

### General Description

The MIC2213 is a dual  $\mu$ Cap low dropout regulator with an open-drain driver and power-on reset circuit. The first regulator is capable of sourcing 150mA, while the second regulator can source up to 300mA. A power-on reset function monitors both outputs, indicating a fault on either output 1 or output 2. The open-drain output is capable of sinking 150mA for LED backlighting applications.

The MIC2213 adds the additional feature of sequencing between the outputs, with the output of regulator 1 having to settle before the output of regulator 2 can begin to turn-on.

Ideal for battery operated applications, the MIC2213 offers 1% accuracy, extremely low dropout voltage (80mV @ 100mA), and extremely low ground current, only 48 $\mu$ A total. Equipped with a TTL logic compatible enable pin, the MIC2213 can be put into a zero-off-mode current state, drawing no current when disabled.

The MIC2213 is a  $\mu$ Cap design, operating with very small ceramic output capacitors for stability, reducing required board space and component cost.

The MIC2213 is available in fixed output voltages in the 10-pin 3mm  $\times$  3mm MLF™ leadless package and is also available with adjustable output voltages in the 4mm  $\times$  4mm 16-pin MLF™ package.

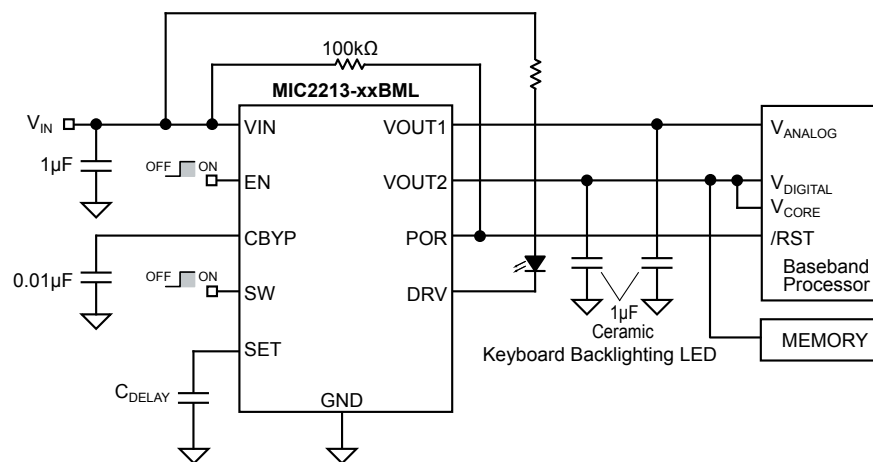
### Features

- 2 LDO outputs
  - Output 1 - 150mA output current
  - Output 2 - 300mA output current
- 1 Open-drain driver
- Power-on reset function with adjustable delay time
- **Sequencing between outputs 1 and 2**
- Input voltage range: 2.25V to 5.5V
- Stable with ceramic output capacitor
- Low dropout voltage of 80mV @ 100mA
- **Ultra-low quiescent current of 48 $\mu$ A**
- High output accuracy:
  - +1.0% initial accuracy
  - +2.0% over temperature
- Thermal Shutdown Protection
- Current Limit Protection
- **Tiny 3mm  $\times$  3mm MLF™-10 package**

### Applications

- Cellular/PCS phones
- Wireless modems
- PDAs

### Typical Application



MIC2213 Typical Cellphone Application

## Ordering Information

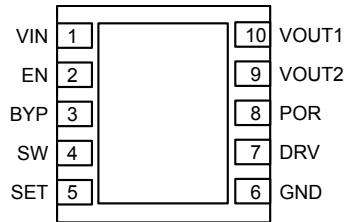
| Part Number         |               |               | Voltage*<br>(VO1 / VO2) | Junction<br>Temperature Range | Package         |
|---------------------|---------------|---------------|-------------------------|-------------------------------|-----------------|
| Full                | Manufacturing | Pb-Free       |                         |                               |                 |
| MIC2213-1.8/2.85BML | MIC2213-GNBML | MIC2213-GNYML | 1.8V/2.85V              | -40°C to +125°C               | 10-Pin 3x3 MLF™ |
| MIC2213-2.5/3.3BML  | MIC2213-JSBML | MIC2213-JSYML | 2.5V/3.3V               | -40°C to +125°C               | 10-Pin 3x3 MLF™ |
| MIC2213-Adj/AdjBML  | MIC2213-AABML | MIC2213-AAYML | Adj/Adj                 | -40°C to +125°C               | 16-Pin 4x4 MLF™ |

\* Contact factory regarding availability for voltages not listed.

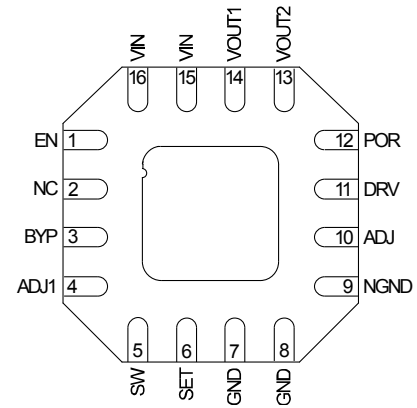
| Voltage | Code |
|---------|------|
| Adj.    | A    |
| 1.5     | F    |
| 1.6     | W    |
| 1.8     | G    |
| 2.0     | H    |
| 2.1     | E    |
| 2.5     | J    |
| 2.6     | K    |
| 2.7     | L    |
| 2.8     | M    |
| 2.850   | N    |
| 2.9     | O    |
| 3.0     | P    |
| 3.1     | Q    |
| 3.2     | R    |
| 3.3     | S    |
| 3.4     | T    |
| 3.5     | U    |
| 3.6     | V    |

**Table 1. Voltage Codes**

## Pin Configuration



**10-Pin 3mm × 3mm MLF™ (ML)  
(Top View)**



**16-Pin 4mm × 4mm MLF™ (ML)**

## Pin Description

| Pin Number<br>MLF-10 (3x3) | Pin Number<br>MLF-16 (4x4) | Pin Name | Pin Function   |
|----------------------------|----------------------------|----------|--|
| 1                          | 15, 16                     | VIN      | Supply Input (VIN1 and VIN2 are internally tied together.)   |
| 2                          | -                          | EN       | Enable Input for Regulator 1: Regulator 2 internally enabled when regulator 1 reaches 90% of nominal output. Active High input.                                  |
| -                          | 2                          | NC       | Not internally connected.  |
| 3                          | 3                          | CBYP     | Reference Bypass: Connect external 0.01μF to GND to reduce output noise. May be left open.   |
| 4                          | 5                          | SW       | Active high signal drives open-drain N-channel MOSFET.   |
| -                          | 4                          | ADJ1     | Adjust Input (Regulator 1): Connect feedback resistors to program the output voltage for the regulator.  |
| 5                          | 6                          | SET      | Delay Set Input: Connect external capacitor to GND to set the internal delay for the POR output. When left open, there is no delay. This pin cannot be grounded. |
| 6                          | 7,8                        | GND      | Ground: Connect externally to Exposed Pad.   |
| -                          | 9                          | NGND     | Ground for the open-drain driver. Tied to the source of the NMOSFET. Tied to GND internally.   |
| -                          | 10                         | ADJ2     | Adjust Input (Regulator 2): Connect feedback resistors to program the output voltage for the regulator.  |
| 7                          | 11                         | DRV      | Open-Drain Output: Capable of sinking 150mA.   |
| 8                          | 12                         | POR      | Power-On Reset Output: Open-drain output. Active low indicates an output undervoltage condition on regulator 2.  |
| 9                          | 13                         | VOUT2    | Output of Regulator 2: 300mA output current  |
| 10                         | 14                         | VOUT1    | Output of Regulator 1: 150mA output current  |
| EP                         | EP                         | GND      | Ground: Internally connected to the Exposed Pad. Connect externally to ground pin.   |

**Absolute Maximum Rating (Note 1)**

|                                      |                                   |
|--------------------------------------|-----------------------------------|
| Supply Input Voltage ( $V_{IN}$ )    | 0V to 7V                          |
| Enable Input Voltage ( $V_{EN}$ )    | 0V to 7V                          |
| Power Dissipation ( $P_D$ )          | Internally Limited, <b>Note 3</b> |
| Junction Temperature                 | -40°C to +125°C                   |
| Storage Temperature ( $T_S$ )        | -65°C to 150°C                    |
| Open-Drain Output (DRV)              | 250mA                             |
| Lead Temperature (soldering, 5 sec.) | 260°C                             |

**Operating Ratings (Note 2)**

|  |                 |
|--|-----------------|
| Supply Input Voltage ( $V_{IN}$ )                | 2.25V to 5.5V   |
| Enable Input Voltage ( $V_{EN}$ )                | 0V to $V_{IN}$  |
| Junction Temperature ( $T_J$ )                   | -40°C to +125°C |
| Package Thermal Resistance                       |                 |
| MLF™-10 ( $\theta_{JA}$ ) 1" square 2 oz. copper | 60°C/W          |

**Electrical Characteristics (Note 4)**

$V_{IN} = V_{OUT} + 1.0V$  for higher output of the regulator pair;  $C_{OUT} = 1.0\mu F$ ,  $I_{OUT} = 100\mu A$ ;  $T_J = 25^\circ C$ , **bold** values indicate  $-40^\circ C \leq T_J \leq +125^\circ C$ ; unless noted.

| Parameter                        | Conditions   | Min                 | Typ  | Max               | Units              |
|----------------------------------|--|---------------------|------|-------------------|--------------------|
| Output Voltage Accuracy          | Variation from nominal $V_{OUT}$                             | -1.0                |      | +1.0              | %                  |
|                                  |  | <b>-2.0</b>         |      | <b>+2.0</b>       | %                  |
| Output Voltage Temp. Coefficient |  |                     | 40   |                   | ppm/C              |
| Line Regulation; <b>Note 5</b>   | $V_{IN} = V_{OUT} + 1V$ to 5.5V                              | -0.3<br><b>-0.6</b> | 0.02 | 0.3<br><b>0.6</b> | %/V                |
| Load Regulation                  | $I_{OUT} = 100\mu A$ to 150mA (Regulator 1 and 2)            |                     | 0.2  | 1.0               | %                  |
|                                  | $I_{OUT} = 100\mu A$ to 300mA (Regulator 2)                  |                     |      | 1.5               | %                  |
| Dropout Voltage; <b>Note 6</b>   | $I_{OUT} = 150mA$ (Regulator 1 and 2)                        |                     | 120  | 190<br><b>250</b> | mV<br>mV           |
|                                  | $I_{OUT} = 300mA$ (Regulator 2)                              |                     | 240  | 340<br><b>420</b> | mV                 |
| Ground Pin Current               | $I_{OUT1} = I_{OUT2} = 0\mu A$                               |                     | 48   | 65<br><b>80</b>   | $\mu A$<br>$\mu A$ |
|                                  | $I_{OUT1} = 150mA$ & $I_{OUT2} = 300mA$                      |                     | 60   |                   | $\mu A$            |
| Ground Pin Current in Shutdown   | $V_{EN} \leq 0.4V$   |                     |      | <b>1.0</b>        | $\mu A$            |
| Ripple Rejection                 | $f = 1kHz$ ; $C_{OUT} = 1.0\mu F$ ceramic; $C_{BYP} = 10nF$  |                     | 60   |                   | dB                 |
|                                  | $f = 20kHz$ ; $C_{OUT} = 1.0\mu F$ ceramic; $C_{BYP} = 10nF$ |                     | 40   |                   | dB                 |
| Current Limit                    | $V_{OUT} = 0V$ (Regulator 1)                                 | 150                 | 280  | 460               | mA                 |
|                                  | $V_{OUT} = 0V$ (Regulator 2)                                 | 300                 | 450  | 700               | mA                 |
| $T_{DELAY}$ ; <b>Note 7</b>      | Sequenced delay time   |                     | 70   |                   | $\mu s$            |
| Output Voltage Noise             | $C_{OUT} = 1\mu F$ , $C_{BYP} = 0.01\mu F$ , 10Hz to 100kHz  |                     | 30   |                   | $\mu V_{rms}$      |
| <b>Enable Input</b>              |  |                     |      |                   |                    |
| Enable Input Voltage             | Logic Low (Regulator Shutdown)                               |                     |      | <b>0.6</b>        | V                  |
|                                  | Logic High (Regulator Enabled)                               | <b>1.8</b>          |      |                   | V                  |
| Enable Input Current             | $V_{IL} < 0.6V$ (Regulator Shutdown)                         | -1                  | 0.01 | +1                | $\mu A$            |
|                                  | $V_{IH} > 1.8V$ (Regulator Enabled)                          | -1                  | 0.01 | +1                | $\mu A$            |
| <b>POR Output</b>                |  |                     |      |                   |                    |
| $V_{TH}$                         | Low Threshold, % of nominal $V_{OUT2}$ (Flag ON)             | 90                  |      |                   | %                  |
|                                  | High Threshold, % of nominal $V_{OUT2}$ (Flag OFF)           |                     |      | 96                | %                  |
| $V_{OL}$                         | POR Output Logic Low Voltage; $I_L = 250\mu A$               |                     | 0.02 | 0.1               | V                  |
| $I_{POR}$                        | Flag Leakage Current, Flag OFF                               | -1                  | 0.01 | +1                | $\mu A$            |

| Parameter                 | Conditions  | Min        | Typ  | Max               | Units         |
|---------------------------|---|------------|------|-------------------|---------------|
| <b>DRV Output</b>         |   |            |      |                   |               |
| Voltage Low               | $I_{DRV} = 150\text{mA}$  |            | 0.2  | 0.5<br><b>0.6</b> | V             |
| Leakage Current           | $I_{DRV} = 0\text{mA}$ , $V_{DRV} = 5.5\text{V}$ , $SW = 0\text{V}$ | -1         | 0.01 | +1                | $\mu\text{A}$ |
| SW Input Voltage          | Logic Low (DRV Shutdown)  |            |      | <b>0.6</b>        | V             |
|                           | Logic High (DRV Enabled)  | <b>1.8</b> |      |                   | V             |
| SW Input Current          | $V_{IL} < 0.6\text{V}$ (DRV Shutdown)                               | -1         | 0.01 | +1                | $\mu\text{A}$ |
|                           | $V_{IH} > 1.8\text{V}$ (DRV Enabled)                                | -1         | 0.01 | +1                | $\mu\text{A}$ |
| <b>SET Input</b>          |   |            |      |                   |               |
| SET Pin Current Source    | $V_{SET} = 0\text{V}$   | 0.75       | 1.25 | 1.75              | $\mu\text{A}$ |
| SET Pin Threshold Voltage | $P_{OR} = \text{High}$  |            | 1.25 |                   | V             |

**Note 1.** Exceeding maximum rating may damage the device.

**Note 2.** The device is not guaranteed to work outside its operating rating.

**Note 3.** The maximum allowable power dissipation of any  $T_A$  (ambient temperature) is  $(P_{D(max)} = T_{J(max)} - T_A) / \theta_{JA}$ . Exceeding the maximum allowable power dissipation will result in excessive die temperature, and the regulator will go into thermal shutdown.

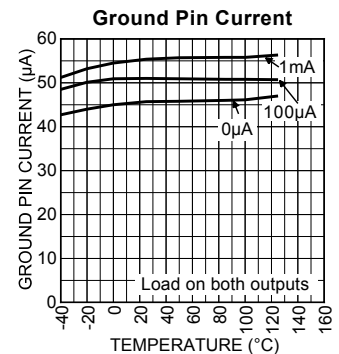
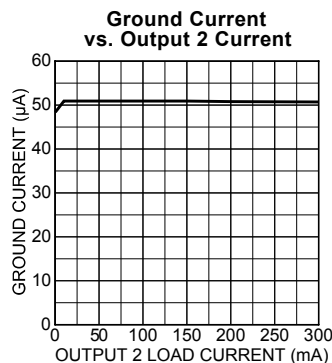
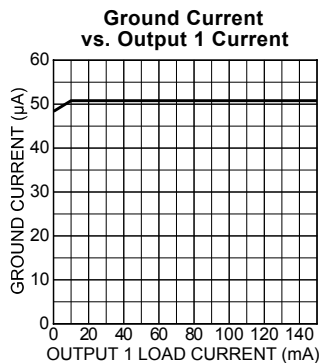
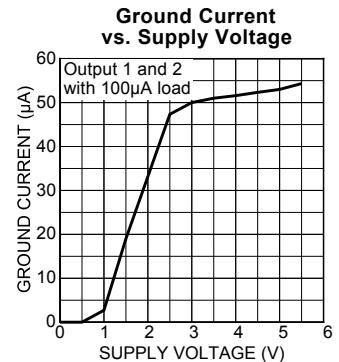
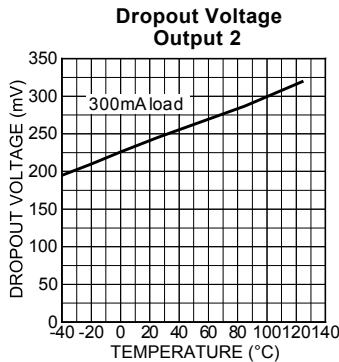
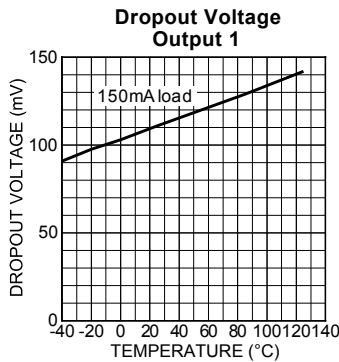
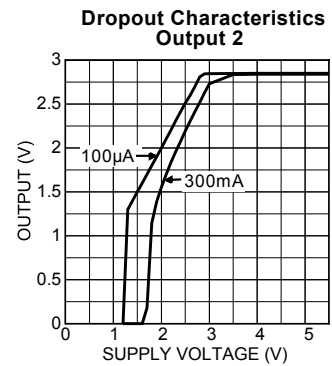
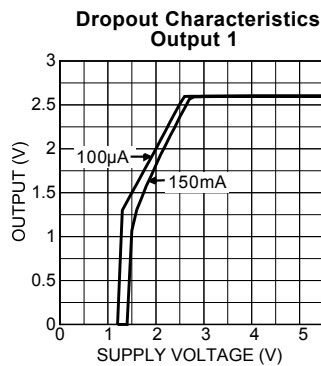
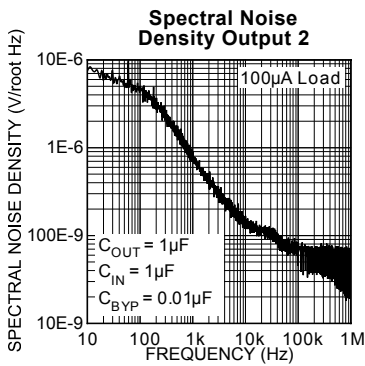
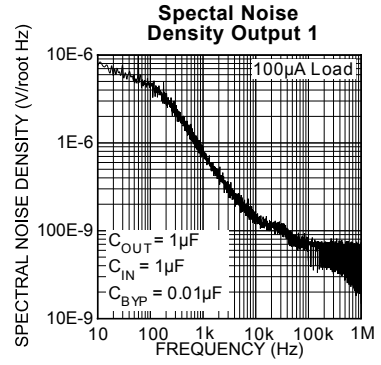
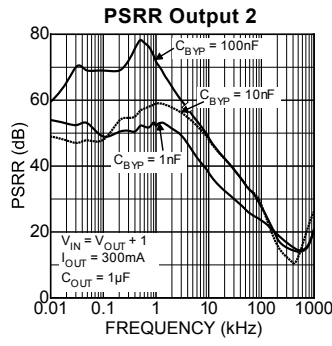
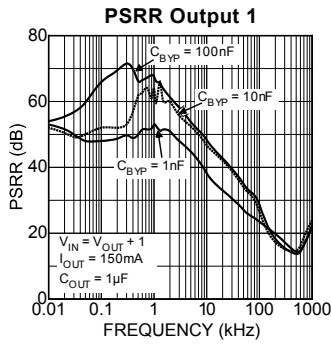
**Note 4.** Specification for packaged product only.

**Note 5.** Minimum input for line regulation test is set to  $V_{OUT} + 1\text{V}$  relative to the highest output voltage.

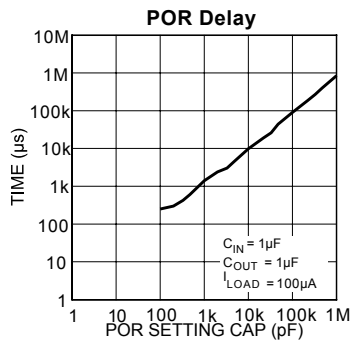
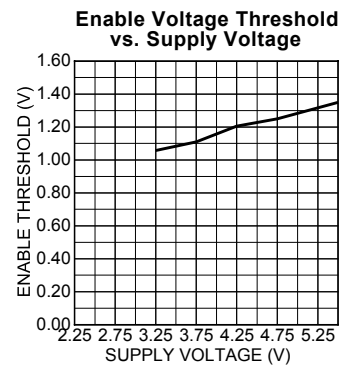
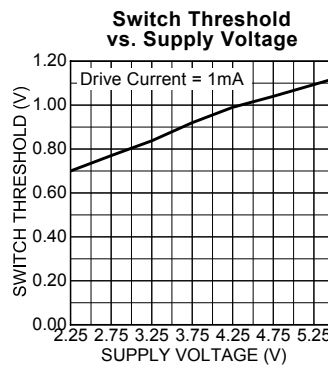
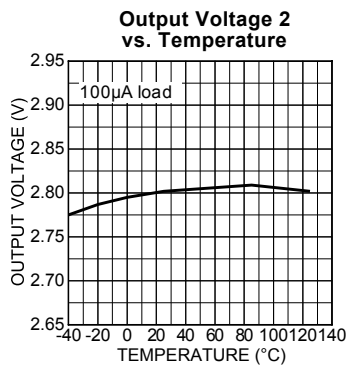
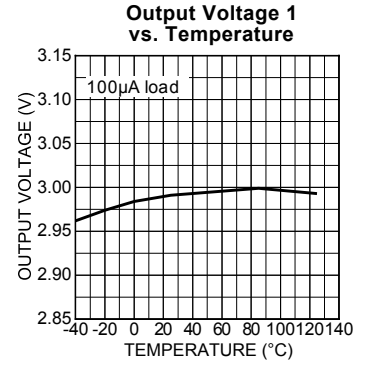
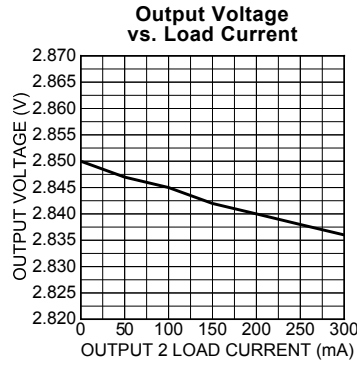
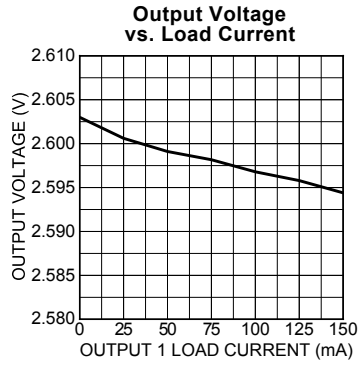
**Note 6.** Dropout voltage is defined as the input-to-output differential at which the output voltage drops 2% below its nominal value measured at 1V differential. For outputs below 2.25V, dropout voltage is the input-to-output voltage differential with the minimum input voltage 2.25V. Minimum input operating voltage is 2.25V.

**Note 7.** Time measured from output of regulator 1 reaching 90% of its final value to output of regulator 2 reaching 90% of its final value.

# Typical Characteristics

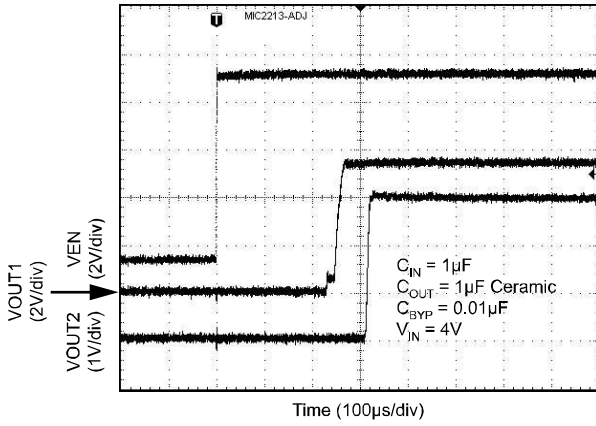


Typical Characteristics (cont.)

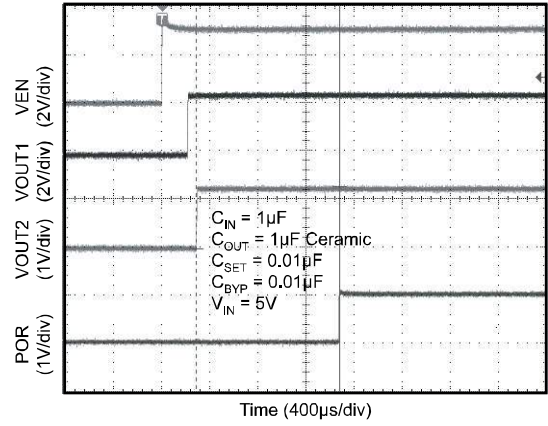


# Functional Characteristics

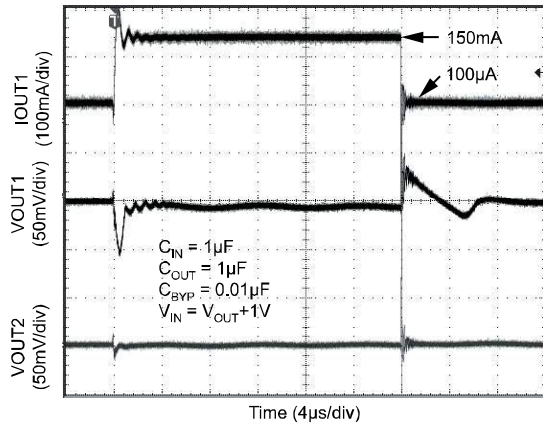
**Enable Characteristics**



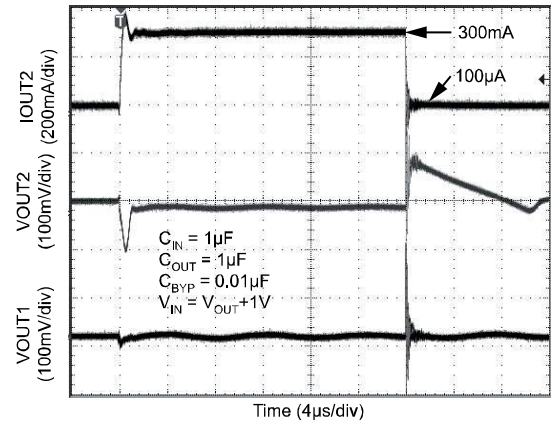
**Power-On Reset Characteristics**



**Load Transient Response (LDO 1)**

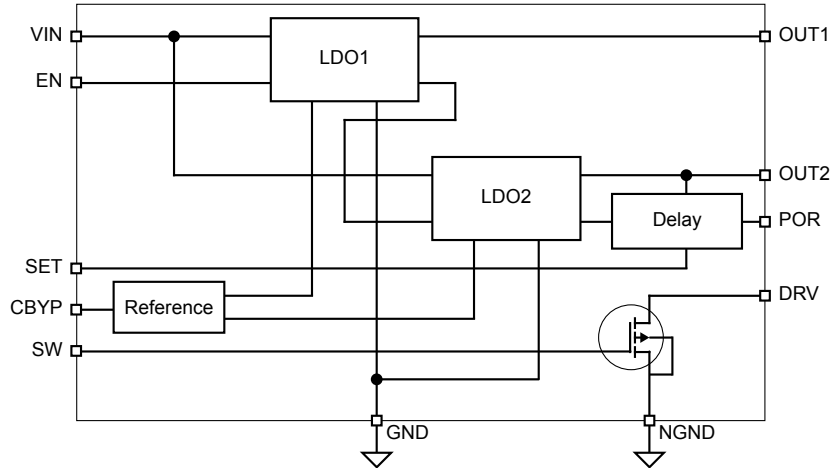


**Load Transient Response (LDO 2)**

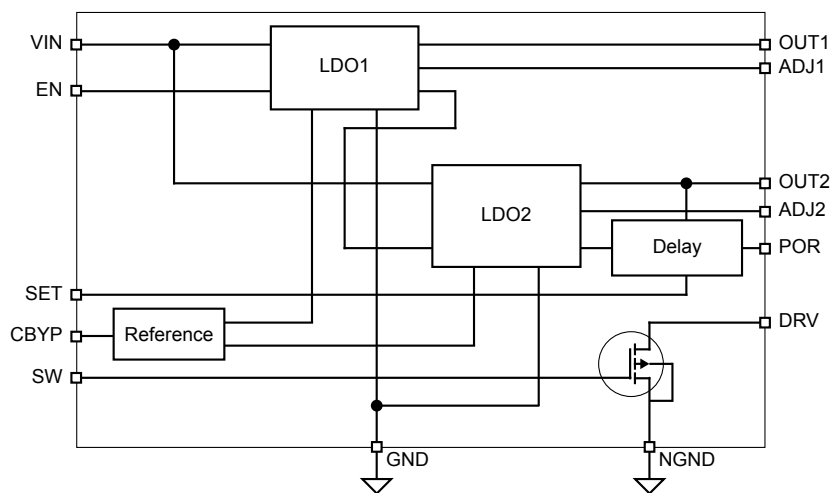




## Functional Diagram



**MIC2213 Fixed Voltage Block Diagram**



**MIC2213 Adjustable Voltage Block Diagram**

## Functional Description

The MIC2213 is a high performance, low quiescent current power management IC consisting of two  $\mu$ Cap low dropout regulators, a power-on reset (POR) circuit and an open-drain driver. The first regulator is capable of sourcing 150mA at output voltages from 1.25V to 5V. The second regulator is capable of sourcing 300mA of current at output voltages from 1.25V to 5V. The second regulator has a POR circuit that monitors its output voltage and indicates when the output voltage is within 5% of nominal. The POR offers a delay time that is externally programmable with a single capacitor to ground. An open-drain driver completes the power management chipset, offering the capability of driving LEDs for keypad backlighting in applications such as cellphones.

### Enable

The enable input allows for logic control of both output voltages with one enable input. The enable input is active high, requiring 1.8V for guaranteed operation. The enable input is CMOS logic and cannot be left floating.

### Power-On Reset (POR)

The power-on reset output is an open-drain N-channel device, requiring a pull-up resistor to either the input voltage or output voltage for proper voltage levels. The POR output has a delay time that is programmable with a capacitor from the SET pin to ground. The delay time can be programmed to be as long as 1 second.

The SET pin is a current source output that charges a capacitor that sets the delay time for the power-on reset output. The current source is a  $1\mu\text{A}$  current source that charges a capacitor up from 0V. When the capacitor reaches 1.25V, the output of the POR is allowed to go high.

### Open-Drain Driver (DRV)

The drive (DRV) pin is an open-drain output capable of sinking 150mA of current. This output is controlled by a logic level input, the switch (SW) pin. The switch pin is an active high input and cannot be left floating.

### Input Capacitor

Good bypassing is recommended from input to ground to help improve AC performance. A 1 $\mu$ F capacitor or greater located close to the IC is recommended.

### Bypass Capacitor

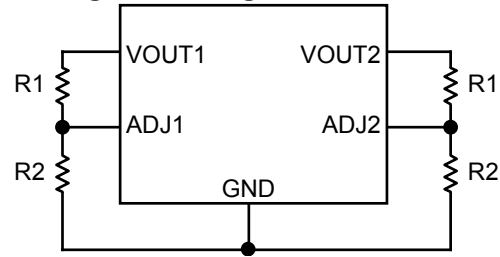
The internal reference voltage of the MIC2213 can be bypassed with a capacitor to ground to reduce output noise and increase power supply rejection (PSRR). A quick-start feature allows for quick turn-on of the output voltage regardless of the size of the capacitor. The recommended nominal bypass capacitor is 0.01 $\mu$ F, but it can be increased without limit.

### Output Capacitor

Each regulator output requires a 1 $\mu$ F ceramic output capacitor for stability. The output capacitor value can be increased to improve transient response, but performance has been optimized for a 1 $\mu$ F ceramic type output capacitor.

X7R/X5R dielectric-type ceramic capacitors are recommended because of their temperature performance. X7R-type capacitors change capacitance by 15% over their operating temperature range and are the most stable type of ceramic capacitors. Z5U and Y5V dielectric capacitors change value by as much as 50% and 60% respectively over their operating temperature ranges. To use a ceramic chip capacitor with Y5V dielectric, the value must be much higher than a X7R ceramic capacitor to ensure the same minimum capacitance over the equivalent operating temperature range.

### Adjustable Regulator Design



#### MIC2213 Adjustable Regulator Design

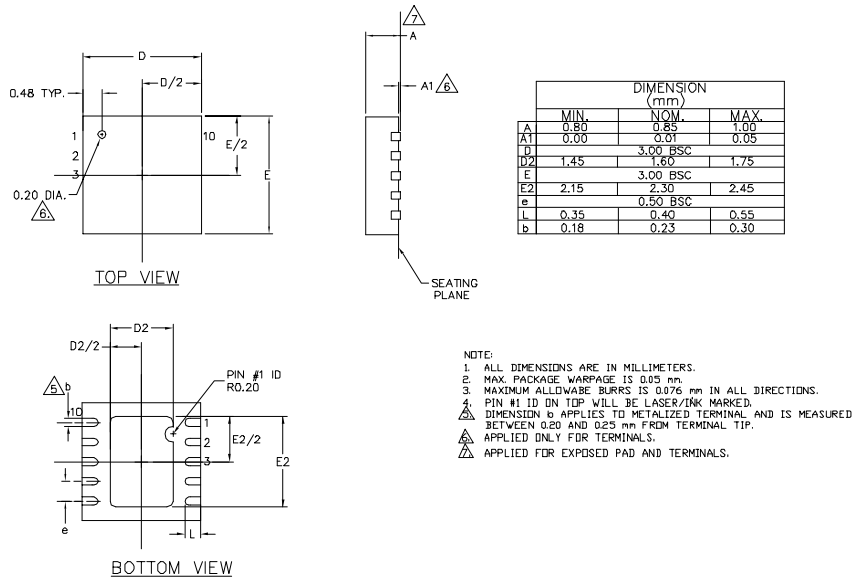
The MIC2213 allows the programming of the output voltages 1 and 2 anywhere between 1.25V and 5.5V, the maximum operating rating of the part. Two resistors are required for each output. Appropriate resistor values are required to prevent the low quiescent current performance being compromised. Resistor values recommended are between 100k $\Omega$  and 500k $\Omega$ .

The resistor values are calculated by:

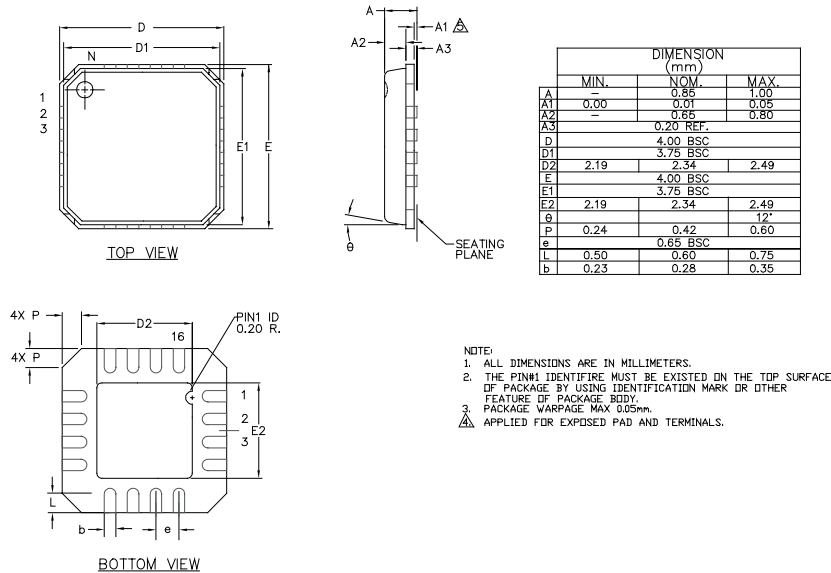
$$R1 = R2 \left( \frac{V_{OUT}}{1.250} - 1 \right)$$

where  $V_{OUT}$  is the desired output voltage. Calculate separately for each output.

Package Information



10-Lead MLF™ (ML)



16-Lead MLF™ (ML)

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