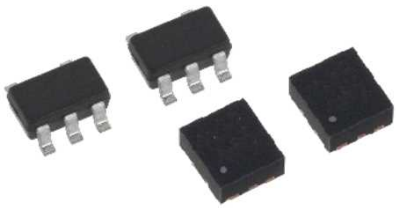
200mA Negative LDO

# MM1998 Series



## Overview

This IC is a negative output 200mA LDO with fast turn-on by bipolar process.
The target applications are a negative power supply for highly sensitive CMOS image sensor by low noise design.
And The IC has the line-up of output voltage -5.0V to -1.1V (0.1V steps) by the specifications of image sensor.
The package can be selected from SOT-25/SSON-6A for low cost or small space of PCB.

## Overview

- ON/OFF control
- Noise reduction capacitor
- Cn charge-up circuit

## Main specifications

| | | |
|---|---|---|
| ■ Maximum rating supply voltage | : | -12V to 0.3V |
| ■ Operating voltage range | : | -10V to -2V |
| ■ Operating ambient temperature | : | -40℃ to 85℃ |
| ■ Output current | : | 200mA |
| ■ Input current (OFF) | : | Typ. 4uA |
| ■ No-load input current | : | Typ. 160uA |
| ■ Output voltage range | : | -5.0V to -1.1V (0.1V step) |
| ■ Output voltage accuracy | : | ±1.0% ($V_{OUT}$(Typ.)≦-1.5V)<br>±15mV ($V_{OUT}$(Typ.)>-1.5V) |
| ■ Line regulation | : | Typ. 0.01%/V ($V_{EE}$=$V_{OUT}$(Typ.)-1V to -10V) |
| ■ Load regulation | : | Typ. 15mV ($I_{OUT}$=1mA to 200mA) |
| ■ Dropout voltage | : | Typ. 0.5V ($I_{OUT}$=200mA) |
| ■ PSRR | : | Typ. 70dB (f=1kHz) |
| ■ Output noise voltage | : | Typ. 25uVrms ($f_{BW}$=10 to 100kHz, $I_{OUT}$=10mA, $V_{OUT}$(Typ.)=-1.4V) |
| ■ Output capacitor | : | 1uF (Ceramic capacitor) |
| ■ Protection function | : | Over current protection, Thermal shutdown |
| ■ Additional function | : | ON/OFF control, Auto discharge, |

## Packages

- SSON-6A
- SOT-25A

## Application

- Photographing / Imaging device
- Power supply for high-sensitivity image sensor
- Power supply for negative voltage circuit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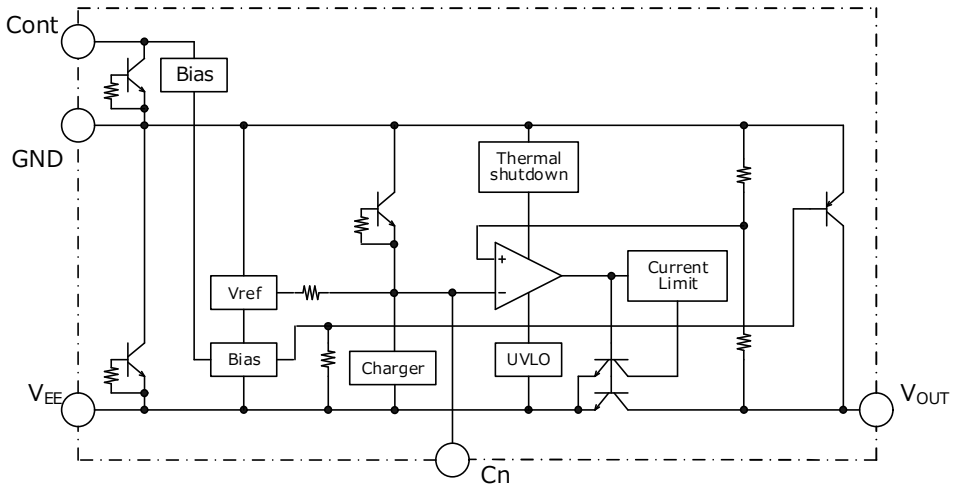
## Model Name

M M 1 9 9 8 A X X X X X

Series name (A) (B) (C) (D) (E)

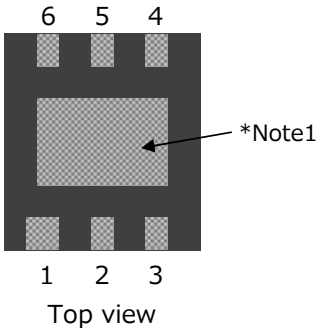
| | | | |
|---|---|---|---|
| (A) | Function Type | A | Cont=H active |
| (B) | Output voltage rank | 11<br>~<br>50 | Output voltage can be designated in the range from -1.1V(11) to -5.0V(50) in 0.1V steps. |
| (C) | Package | R | SSON-6A |
| | | N | SOT-25A |
| (D) | Packing specifications 1 | R | R housing (Standard) |
| | | L | L housing |
| (E) | Packing specifications 2 | E | Emboss tape / Halogen free (SSON-6A) |
| | | E | Emboss tape / Halogen contained (SOT-25A) |

## Block Diagram



## Pin Configuration

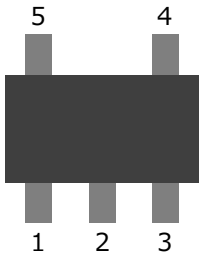
- SSON-6A




| Pin No. | Pin name | Function |
|---|---|---|
| 1 | Cont | Control pin<br>Vcont=H : Output ON<br>Vcont=L : Output OFF |
| 2 | GND | GND pin |
| 3 | $V_{EE}$ | Negative voltage input pin |
| 4 | $V_{OUT}$ | Negative voltage output pin |
| 5 | NC | No connection pin |
| 6 | Cn | Reducing noise pin with capacitor |

*Note1:Heat spreader bottom with VEE. Not connect to GND.

- SOT-25A

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| 1 | GND | GND pin |
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| 3 | Cont | Control pin<br>Vcont=H : Output ON<br>Vcont=L : Output OFF |
| 4 | Cn | Reducing noise pin with capacitor |
| 5 | $V_{OUT}$ | Negative voltage output pin |

## Absolute Maximum Ratings

| Item | | Symbol | Min. | Max. | Unit |
|---|---|---|---|---|---|
| Storage temperature | | Tstg | -55 | 125 | V |
| Junction temperature | | $Tj_{MAX}$ | - | 125 | V |
| Supply voltage | | $V_{EE}$ | -12 | 0.3 | V |
| Cont input voltage | | $V_{cont}$ | -0.3 | 5.0 | V |
| Output current | | $I_{OUT}$max | 0 | 400 | mW |
| Power dissipation | SSON-6A | Pd1 | - | 1000 | mW |
| *Note2 | SOT-25A | | - | 560 | mW |

*Note2:JEDEC51-7 standard

## Recommended Operating Conditions

| Item | Symbol | Min. | Max. | Unit |
|---|---|---|---|---|
| Operating ambient temperature | Topr | -40 | 85 | ℃ |
| Operating voltage | Vop | -10 | -2.0 | V |
| Output current | Iop | 0 | 200 | mA |

## Electrical Characteristics

($V_{EE}$=$V_{OUT}$(Typ.)-1V, $V_{cont}$=1.6V, $I_{OUT}$=1mA, Ta=25℃ unless otherwise specified)

| Item | Symbol | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Input current (OFF) | $I_{EEOff}$ | $V_{EE}$=-5V,$V_{cont}$=0V | - | 4 | 8.0 | μA |
| No-Load input current | $I_{EE}$ | $I_{OUT}$=0mA | - | 160 | 240 | μA |
| Output voltage *Note3 | $V_{OUT}$ | $V_{OUT}$≦-1.5V | ×1.01 | - | ×0.99 | V |
| | | $V_{OUT}$＞-1.5V | -0.015 | - | +0.015 | V |
| Dropout voltage | Vio | $V_{EE}$=$V_{OUT}$+0.2V, $I_{OUT}$=200mA | - | 0.5 | 0.8 | V |
| Line regulation | $V_{LINE}$ | $V_{EE}$=$V_{OUT}$(Typ.)-1V to -10V | - | 0.01 | 0.10 | %/V |
| Load regulation | $V_{LOAD}$ | 1mA≦$I_{OUT}$≦200mA | - | 15 | 100 | mV |
| Vout temperature coefficient *Note4 | $\Delta V_{OUT}$ /$\Delta T_{OP}$ | -40≦Ta≦85℃ | - | ±100 | - | ppm/℃ |
| Ripple rejection *Note4 | RR | f=1kHz, Vripple=0.5V $I_{OUT}$=10mA, Cn=0.01μF | - | 70 | - | dB |
| Output noise voltage *Note4 | Vn | $V_{OUT}$=-1.4V, fBW=10～100kHz, $I_{OUT}$=10mA, Cn=0.01μF | - | 25 | - | μVrms |

*Note3:Please refer to another page.

*Note4:The parameter is guaranteed by design.

## Electrical Characteristics

($V_{EE}$=$V_{OUT}$(Typ.)-1V, $V_{cont}$=1.6V, $I_{OUT}$=1mA, Ta=25℃ unless otherwise specified)

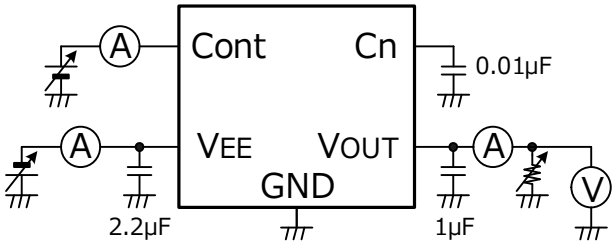
| Item | Symbol | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Cont pin input current | $I_{cont}$ | $V_{cont}$=1.6V | - | 4 | 12 | μA |
| Cont pin High Threshold level | $V_{cont}H$ | | 1.2 | - | - | V |
| Cont pin Low Threshold level | $V_{cont}L$ | | - | - | 0.3 | V |
| Output rise time | Ishort | Cn=0.01μF, $I_{OUT}$=0mA<br>*Note5 | - | 0.17 | - | ms |
| UVLO detective voltage | VUVLO | | -1.85 | -1.75 | -1.65 | V |
| UVLO hysteresis voltage | ⊿VUVLO | | - | 0.15 | - | V |
| Discharge current | Idis | $V_{EE}$=-5V, $V_{cont}$=0V | - | 4.0 | - | mA |

*Note4:The parameter is guaranteed by design.

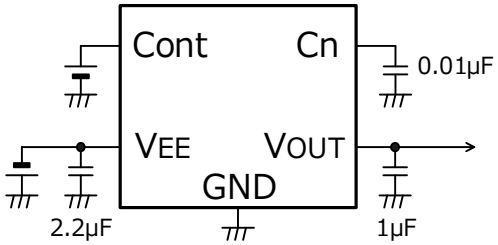
*Note5:Vcont=H to 90% of Vout(Typ.)

| Model name | Conditions | Output voltage [V] | | | Model name | Conditions | Output voltage [V] | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | | Min. | Typ. | Max. |
| MM1998A11 | $I_{OUT}$=1mA | -1.115 | -1.100 | -1.085 | MM1998A31 | $I_{OUT}$=1mA | -3.131 | -3.100 | -3.069 |
| MM1998A12 | | -1.215 | -1.200 | -1.185 | MM1998A32 | | -3.232 | -3.200 | -3.168 |
| MM1998A13 | | -1.315 | -1.300 | -1.285 | MM1998A33 | | -3.333 | -3.300 | -3.267 |
| MM1998A14 | | -1.415 | -1.400 | -1.385 | MM1998A34 | | -3.434 | -3.400 | -3.366 |
| MM1998A15 | | -1.515 | -1.500 | -1.485 | MM1998A35 | | -3.535 | -3.500 | -3.465 |
| MM1998A16 | | -1.616 | -1.600 | -1.584 | MM1998A36 | | -3.636 | -3.600 | -3.564 |
| MM1998A17 | | -1.717 | -1.700 | -1.683 | MM1998A37 | | -3.737 | -3.700 | -3.663 |
| MM1998A18 | | -1.818 | -1.800 | -1.782 | MM1998A38 | | -3.838 | -3.800 | -3.762 |
| MM1998A19 | | -1.919 | -1.900 | -1.881 | MM1998A39 | | -3.939 | -3.900 | -3.861 |
| MM1998A20 | | -2.020 | -2.000 | -1.980 | MM1998A40 | | -4.040 | -4.000 | -3.960 |
| MM1998A21 | | -2.121 | -2.100 | -2.079 | MM1998A41 | | -4.141 | -4.100 | -4.059 |
| MM1998A22 | | -2.222 | -2.200 | -2.178 | MM1998A42 | | -4.242 | -4.200 | -4.158 |
| MM1998A23 | | -2.323 | -2.300 | -2.277 | MM1998A43 | | -4.343 | -4.300 | -4.257 |
| MM1998A24 | | -2.424 | -2.400 | -2.376 | MM1998A44 | | -4.444 | -4.400 | -4.356 |
| MM1998A25 | | -2.525 | -2.500 | -2.475 | MM1998A45 | | -4.545 | -4.500 | -4.455 |
| MM1998A26 | | -2.626 | -2.600 | -2.574 | MM1998A46 | | -4.646 | -4.600 | -4.554 |
| MM1998A27 | | -2.727 | -2.700 | -2.673 | MM1998A47 | | -4.747 | -4.700 | -4.653 |
| MM1998A28 | | -2.828 | -2.800 | -2.772 | MM1998A48 | | -4.848 | -4.800 | -4.752 |
| MM1998A29 | | -2.929 | -2.900 | -2.871 | MM1998A49 | | -4.949 | -4.900 | -4.851 |
| MM1998A30 | | -3.030 | -3.000 | -2.970 | MM1998A50 | | -5.050 | -5.000 | -4.950 |

## Test Circuit




## Application Circuit

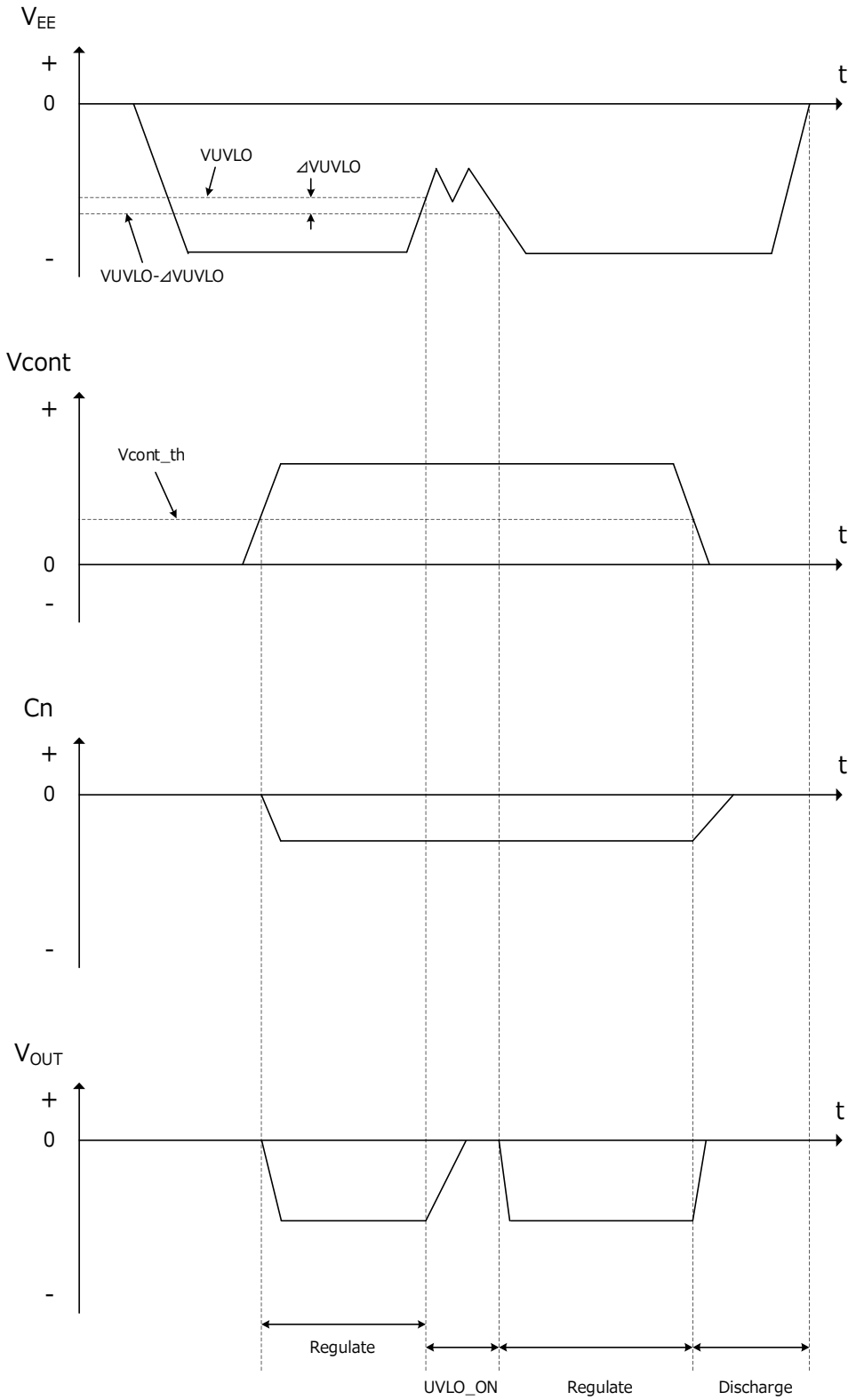



(Example of external parts)

- Output capacitor　Ceramic capacitor 1.0μF($V_{OUT}$≧-1.3V:2.2μF)
- Input capacitor　Ceramic capacitor 2.2μF　*Temperature characteristics : B

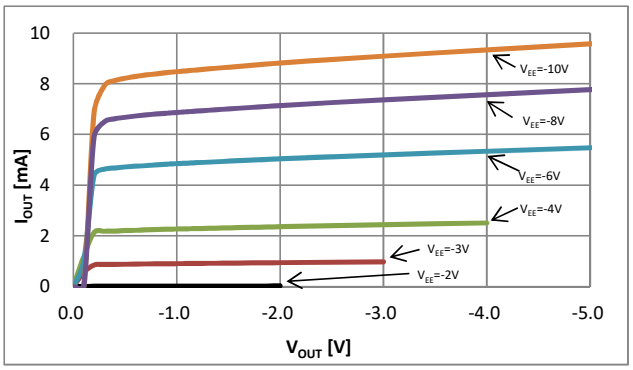
- In the event a problem which may affect industrial property or any other rights of us or a third party is encountered during the use of information described in these circuit, we shall not be liable for any such problem, nor grant a license therefore.

## タイミングチャート


VEE
+
0
-
t
VUVLO
⊿VUVLO
VUVLO-⊿VUVLO
Vcont
+
Vcont_th
0
-
t
Cn
+
0
-
t
VOUT
+
0
-
t
Regulate
UVLO_ON
Regulate
Discharge

## Discharge current depending ON power supply

Discharge current depend on power supply VEE.
Reference to Below current characteristics.
In case of discharge current being low, contact us.

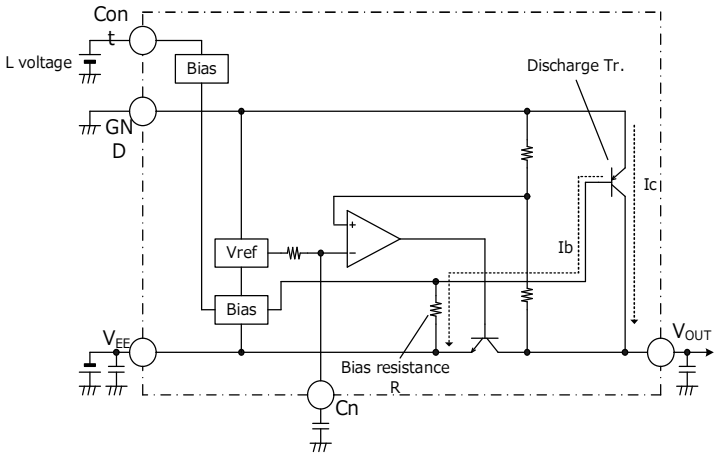



Discharge current

## Discharge circuit current

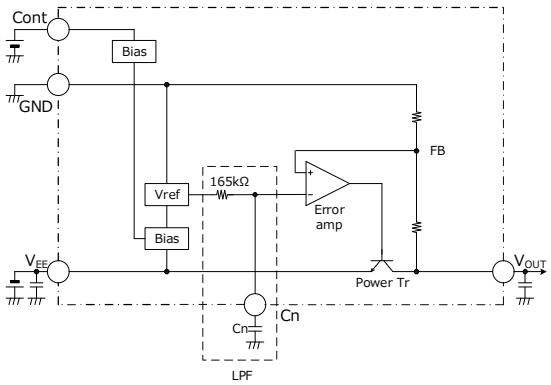
Discharge current is collector current of discharge element in IC.
Collector current Ic is hfe times as many as base current Ib, equation (1).
Base current Ib depend on bias resistance R, equation (2).
Collector current express equation (3).
Discharge current (collector current) depend on VEE voltage.
And base current is input current (OFF).

$$Ic=hfe\times Ib \quad \cdots(1)$$
$$Ib=(V_{EE}-0.7)\div R \quad \cdots(2)$$
$$Ic=hfe\times(V_{EE}-0.7)\div R \quad \cdots(3)$$



## Cn pin

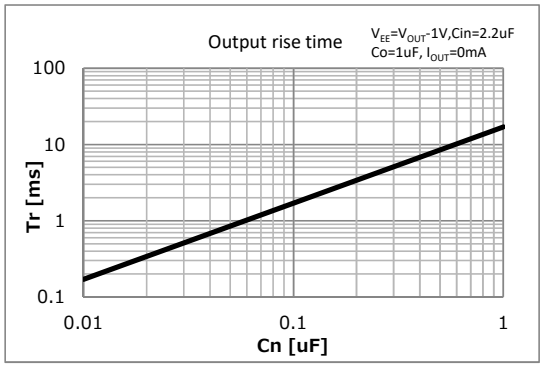
Cn pin is connected with resistance 165kΩ in IC.
LPF is composed of capacitor, Cn noise is reduced and Vout noise is reduced too.
This IC feedback FB that is divided from Vout by resistance equal with Cn voltage.
Noise of FB is feedbacked equal with noise of Cn too.
So noise of Vout depend on noise of Cn. The capacitor of Cn pin more than 0.01uF is recommended.
If Cn pin influence by noise for outside, noise of Vout pin is bad characteristics.




## Output rise time

MM1998 rise time Tr in depend on capacitor connected with Cn pin.
Cn voltage start when current from charge up circuit flow to capacitor.
FB voltage is feedback equal to Cn voltage, therefore FB and Vout voltage start.
About output rise time, refer to below equation and characteristics.

$$Tr\ [ms] \fallingdotseq 17 \times Cn\ [\mu F]$$



## Note

1. There is a possibility with deterioration and destruction of IC when using it exceeding the absolute maximum rating.
   The absolute maximum rating , Never exceed it.
   The functional operation is not assured.

2. There is a possibility that it becomes impossible to maintain this performance and reliability IC original when using it exceeding recommended operation voltage.
   Please use it in recommended operation voltage.

3. Due to restrictions on the package power dissipation, the output current value may not be satisfied. Attention should be paid to the power dissipation of the package when the output current is large or the voltage between Input and Output is high.

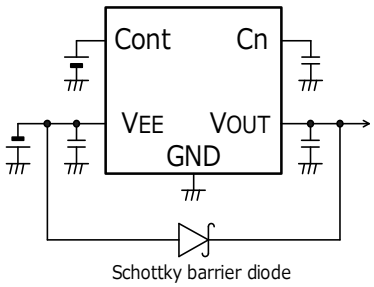
4. The output capacitor is required between output and GND to prevent oscillation.

5. The ESR of capacitor must be defined in ESR stability area.
   It is possible to use a ceramic capacitor without ESR resistance for output.
   The ceramic capacitor must be used more than 1.0μF and B temperature characteristics.
   The ceramic capacitor must be used more than 2.2μF and B temperature characteristics for Vo≧-1.3V.

6. The wire of VEE and GND is required to print full ground plane for noise and stability.

7. The input capacitor must be connected a distance of less than 1cm from input pin.

8. In case the output voltage is above the input voltage, the overcurrent flow by internal parasitic diode from output to input. In such application, the external bypass diode must be connected between output and input pin.




9. It is able to an unstable operation when you use the capacitor with intense capacitance change
   The capacitor has the dependency at the power-supply voltage and the temperature.
   The capacity value changes by the environment used. Please evaluate IC in the set.

10. The IC has the thermal shutdown protection.

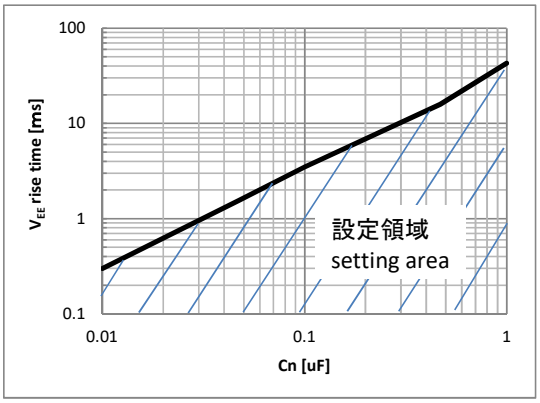
## Note

11. This IC will limit the output current with the overcurrent protection circuit when the overcurrent and the output do short-circuit.
    However, IC generates heat because of the substrate and use conditions and there is a possibility of destroying it exceeding a permissible loss.
    The characteristic changes depending on the substrate condition.
    Please evaluate IC in the set.

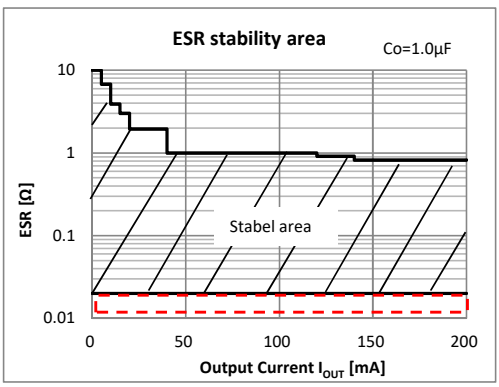
12. Cont pin control ON/OFF of this IC. Cont pin is used to input plus voltage.
    If this pin is open, this IC is OFF.

    ON : +1.2V≦Vcont≦+5.0V
    OFF : 0V≦Vcont≦+0.3V

13. The overshoot might be generated in UVLO releasing for low output voltage rank.
    It is above fanction When VEE rise time is late and strating by not Cont but VEE
    So set the setting area in below graf.




14. It is no data in under 0.02Ω of ESR characteristics.(dotted line area)
    Don't be measured in this area because ceramic capacitor contain 0.02Ω in parts self.
    Ceramic capacitor only can be used without ESR resistance parts.
    Please evaluate IC in the set if the capacitor that is low resistance used.



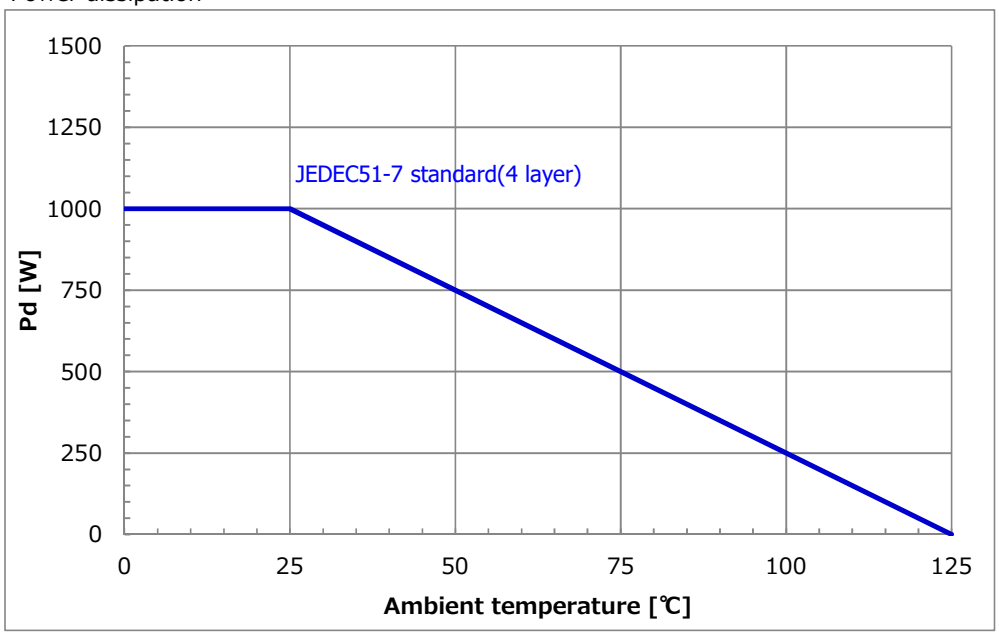
## 許容損失について

The Power dissipation change if board to mount IC change because radiative heat fix at board.
It is reference data below, Evaluate IC in the set.

- SSON-6A

1. JEDEC51-7 standard (4 layer FR-4 board)

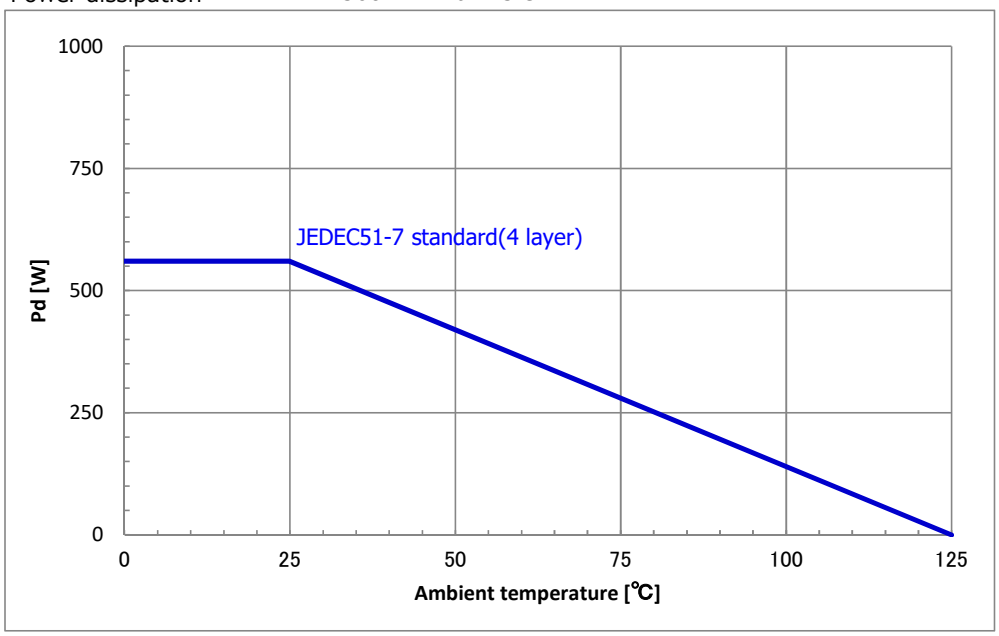
Board size 114.3mm×76.2mm t=1.6mm Copper foil area 80%
Power dissipation 1000mW Ta=25℃




- SOT-25A

1. JEDEC51-7 standard (4 layer FR-4 board)

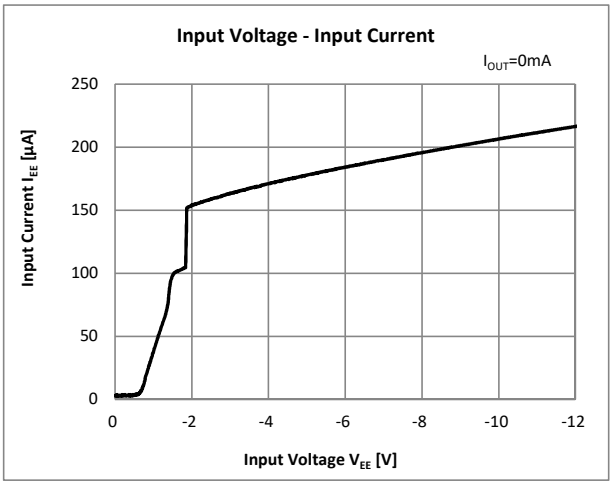
Board size 114.3mm×76.2mm t=1.6mm Copper foil area 80%
Power dissipation 560mW Ta=25℃

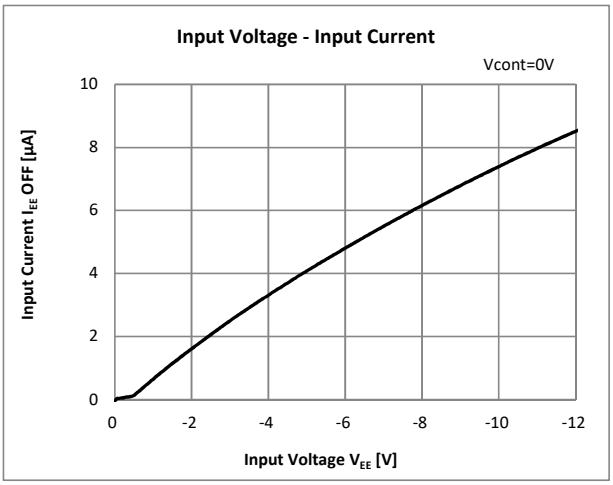


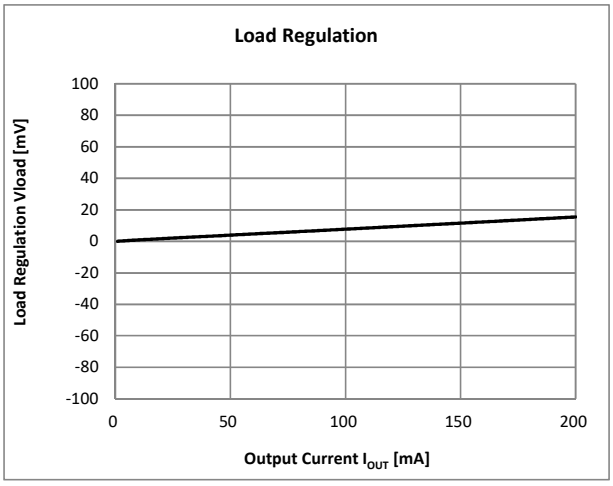

It is recommended to layout the VIA for heat radiation in the GND pattern of reverse (of IC) when there is the GND pattern in the inner layer (in using multiplayer substrate).
By increasing these copper foil pattern area of PCB, Power dissipation improves.

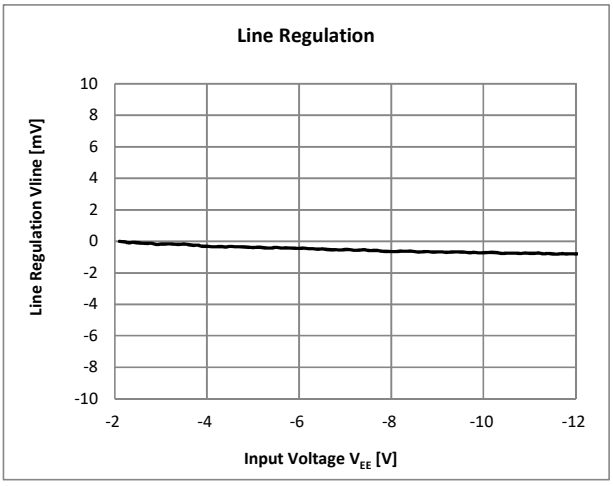
## Typical Performance Characteristics ($V_{OUT}$=-1.1V)

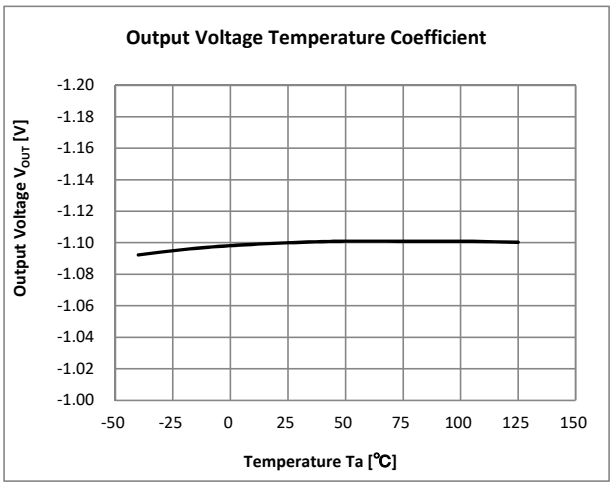
($V_{EE}$=$V_{OUT}$(Typ.)-1V, $V_{cont}$=1.6V, $I_{OUT}$=1mA, Ta=25℃ unless otherwise specified)

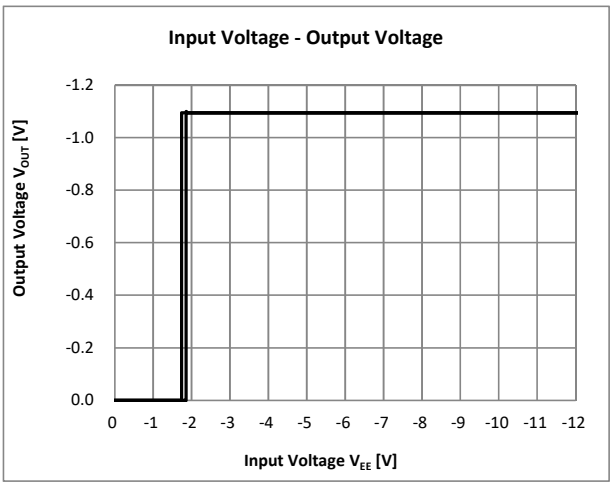


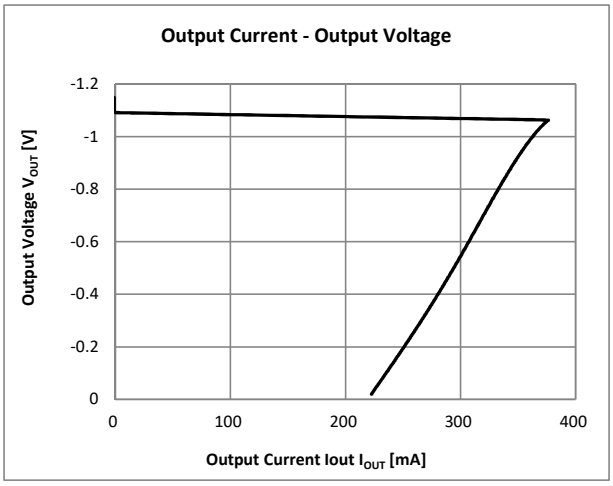



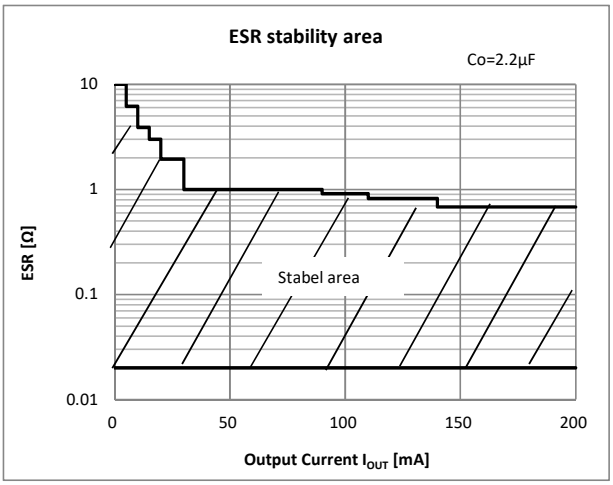



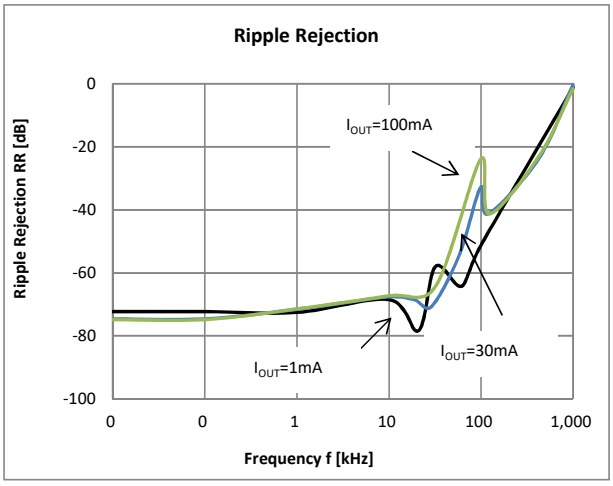



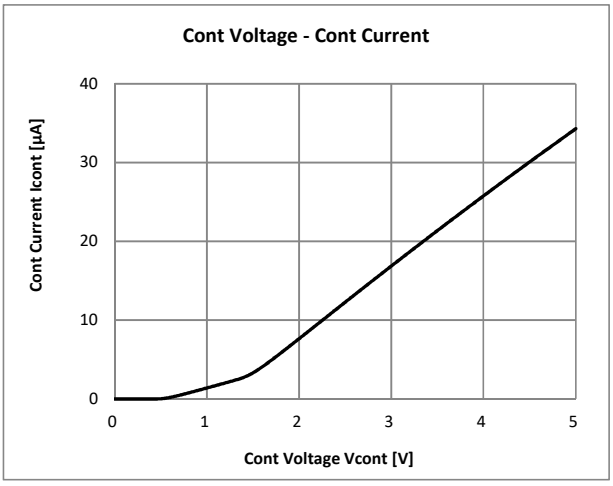
## Typical Performance Characteristics ($V_{OUT}$=-1.1V)

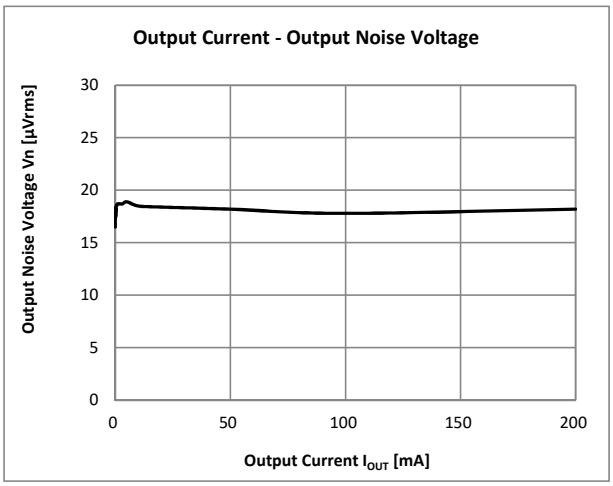
($V_{EE}$=$V_{OUT}$(Typ.)-1V, $V_{cont}$=1.6V, $I_{OUT}$=1mA, Ta=25℃ unless otherwise specified)



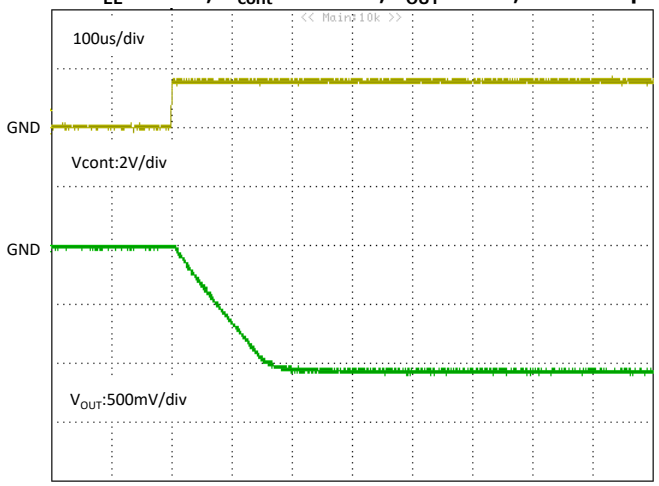



## Typical Performance Characteristics ($V_{OUT}$=-1.1V)

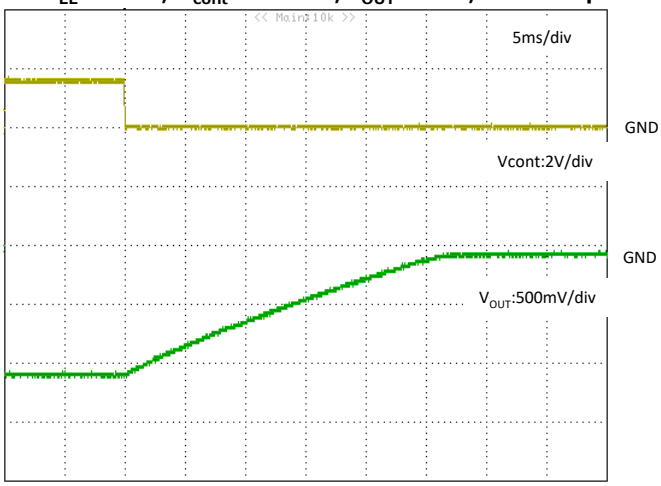
($V_{EE}$=$V_{OUT}$(Typ.)-1V, $V_{cont}$=1.6V, $I_{OUT}$=1mA, Ta=25℃ unless otherwise specified)

- Cont rise & fall characteristics

**$V_{EE}$=-2.1V, $V_{cont}$=0→1.6V, $I_{OUT}$=0mA, Cn=0.01μF**

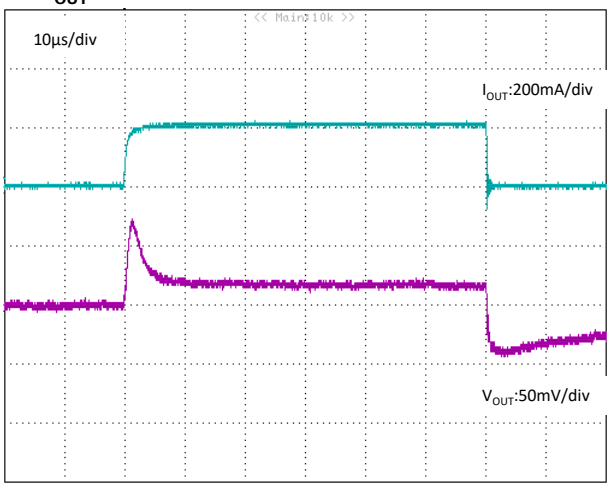



**$V_{EE}$=-2.1V, $V_{cont}$=1.6→0V, $I_{OUT}$=0mA, Cn=0.01μF**

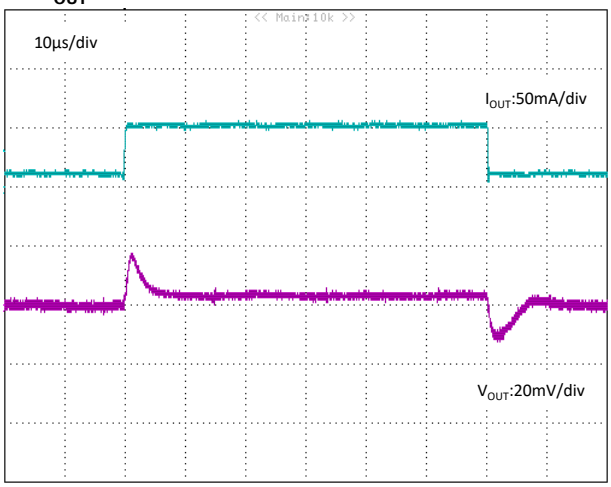



- Load trainsient characteristics

**$I_{OUT}$ : 0.1mA⇔200mA**

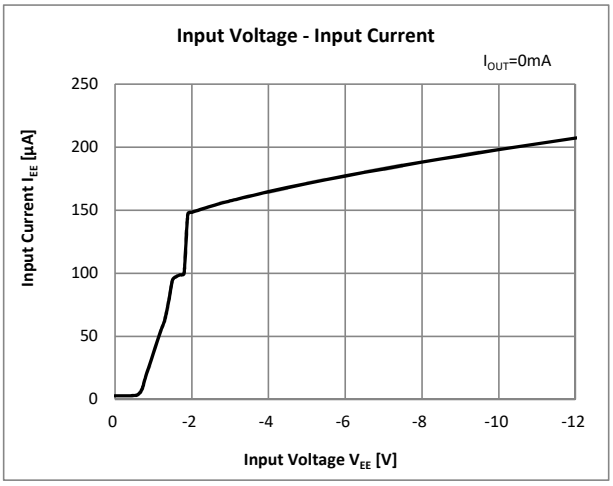


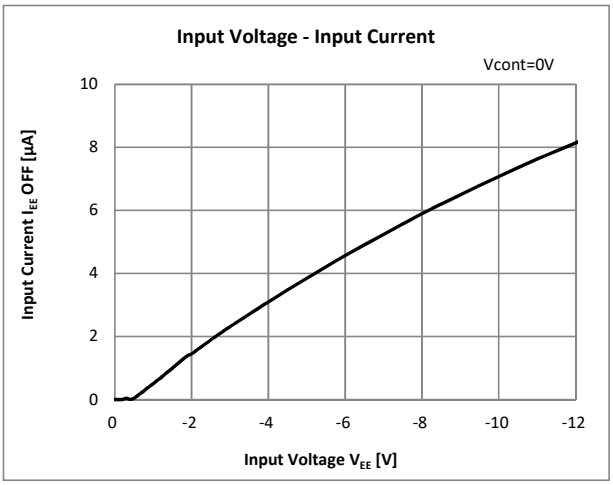

**$I_{OUT}$ : 10mA⇔50mA**

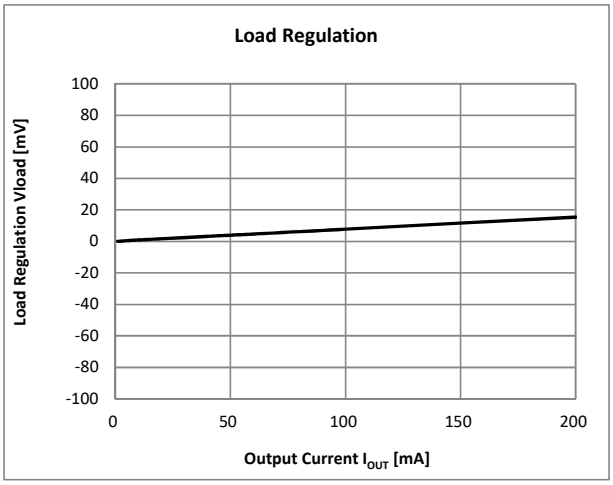


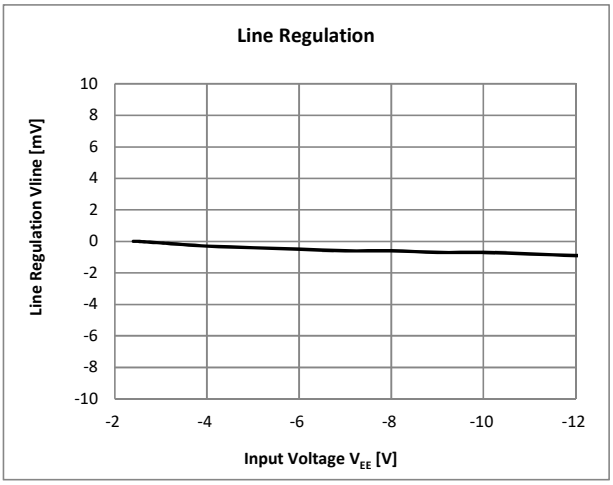
## Typical Performance Characteristics ($V_{OUT}$=-1.4V)

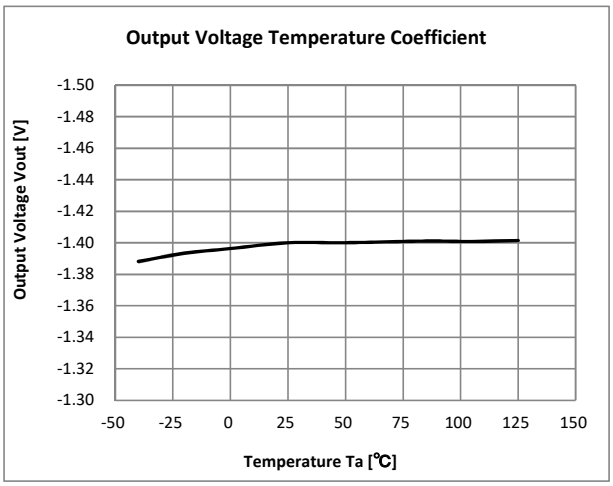
($V_{EE}$=$V_{OUT}$(Typ.)-1V, $V_{cont}$=1.6V, $I_{OUT}$=1mA, Ta=25℃ unless otherwise specified)

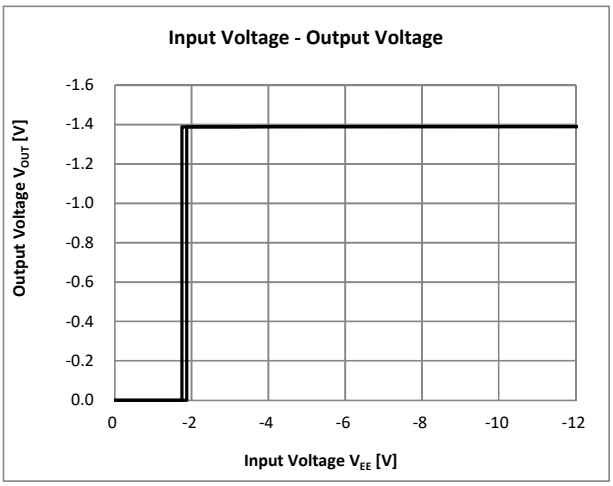


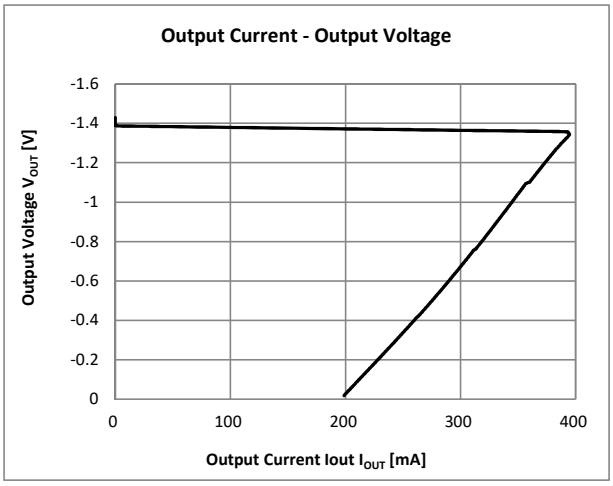



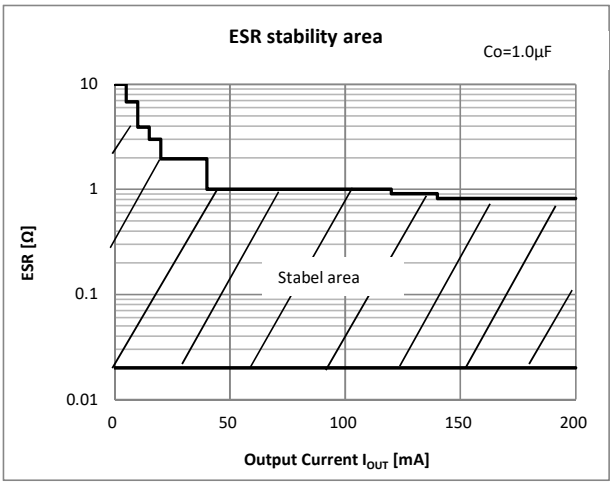



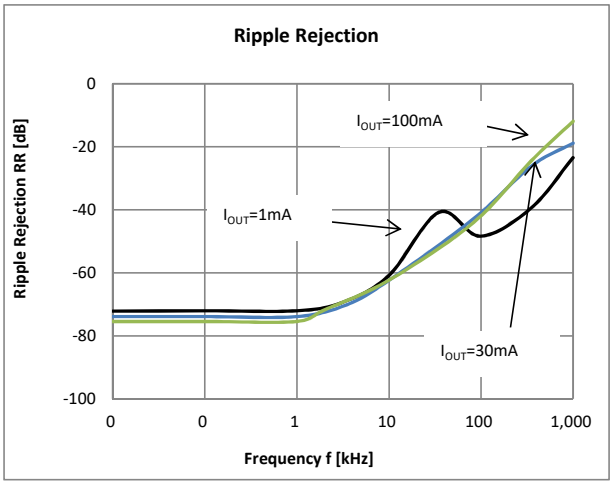



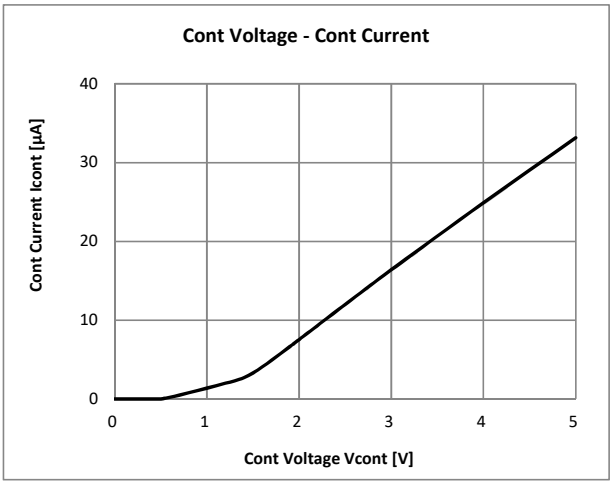
## Typical Performance Characteristics ($V_{OUT}$=-1.4V)

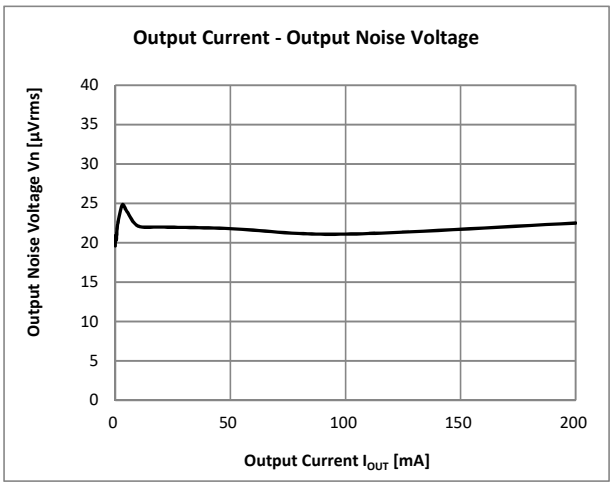
($V_{EE}$=$V_{OUT}$(Typ.)-1V, $V_{cont}$=1.6V, $I_{OUT}$=1mA, Ta=25℃ unless otherwise specified)



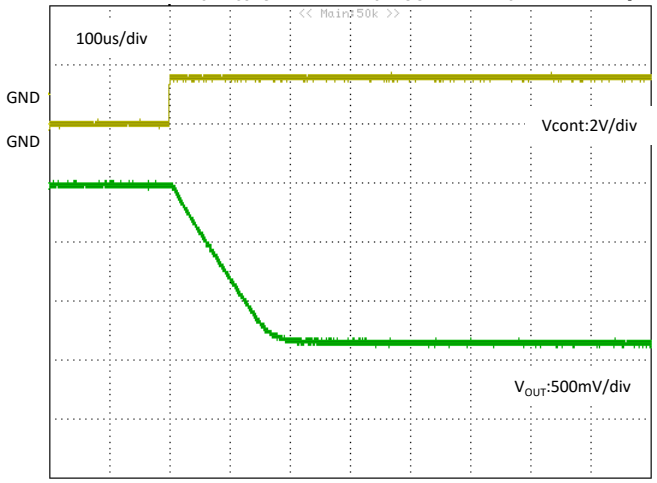



## Typical Performance Characteristics ($V_{OUT}$=-1.4V)

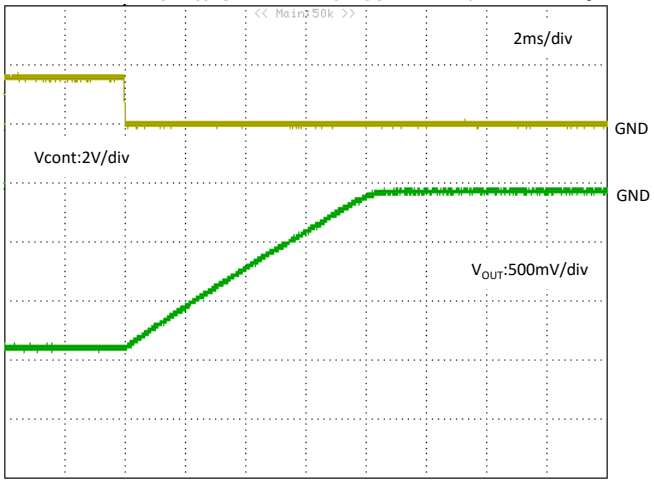
($V_{EE}$=$V_{OUT}$(Typ.)-1V, $V_{cont}$=1.6V, $I_{OUT}$=1mA, Ta=25℃ unless otherwise specified)

- Cont rise & fall characteristics

**$V_{EE}$=-2.4V, $V_{cont}$=0→1.6V, $I_{OUT}$=0mA, Cn=0.01μF**

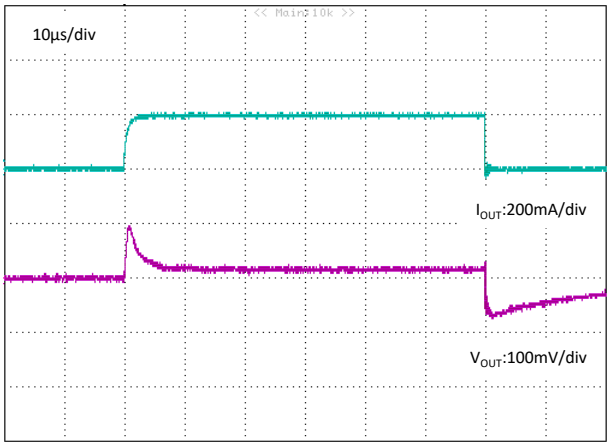



**$V_{EE}$=-2.4V, $V_{cont}$=1.6→0V, $I_{OUT}$=0mA, Cn=0.01μF**

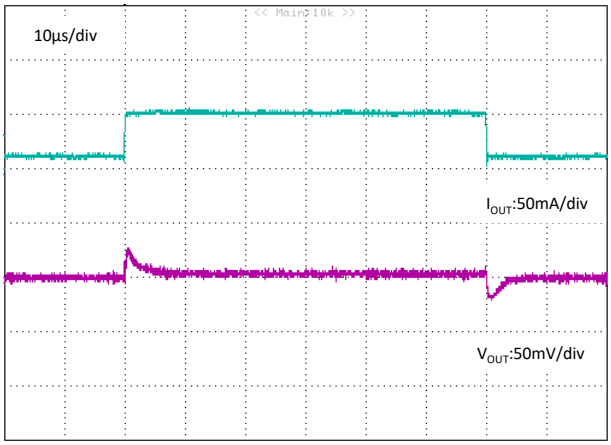



- Load trainsient characteristics

**$I_{OUT}$ : 0.1mA⇔200mA**

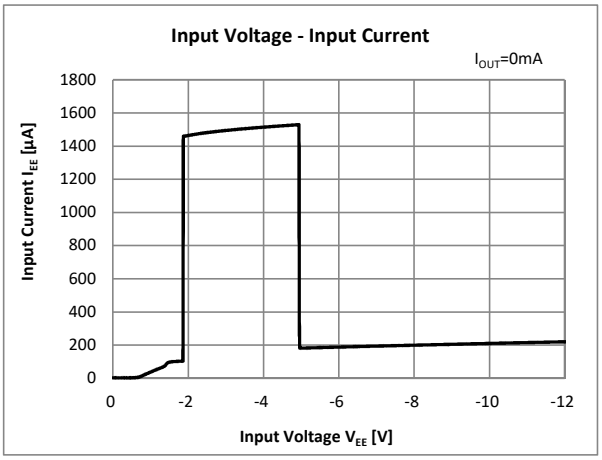


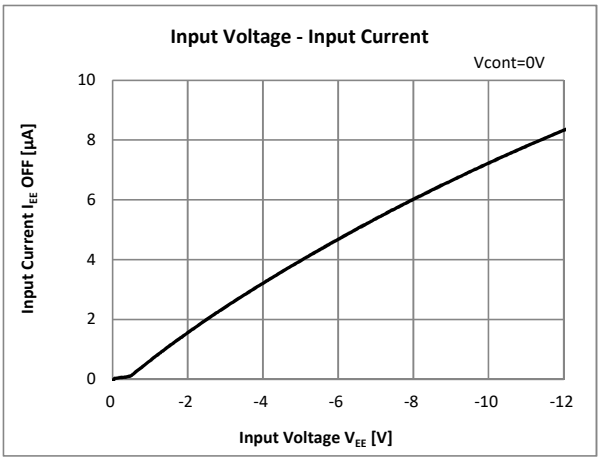

**$I_{OUT}$ : 10mA⇔50mA**

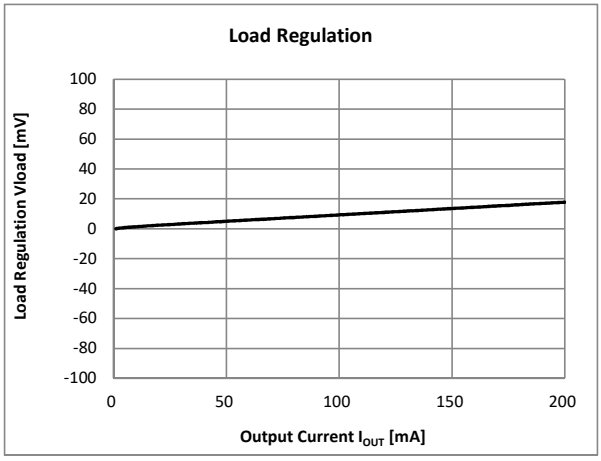


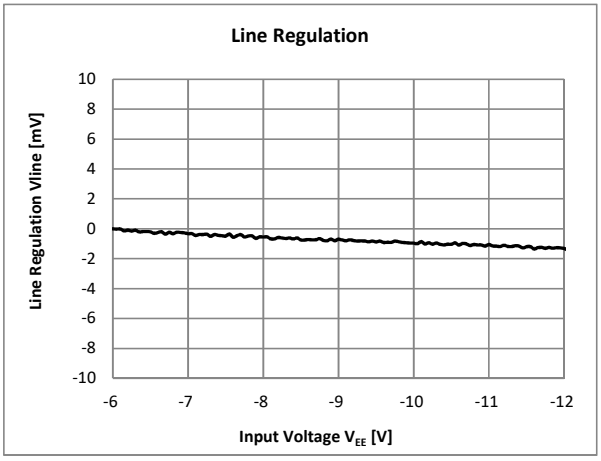
## Typical Performance Characteristics ($V_{OUT}$=-5.0V)

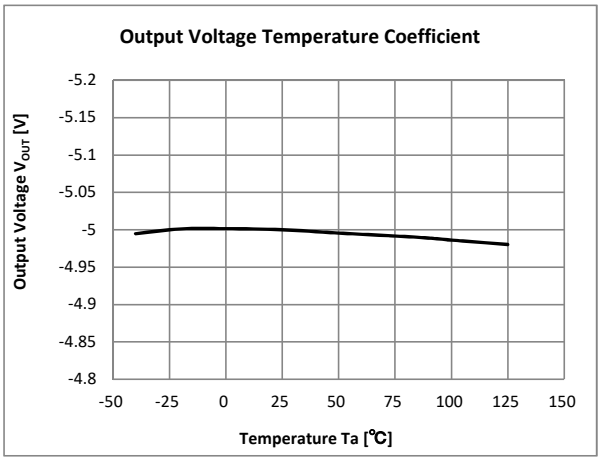
($V_{EE}$=$V_{OUT}$(Typ.)-1V, $V_{cont}$=1.6V, $I_{OUT}$=1mA, Ta=25℃ unless otherwise specified)

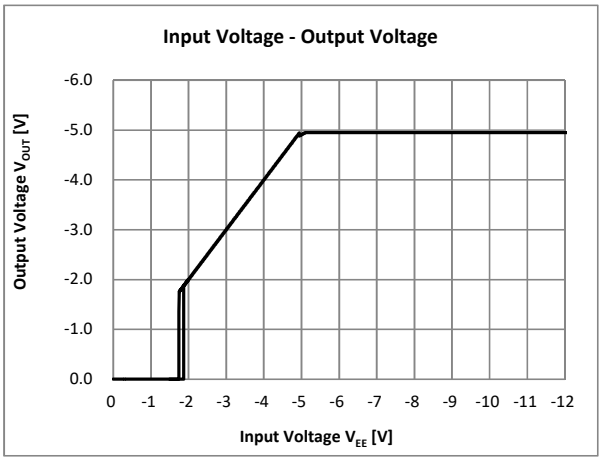


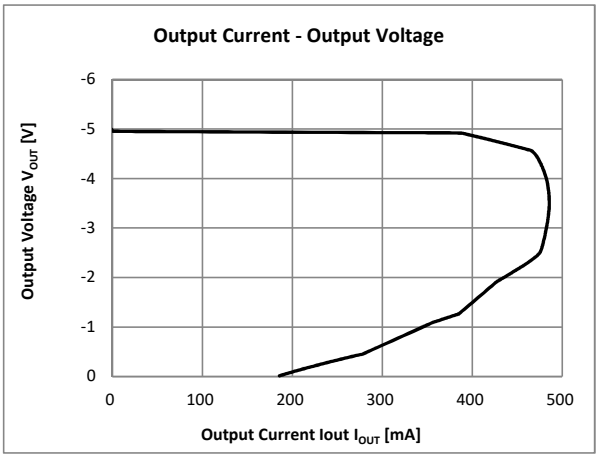



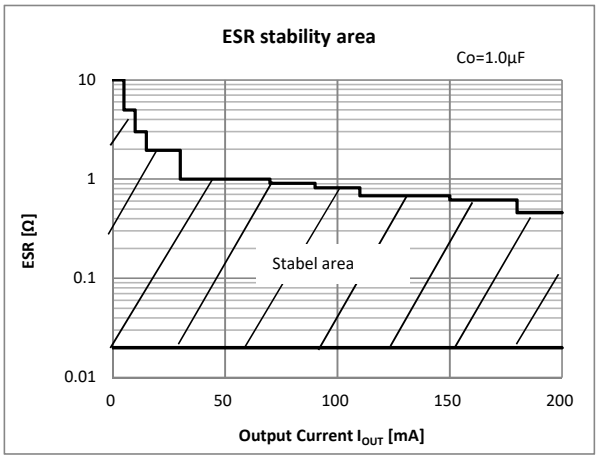



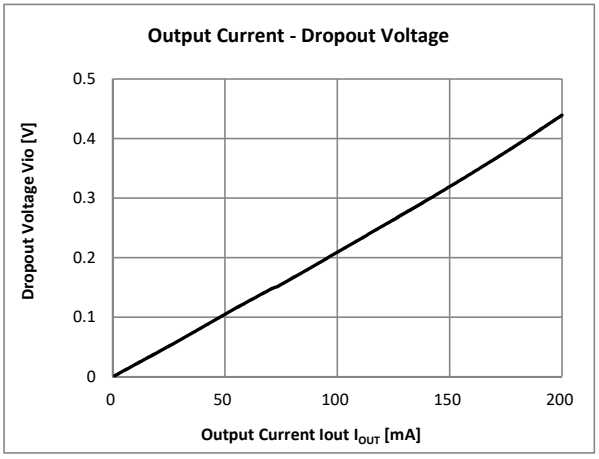



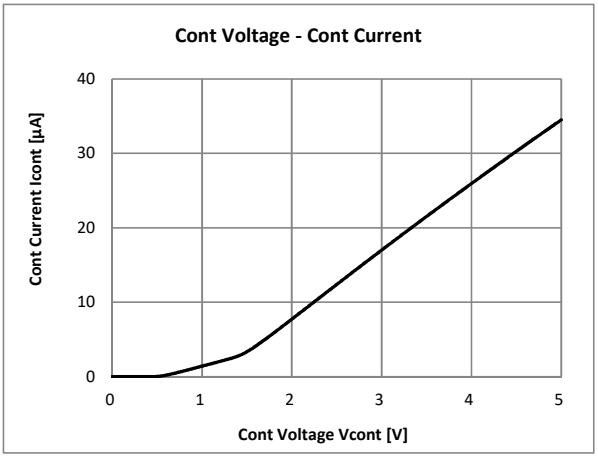
## Typical Performance Characteristics ($V_{OUT}$=-5.0V)

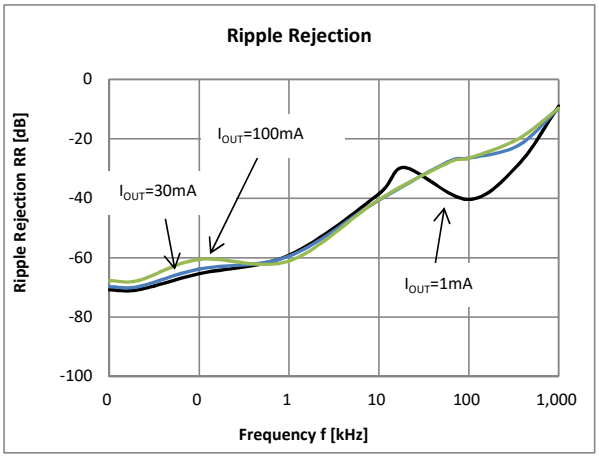
($V_{EE}$=$V_{OUT}$(Typ.)-1V, $V_{cont}$=1.6V, $I_{OUT}$=1mA, Ta=25℃ unless otherwise specified)

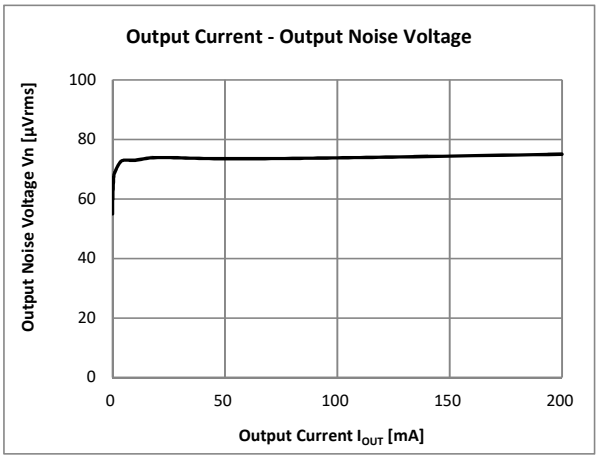


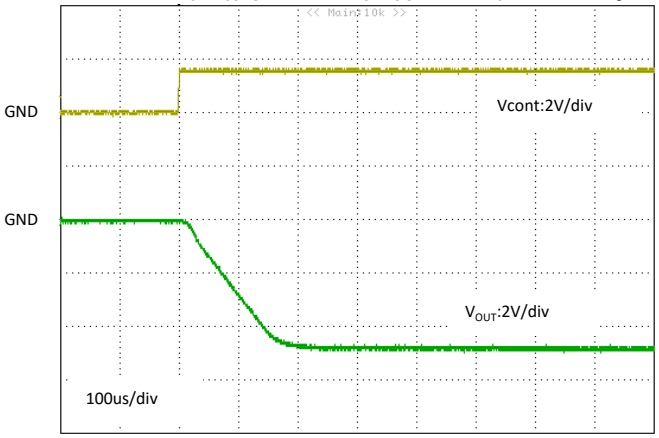



## Typical Performance Characteristics ($V_{OUT}$=-5.0V)

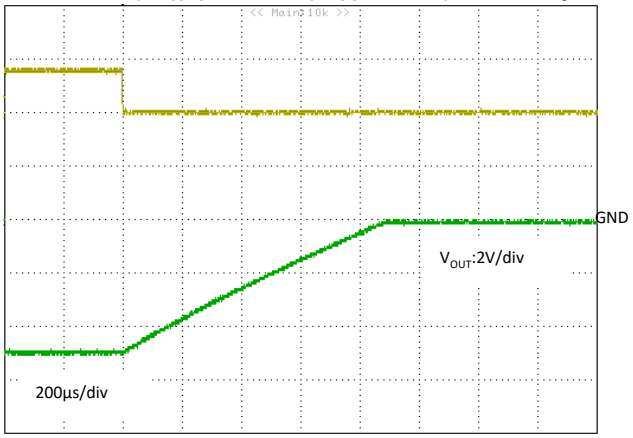
($V_{EE}$=$V_{OUT}$(Typ.)-1V, $V_{cont}$=1.6V, $I_{OUT}$=1mA, Ta=25℃ unless otherwise specified)

- Cont rise & fall characteristics

**$V_{EE}$=-6V, $V_{cont}$=0→1.6V, $I_{OUT}$=0mA, Cn=0.01μF**

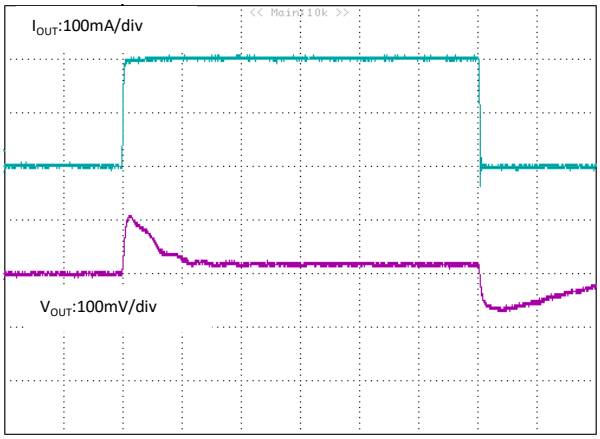



**$V_{EE}$=-6V, $V_{cont}$=1.6→0V, $I_{OUT}$=0mA, Cn=0.01μF**




- Load trainsient characteristics

**$I_{OUT}$ : 0.1mA⇔200mA**




**$I_{OUT}$ : 10mA⇔50mA**