VCE=VSS	-20		0.10	-25		0.15	μA	2
CE "Low" Current (H series)	ICEL	VIN=VOUT(T)+1.0V, VCE=VSS	-0.1		0.10	-0.15		0.15	μA	2

* 300mA (VOUT≥2.0V, VIN=VOUT+1V)
(VOUT<2.0V, VIN=3.0V)

Note

(NOTE 1) Unless otherwise stated, VIN=VOUT(T)+1.0V
(NOTE 2) VOUT(T)=Specified Output Voltage
(NOTE 3) 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 4) Vdif={VIN1(NOTE6)-VOUT1(NOTE5)}
(NOTE 5) VOUT1=A voltage equal to 98% of the Output Voltage whenever an amply stabilized IOUT {VOUT(T)+1.0V} is input.
(NOTE 6) VIN1=The Input Voltage when VOUT1 appears as Input Voltage is gradually decreased.
(NOTE 7) The values for -40°C≤Ta≤85°C are designed values.

Dropout Voltage 1

SYMBOL	E-0		E-1				E-2			
PARAMETER / OUTPUT VOLTAGE	Output Voltage (V)		Dropout Voltage 1 (mV) (IOUT=30mA)				Dropout Voltage 2 (mV) (IOUT=100mA)			
			Ta=25°C		-40°C≤Topr≤85°C		Ta=25°C		-40°C≤Topr≤85°C	
VOUT(T)	VOUT		Vdif1	Vdif1	Vdif1	Vdif1	Vdif2	Vdif2	Vdif2	Vdif2
	MIN	MAX	TYP	MAX	TYP	MAX	TYP	MAX	TYP	MAX
1.80	1.764	1.836	200	210	210	230	300	400	340	480
1.85	1.813	1.887	200	210	210	230	300	400	340	480
1.90	1.862	1.938	120	150	130	170	280	380	320	460
1.95	1.911	1.989	120	150	130	170	280	380	320	460
2.00	1.960	2.040	80	120	90	140	240	350	280	430
2.05	2.009	2.091	80	120	90	140	240	350	280	430
2.10	2.058	2.142	80	120	90	140	240	330	280	410
2.15	2.107	2.193	80	120	90	140	240	330	280	410
2.20	2.156	2.244	80	120	90	140	240	330	280	410
2.25	2.205	2.295	80	120	90	140	240	330	280	410
2.30	2.254	2.346	80	120	90	140	240	310	280	390
2.35	2.303	2.397	80	120	90	140	240	310	280	390
2.40	2.352	2.448	80	120	90	140	240	310	280	390
2.45	2.401	2.499	80	120	90	140	240	310	280	390
2.50	2.450	2.550	70	100	80	120	220	290	260	370
2.55	2.499	2.601	70	100	80	120	220	290	260	370
2.60	2.548	2.652	70	100	80	120	220	290	260	370
2.65	2.597	2.703	70	100	80	120	220	290	260	370
2.70	2.646	2.754	70	100	80	120	220	290	260	370
2.75	2.695	2.805	70	100	80	120	220	290	260	370
2.80	2.744	2.856	70	100	80	120	220	270	260	350
2.85	2.793	2.907	70	100	80	120	220	270	260	350
2.90	2.842	2.958	70	100	80	120	220	270	260	350
2.95	2.891	3.009	70	100	80	120	220	270	260	350
3.00	2.940	3.060	60	90	70	110	200	270	240	350
3.05	2.989	3.111	60	90	70	110	200	270	240	350
3.10	3.038	3.162	60	90	70	110	200	250	240	330
3.15	3.087	3.213	60	90	70	110	200	250	240	330
3.20	3.136	3.264	60	90	70	110	200	250	240	330

Dropout Voltage 2

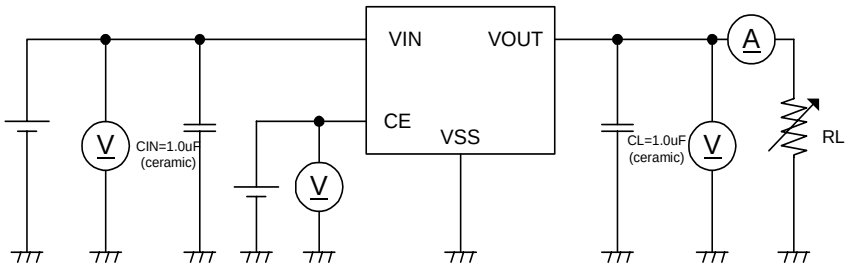
SYMBOL	E-0		E-1				E-2			
PARAMETER / OUTPUT VOLTAGE	Output Voltage (V)		Dropout Voltage 1 (mV) (IOUT=30mA)				Dropout Voltage 2 (mV) (IOUT=100mA)			
			Ta=25°C		-40°C≤Topr≤85°C		Ta=25°C		-40°C≤Topr≤85°C	
VOUT(T)	VOUT		Vdif1	Vdif1	Vdif1	Vdif1	Vdif2	Vdif2	Vdif2	Vdif2
	MIN	MAX	TYP	MAX	TYP	MAX	TYP	MAX	TYP	MAX
3.25	3.185	3.315	60	90	70	110	200	250	240	330
3.30	3.234	3.366	60	90	70	110	200	250	240	330
3.35	3.283	3.417	60	90	70	110	200	250	240	330
3.40	3.332	3.468	60	90	70	110	200	250	240	330
3.45	3.381	3.519	60	90	70	110	200	250	240	330
3.50	3.430	3.570	60	90	70	110	200	250	240	330
3.55	3.479	3.621	60	90	70	110	200	250	240	330
3.60	3.528	3.672	60	90	70	110	200	250	240	330
3.65	3.577	3.723	60	90	70	110	200	250	240	330
3.70	3.626	3.774	60	90	70	110	200	250	240	330
3.75	4.675	3.825	60	90	70	110	200	250	240	330
3.80	3.724	3.876	60	90	70	110	200	250	240	330
3.85	3.773	3.927	60	90	70	110	200	250	240	330
3.90	3.822	3.978	60	90	70	110	200	250	240	330
3.95	3.871	4.029	60	90	70	110	200	250	240	330
4.00	3.920	4.080	60	80	70	100	180	230	220	310
4.05	3.969	4.131	60	80	70	100	180	230	220	310
4.10	4.018	4.182	60	80	70	100	180	230	220	310
4.15	4.067	4.233	60	80	70	100	180	230	220	310
4.20	4.116	4.284	60	80	70	100	180	230	220	310
4.25	4.165	4.335	60	80	70	100	180	230	220	310
4.30	4.214	4.386	60	80	70	100	180	230	220	310
4.35	4.263	4.437	60	80	70	100	180	230	220	310
4.40	4.312	4.488	60	80	70	100	180	230	220	310
4.45	4.361	4.539	60	80	70	100	180	230	220	310
4.50	4.410	4.590	60	80	70	100	180	230	220	310
4.55	4.459	4.641	60	80	70	100	180	230	220	310
4.60	4.508	4.692	60	80	70	100	180	230	220	310
4.65	4.557	4.743	60	80	70	100	180	230	220	310

Dropout Voltage 3

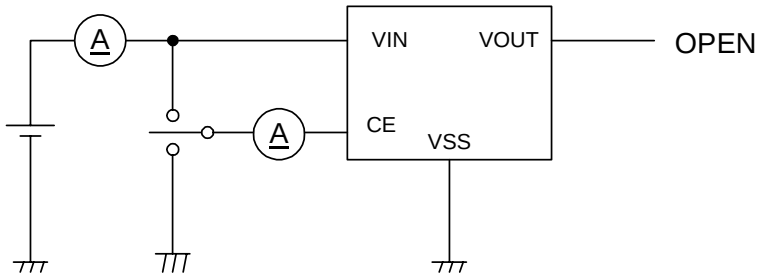
SYMBOL	E-0		E-1				E-2			
PARAMETER / OUTPUT VOLTAGE	Output Voltage (V)		Dropout Voltage 1 (mV) (IOUT=30mA)				Dropout Voltage 2 (mV) (IOUT=100mA)			
			Ta=25°C		-40°C≤Topr≤85°C		Ta=25°C		-40°C≤Topr≤85°C	
VOUT(T)	VOUT		Vdif1	Vdif1	Vdif1	Vdif1	Vdif2	Vdif2	Vdif2	Vdif2
	MIN	MAX	TYP	MAX	TYP	MAX	TYP	MAX	TYP	MAX
4.70	4.606	4.794	60	80	70	100	180	230	220	310
4.75	4.655	4.845	60	80	70	100	180	230	220	310
4.80	4.704	4.896	60	80	70	100	180	230	220	310
4.85	4.753	4.947	60	80	70	100	180	230	220	310
4.90	4.802	4.998	60	80	70	100	180	230	220	310
4.95	4.851	5.049	60	80	70	100	180	230	220	310
5.00	4.900	5.100	50	70	60	90	160	210	200	290
5.05	4.949	5.151	50	70	60	90	160	210	200	290
5.10	4.998	5.202	50	70	60	90	160	210	200	290
5.15	5.047	5.253	50	70	60	90	160	210	200	290
5.20	5.096	5.304	50	70	60	90	160	210	200	290
5.25	5.145	5.355	50	70	60	90	160	210	200	290
5.30	5.194	5.406	50	70	60	90	160	210	200	290
5.35	5.243	5.457	50	70	60	90	160	210	200	290
5.40	5.292	5.508	50	70	60	90	160	210	200	290
5.45	5.341	5.559	50	70	60	90	160	210	200	290
5.50	5.390	5.610	50	70	60	90	160	210	200	290
5.55	5.439	5.661	50	70	60	90	160	210	200	290
5.60	5.488	5.712	50	70	60	90	160	210	200	290
5.65	5.537	5.763	50	70	60	90	160	210	200	290
5.70	5.586	5.814	50	70	60	90	160	210	200	290
5.75	5.635	5.865	50	70	60	90	160	210	200	290
5.80	5.684	5.916	50	70	60	90	160	210	200	290
5.85	5.733	5.967	50	70	60	90	160	210	200	290
5.90	5.782	6.018	50	70	60	90	160	210	200	290
5.95	5.831	6.069	50	70	60	90	160	210	200	290
6.00	5.880	6.120	50	70	60	90	160	210	200	290

■ Test Circuits

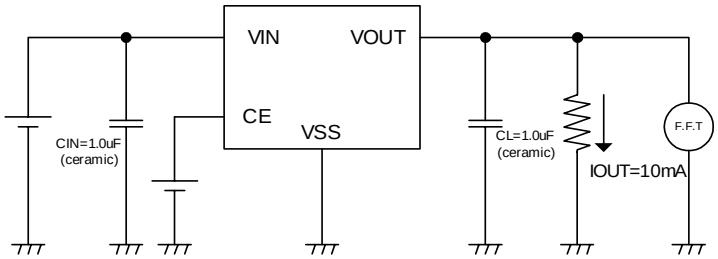
Circuit 1



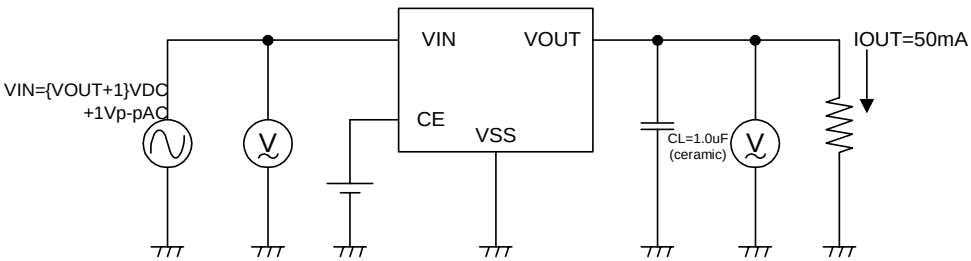
Circuit 2



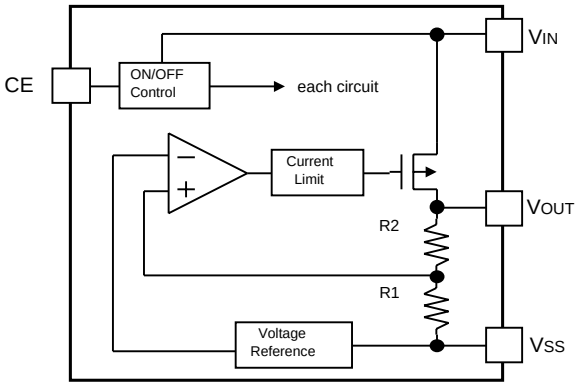
Circuit 3



Circuit 4



■ Operational Explanation



Output voltage control with the XC6204 series :

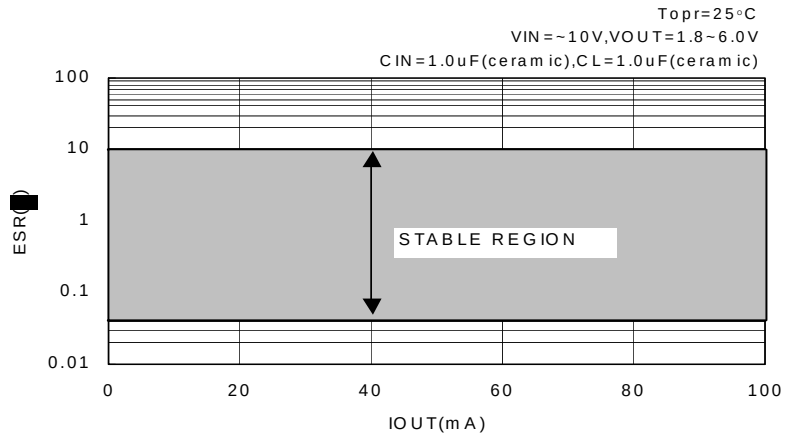
The voltage divided by resistors R1 & R2 is compared with the internal reference voltage by the error amplifier.

The P-Channel MOSFET, which is connected to the VOUT pin, is then driven by the subsequent output signal. The ouput voltage at the VOUT pin is controlled & stabilised 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 CE pin's signal.

Low ESR Capacitors

With the XC6204 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 an output capacitor (CL) is connected as close as possible to the output pin (VOUT) and the VSS pin. Please use an output capacitor with a capacitance value of at least 1μF. Also, please connect an input capacitor (CIN) of 0.1μF between the VIN pin and the VSS pin in order to ensure a stable power input.



Current Limiter, Short-Circuit Protection

The XC6204 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 50mA flows.

CE Pin

The IC's internal circuitry can be shutdown via the signal from the CE pin with the XC6204 series. In shutdown mode, output at the VOUT pin will be pulled down to the VSS level via R1 & R2. The operational logic of the IC's CE pin is selectable (please refer to the selection guide on page 2). Note that as the standard XC6204F type is *' High Active/No Pull Down'* , operations will become unstable with the CE pin open. Although the CE pin is equal to an inverter input with CMOS hysteresis, with either the pull-up or pull-down options, the CE pin 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 CE pin. If this IC is used with the correct specifications for the CE pin, 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 if a voltage between 0.25V and 1.5V is input.

■ Notes 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 impedence 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 capacitor (CL) as close to the IC as possible.