MIC2213

Sequenced Portable Power Management IC

General Description

The MIC2213 is a dual µCap 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 48µA 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 µCap 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 × 3mm MLF™ leadless package and is also available with adjustable output voltages in the 4mm × 4mm 16-pin MLF™ package.

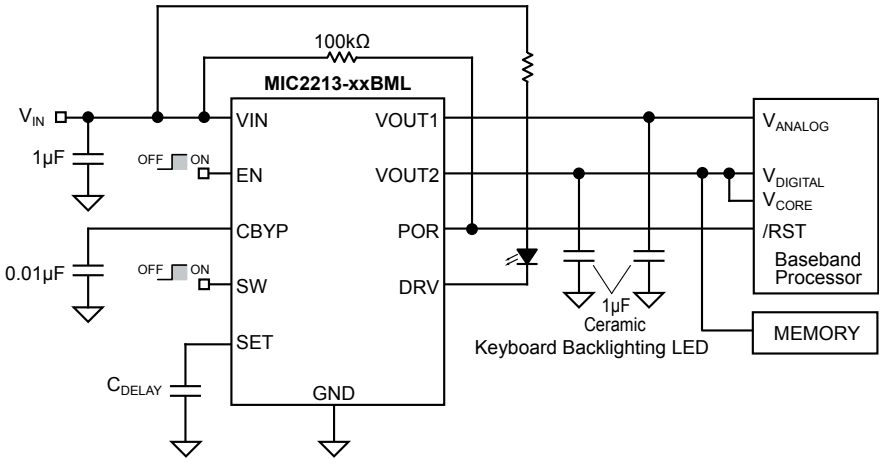
Features

- 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 48µA**
- High output accuracy:
  - +1.0% initial accuracy
  - +2.0% over temperature
- Thermal Shutdown Protection
- Current Limit Protection
- **Tiny 3mm × 3mm MLF™-10 package**

Applications

- Cellular/PCS phones
- Wireless modems
- PDAs

Typical Application



MIC2213 Typical Cellphone Application

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Micrel, Inc. • 2180 Fortune Drive • San Jose, CA 95131 • USA • tel + 1 (408) 944-0800 • fax + 1 (408) 474-1000 • http://www.micrel.com

Ordering Information

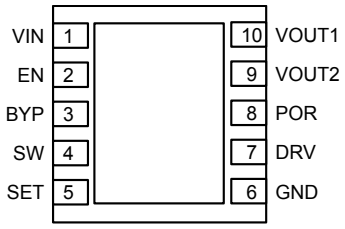
Part Number			Voltage* (VO1 / VO2)	Junction Temperature Range	Package
Full	**Manufacturing**	**Pb-Free**			
MIC2213-1.8/2.85BML	MIC2213-GNBML	MIC2213-GNYML	1.8V/2.85V	–40ºC to +125ºC	10-Pin 3x3 MLF™
MIC2213-2.5/3.3BML	MIC2213-JSBML	MIC2213-JSYML	2.5V/3.3V	–40ºC to +125ºC	10-Pin 3x3 MLF™
MIC2213-Adj/AdjBML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

* Contact factory regarding availability for voltages not listed.

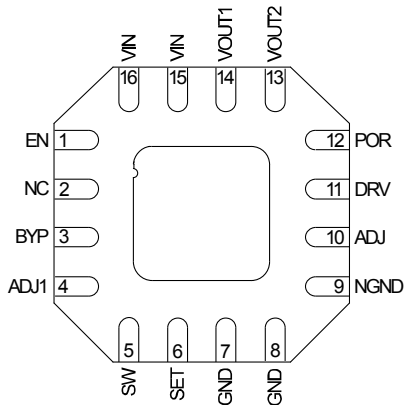
Voltage	Code
Adj.	A
1.5	F
1.6	W
1.8	G
2.0	H
2.1	E
2.5	J
2.6	K
2.7	L
2.8	M
2.850	N
2.9	O
3.0	P
3.1	Q
3.2	R
3.3	S
3.4	T
3.5	U
3.6	V

Table 1. Voltage Codes

Pin Configuration



10-Pin 3mm × 3mm MLF™ (ML)
(Top View)



16-Pin 4mm × 4mm MLF™ (ML)

Pin Description

Pin Number MLF-10 (3x3)	Pin Number 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, **Note 3**
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 Vin
Junction Temperature (T_J) ..... –40°C to +125°C
Package Thermal Resistance
MLF™-10 (θ_{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} = 1.0µF, I_{OUT} = 100µA; T_J = 25°C, **bold** values indicate –40°C ≤ T_J ≤ +125°C; unless noted.

Parameter	Conditions	Min	Typ	Max	Units
Output Voltage Accuracy	Variation from nominal V_{OUT}	–1.0 **–2.0**		+1.0 **+2.0**	% %
Output Voltage Temp. Coefficient			40		ppm/C
Line Regulation; **Note 5**	$V_{IN} = V_{OUT}$ +1V to 5.5V	–0.3 **–0.6**	0.02	0.3 **0.6**	%/V
Load Regulation	I_{OUT} = 100µA to 150mA (Regulator 1 and 2)		0.2	1.0	%
	I_{OUT} = 100µA to 300mA (Regulator 2)			1.5	%
Dropout Voltage; **Note 6**	I_{OUT} = 150mA (Regulator 1 and 2)		120	190 **250**	mV mV
	I_{OUT} = 300mA (Regulator 2)		240	340 **420**	mV
Ground Pin Current	$I_{OUT1} = I_{OUT2}$ = 0µA		48	65 **80**	µA µA
	I_{OUT1} = 150mA & I_{OUT2} = 300mA		60		µA
Ground Pin Current in Shutdown	V_{EN} ≤ 0.4V			**1.0**	µA
Ripple Rejection	f = 1kHz; C_{OUT} = 1.0µF ceramic; C_{BYP} = 10nF		60		dB
	f = 20kHz; C_{OUT} = 1.0µF 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}; **Note 7**	Sequenced delay time		70		µs
Output Voltage Noise	C_{OUT} =1µF, C_{BYP} =0.01µF, 10Hz to 100kHz		30		µVrms
Enable Input					
Enable Input Voltage	Logic Low (Regulator Shutdown)			**0.6**	V
	Logic High (Regulator Enabled)	**1.8**			V
Enable Input Current	V_{IL} < 0.6V (Regulator Shutdown)	–1	0.01	+1	µA
	V_{IH} > 1.8V (Regulator Enabled)	–1	0.01	+1	µA
POR Output					
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 = 250µA		0.02	0.1	V
I_{POR}	Flag Leakage Current, Flag OFF	–1	0.01	+1	µA

Parameter	Conditions	Min	Typ	Max	Units
DRV Output					
Voltage Low	I_{DRV} = 150mA		0.2	0.5 **0.6**	V
Leakage Current	I_{DRV} = 0mA, V_{DRV} = 5.5V, SW = 0V	–1	0.01	+1	µA
SW Input Voltage	Logic Low (DRV Shutdown)			**0.6**	V
	Logic High (DRV Enabled)	**1.8**			V
SW Input Current	V_{IL} < 0.6V (DRV Shutdown)	–1	0.01	+1	µA
	V_{IH} > 1.8V (DRV Enabled)	–1	0.01	+1	µA
SET Input					
SET Pin Current Source	V_{SET} = 0V	0.75	1.25	1.75	µA
SET Pin Threshold Voltage	P_{OR} = 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.

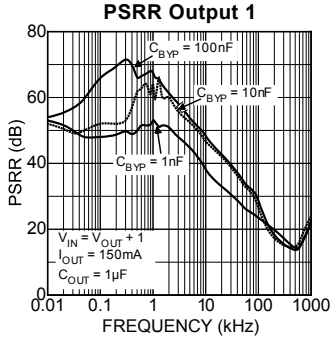
Note 5. Minimum input for line regulation test is set to V_{OUT} + 1V relative to the highest output voltage.

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.

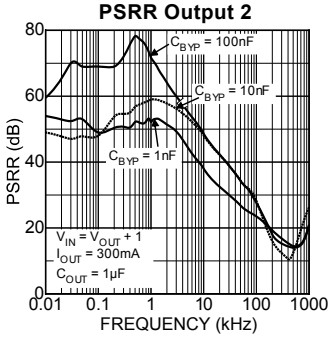
Note 7. Time measured from output of regulator 1 reaching 90% of its final value to output of regulator 2 reaching 90% of its final value.

Typical Characteristics

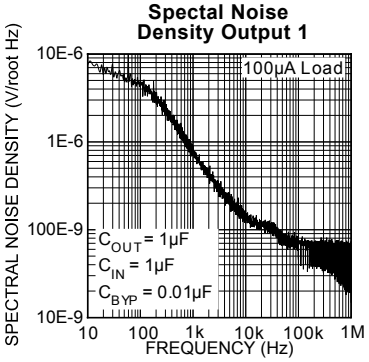
PSRR Output 1



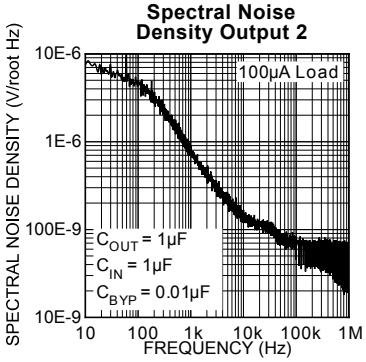
PSRR Output 2



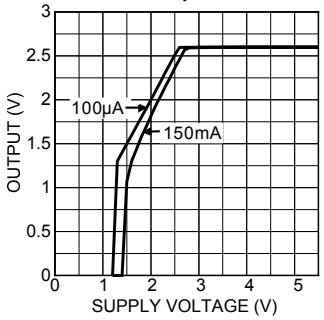
Spectal Noise Density Output 1



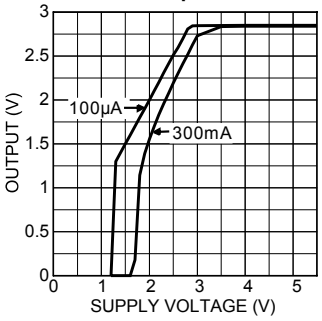
Spectral Noise Density Output 2



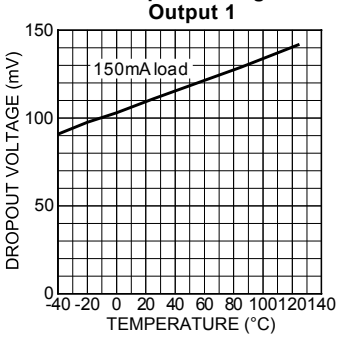
Dropout Characteristics Output 1



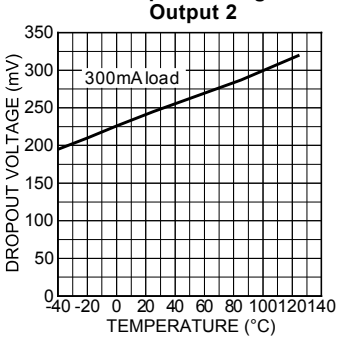
Dropout Characteristics Output 2



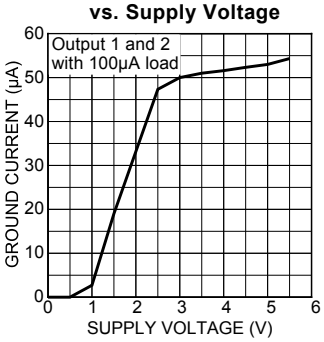
Dropout Voltage Output 1



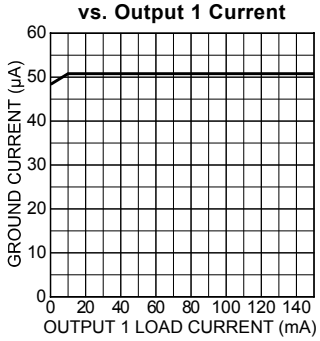
Dropout Voltage Output 2



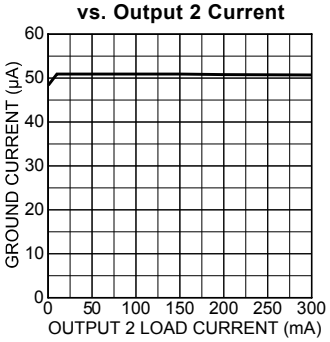
Ground Current vs. Supply Voltage



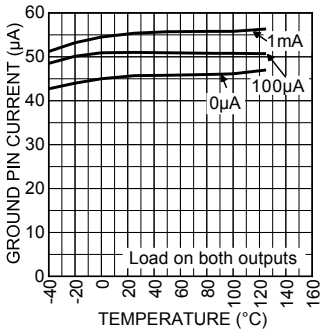
Ground Current vs. Output 1 Current



Ground Current vs. Output 2 Current

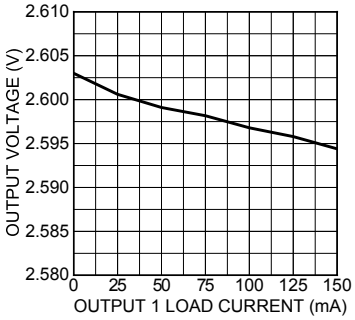


Ground Pin Current

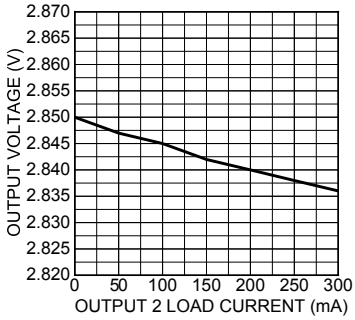


Typical Characteristics (cont.)

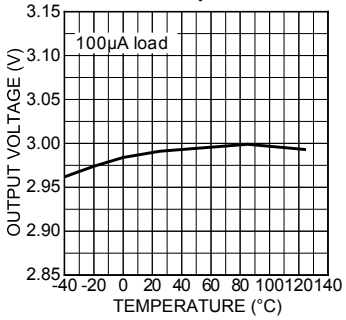
Output Voltage vs. Load Current



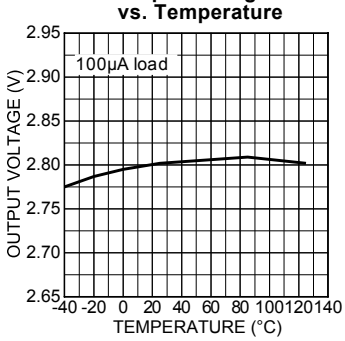
Output Voltage vs. Load Current



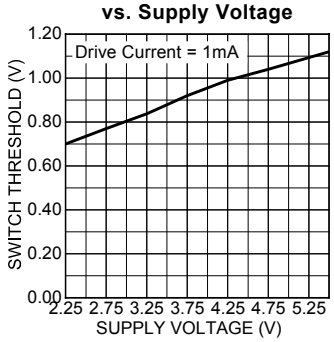
Output Voltage 1 vs. Temperature



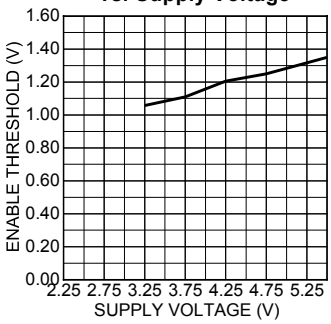
Output Voltage 2 vs. Temperature



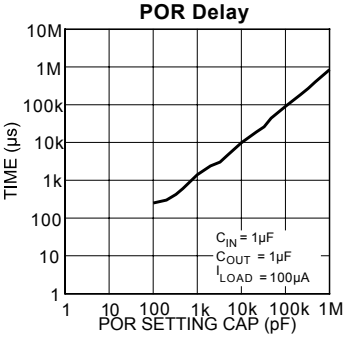
Switch Threshold vs. Supply Voltage



Enable Voltage Threshold vs. Supply Voltage

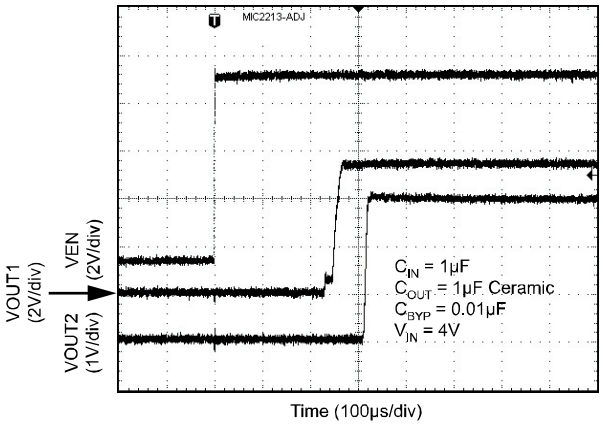


POR Delay

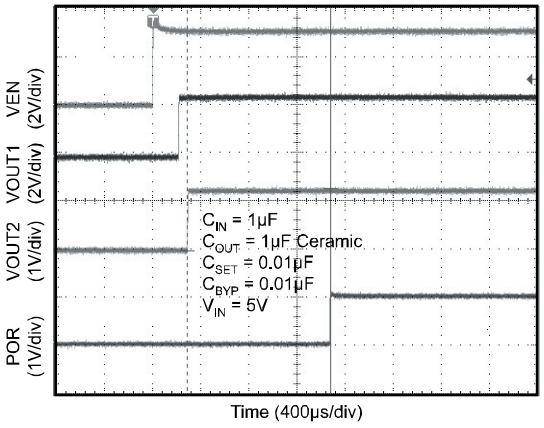


Functional Characteristics

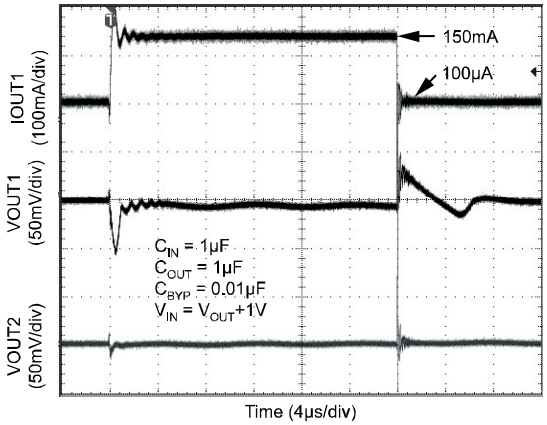
Enable Characteristics



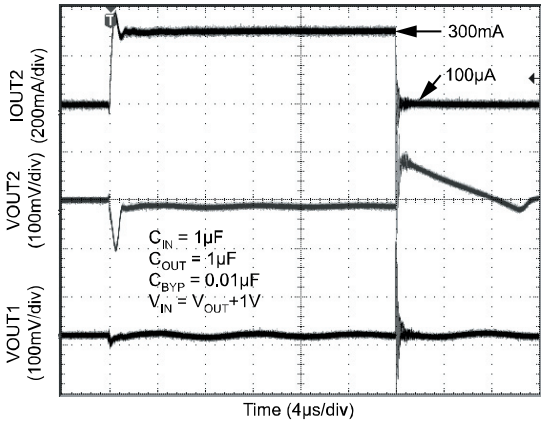
Power-On Reset Characteristics



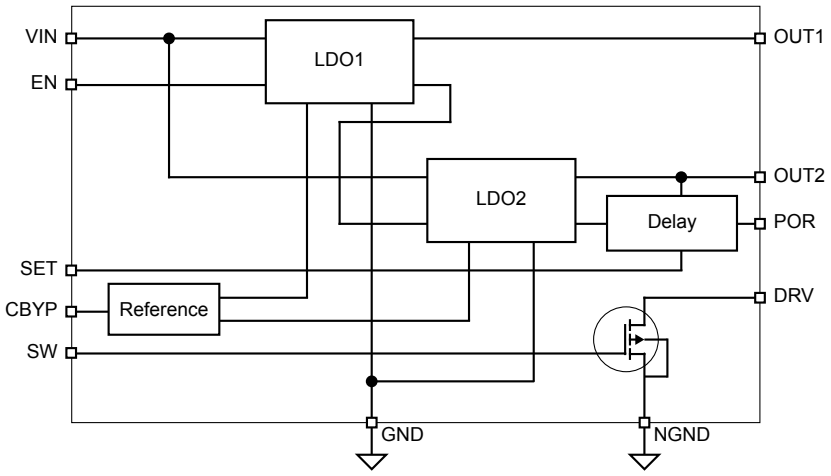
Load Transient Response (LDO 1)



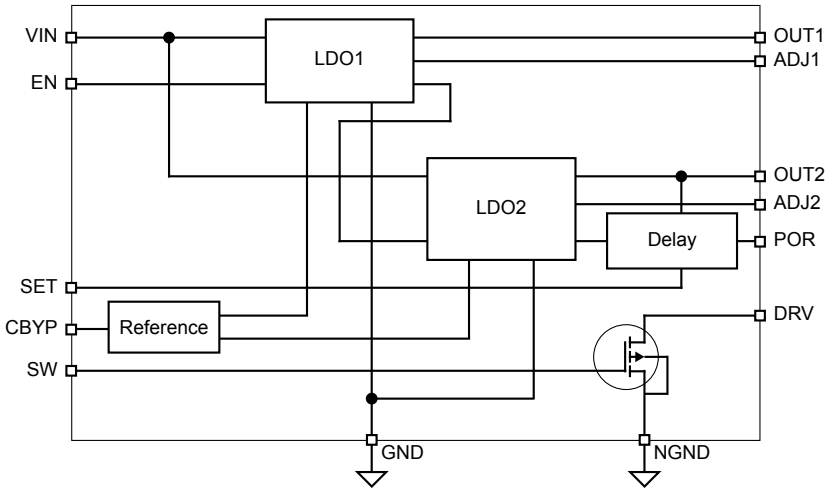
Load Transient Response (LDO 2)



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 µCap 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 by 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 1µA 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 1µF capacitor or greater located close to the IC is recommended.

Bypass Capacitor

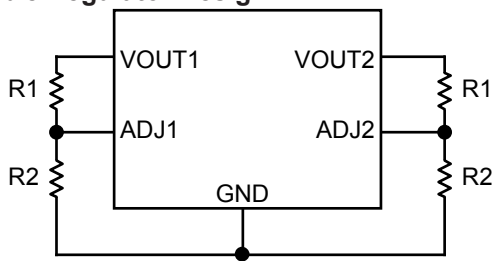
The internal reference voltage of the MIC2213 can be bypassed with a capacitor to ground to reduce output noise and increase power supply rejection (PSRR). A quick-start feature allows for quick turn-on of the output voltage regardless of the size of the capacitor. The recommended nominal bypass capacitor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

Output Capacitor

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

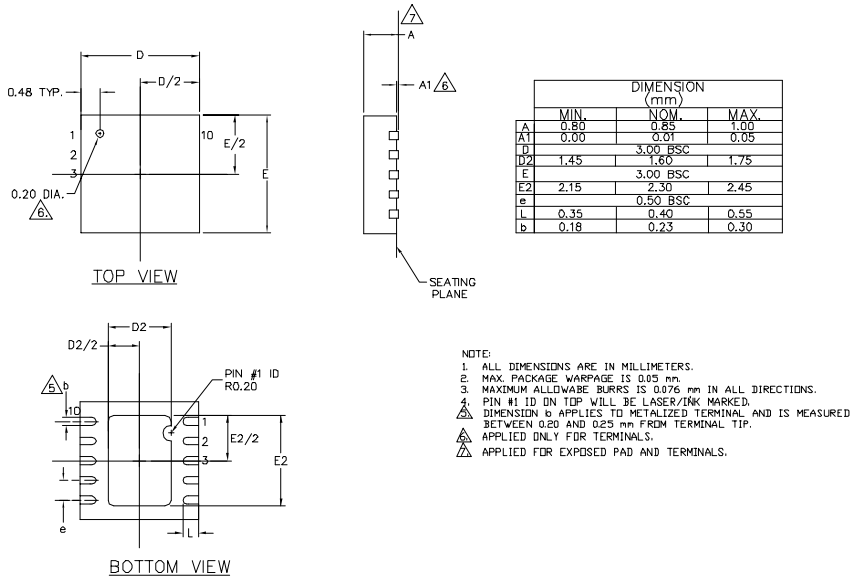
The MIC2213 allows the programming of the output voltages 1 and 2 anywhere between 1.25V and 5.5V, the maximum operating rating of the part. Two resistors are required for each output. Appropriate resistor values are required to prevent the low quiescent current performance being compromised. Resistor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

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.

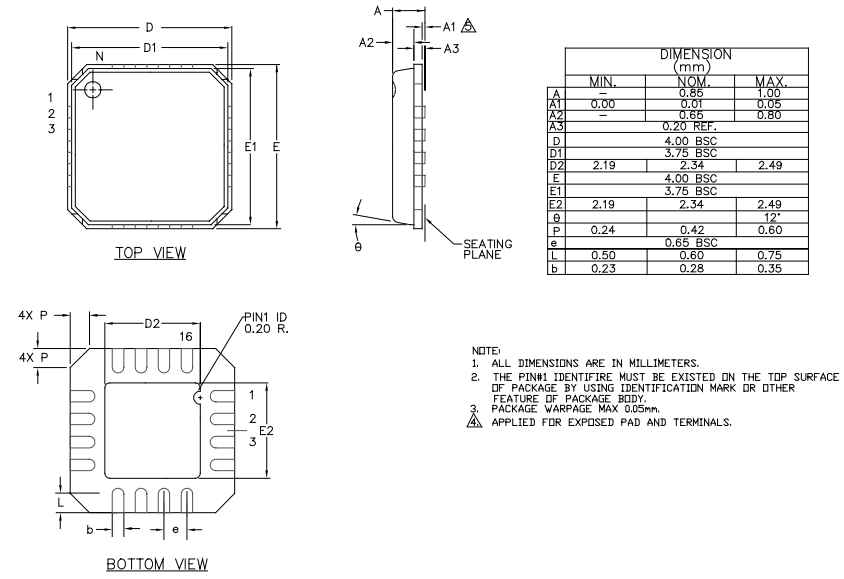
Package Information



	DIMENSION (mm)		
	MIN.	NOM.	MAX.
A	0.80	0.85	1.00
A1	0.00	0.01	0.05
D		3.00 BSC	
D2	1.45	1.60	1.75
E		3.00 BSC	
E2	2.15	2.30	2.45
e		0.50 BSC	
L	0.35	0.40	0.55
b	0.18	0.23	0.30

NOTE:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. MAX. PACKAGE WARPAGE IS 0.05 mm.
3. MAXIMUM ALLOWABE BURRS IS 0.076 mm IN ALL DIRECTIONS.
4. PIN #1 ID ON TOP WILL BE LASER/INK MARKED.
5. DIMENSION b APPLIES TO METALIZED TERMINAL AND IS MEASURED BETWEEN 0.20 AND 0.25 mm FROM TERMINAL TIP.
6. APPLIED ONLY FOR TERMINALS.
7. APPLIED FOR EXPOSED PAD AND TERMINALS.

10-Lead MLF™ (ML)



	DIMENSION (mm)		
	MIN.	NOM.	MAX.
A	–	0.85	1.00
A1	0.00	0.01	0.05
A2	–	0.65	0.80
A3		0.20 REF.	
D		4.00 BSC	
D1		3.75 BSC	
D2	2.19	2.34	2.49
E		4.00 BSC	
E1		3.75 BSC	
E2	2.19	2.34	2.49
θ			12°
P	0.24	0.42	0.60
e		0.65 BSC	
L	0.50	0.60	0.75
b	0.23	0.28	0.35

NOTE:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. THE PIN#1 IDENTIFIRE MUST BE EXISTED ON THE TOP SURFACE OF PACKAGE BY USING IDENTIFICATION MARK OR OTHER FEATURE OF PACKAGE BODY.
3. PACKAGE WARPAGE MAX 0.05mm.
4. APPLIED FOR EXPOSED PAD AND TERMINALS.

16-Lead MLF™ (ML)

MICREL INC. 2180 FORTUNE DRIVE SAN JOSE, CA 95131 USA
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