
4A Sequencing LDO with Tracking and Ramp Control

Features

- Stable with 10 μ F Ceramic Capacitor
- Input Voltage Range: 1.65V to 5.5V
- 0.5V Reference
- $\pm 2.0\%$ Output Tolerance over Temperature
- 4A Maximum Output Current – Peak Start-Up
- 3A Continuous Operating Current
- Tracking on Turn-On and Turn-Off with Pin Strapping
- Timing Controlled Sequencing On/Off
- Programmable Ramp Control for In-Rush Current Limiting and Slew Rate Control of the Output Voltage During Turn-On and Turn-Off
- Power-On Reset (POR) Supervisor with Programmable Delay Time
- Single Master can Control Multiple Slave Regulators with Tracking Output Voltages
- Tiny 4 mm x 4 mm QFN Package
- Maximum Dropout ($V_{IN} - V_{OUT}$) of 500 mV over Temperature at 3A Output Current
- Fixed and Adjustable Output Voltages
- Excellent Line and Load Regulation Specifications
- Logic Controlled Shutdown
- Thermal Shutdown and Current-Limit Protection

Applications

- FPGA/PLD Power Supply
- Networking/Telecom Equipment
- Microprocessor Core Voltage
- High Efficiency Linear Post Regulator
- Sequenced or Tracked Power Supply

General Description

The MIC68400 is a high peak current LDO regulator designed specifically for powering applications such as FPGA core voltages that require high start up current with lower nominal operating current. Capable of sourcing 4A of current for start-up, the MIC68400 provides high power from a small QFN leadless package. The MIC68400 can also implement a variety of power-up and power-down protocols such as sequencing, tracking, and ratiometric tracking.

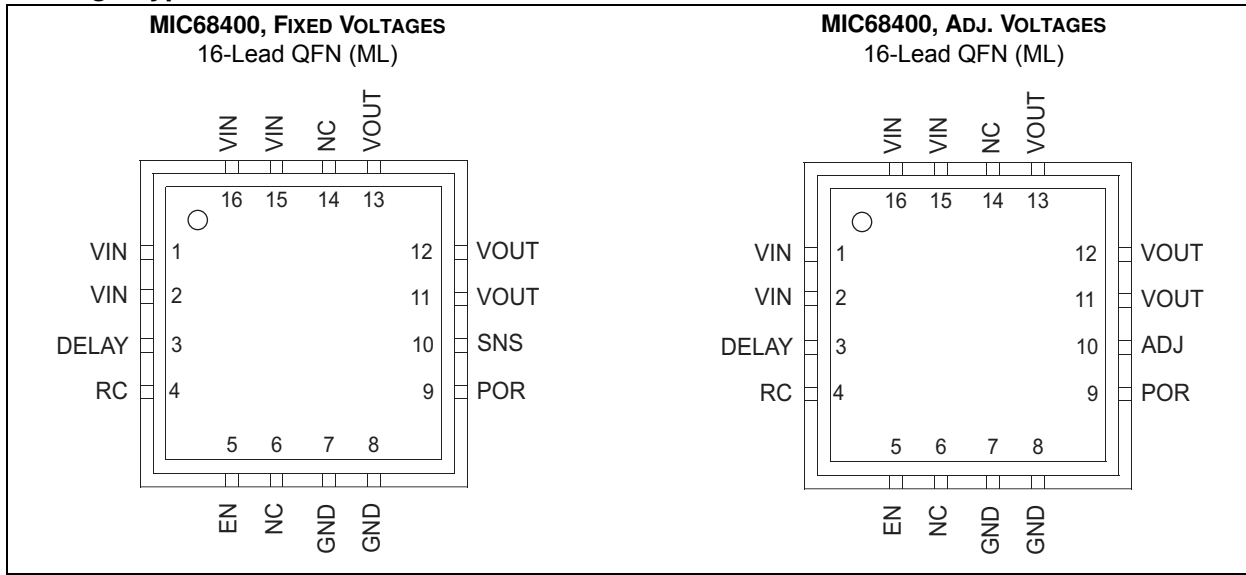
The MIC68400 operates from a wide input range of 1.65V to 5.5V, which includes all of the main supply voltages commonly available today. It is designed to drive digital circuits requiring low voltage at high currents (i.e. PLDs, DSP, microcontroller, etc.). The MIC68400 incorporates a delay pin (Delay) for control of power on reset output (POR) at turn-on and power-down delay at turn-off. In addition there is a ramp control pin (RC) for either tracking applications or output voltage slew rate adjustment at turn-on and turn-off. This is important in applications where the load is highly capacitive and in-rush currents can cause supply voltages to fail and microprocessors or other complex logic chips to hang up.

Multiple MIC68400s can be daisy chained in two modes. In tracking mode the output voltage of the Master drives the RC pin of a Slave so that the Slave tracks the main regulator during turn-on and turn-off. In sequencing mode the POR of the Master drives the enable (EN) of the Slave so that it turns on after the Master and turns off before (or after) the Master. This behavior is critical for power-up and power-down control in multi-output power supplies. The MIC68400 is fully protected offering both thermal, current limit protection, and reverse current protection.

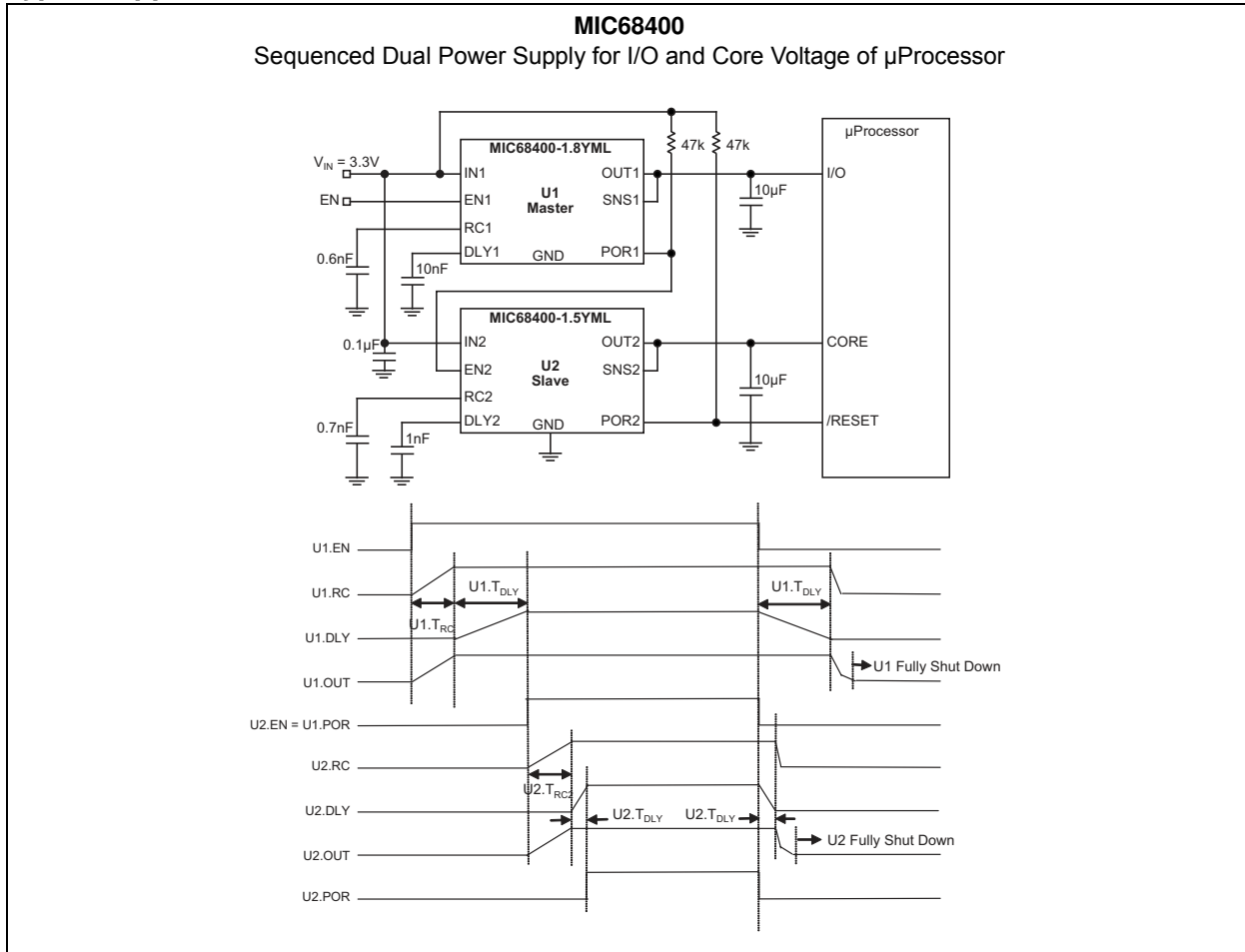
The MIC68400 has a junction temperature range of -40°C to $+125^{\circ}\text{C}$ and is available in fixed as well as an adjustable option. The MIC68400 is offered in the tiny 16-pin 4 mm x 4 mm QFN package.

MIC68400

Package Types



Typical Application Circuits



MIC68400

1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{IN}).....	+6V
Enable Input Voltage (V_{EN}).....	+6V
POR (V_{POR}).....	$V_{IN} + 0.3V$
RC.....	$V_{IN} + 0.3V$
Power Dissipation (P_D), (Note 1).....	Internally Limited

Operating Ratings ‡

Supply Voltage (V_{IN}).....	+1.65V to +5.5V
Enable Input Voltage (V_{EN}).....	0V to V_{IN}
Ramp Control (V_{RC}).....	0V to +5.5V

† **Notice:** Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

‡ **Notice:** The device is not guaranteed to function outside its operating ratings.

Note 1: 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.

TABLE 1-1: ELECTRICAL CHARACTERISTICS

Electrical Characteristics: $T_A = +25^\circ C$ with $V_{IN} = V_{OUT} + 1V$; $V_{EN} = V_{IN}$; $I_{OUT} = 10\text{ mA}$; **bold** values indicate $-40^\circ C \leq T_J \leq +125^\circ C$, unless noted. [Note 1](#)

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Output Voltage Accuracy		-2	—	2	%	$10\text{ mA} < I_{OUT} < I_{L(MAX)}$, $V_{OUT} + 1 \leq V_{IN} \leq 5.5V$
Feedback Voltage	V_{FB}	0.49	0.50	0.51	V	Adjustable version only
Feedback Current	I_{FB}	—	20	—	nA	Adjustable version only
Output Voltage Line Regulation		—	0.06	0.5	%	$V_{IN} = V_{OUT} + 1V$ to 5.0V
Output Voltage Load Regulation		—	0.5	1	%	$I_L = 10\text{ mA}$ to 3A
$V_{IN} - V_O$: Dropout Voltage		—	—	400	mV	$I_L = 1.5A$
		—	300	500		$I_L = 3.0A$
		—	360	800		$I_L = 4.0A$
Ground Pin Current	I_{GND}	—	1.2	—	mA	$I_L = 10\text{ mA}$
		—	20	—		$I_L = 1.5A$
		—	55	—		$I_L = 3.0A$
		—	90	130		$I_L = 4.0A$
Shutdown Current	I_{SHDN}	—	0.01	10	μA	$V_{EN} = 0V$; $V_{OUT} = 0V$
Current Limit	I_{LIMIT}	4.0	6.0	—	A	$V_{OUT} = 0V$; $V_{IN} = 3.0V$
Start-Up Time	t_{SU}	—	35	150	μs	$V_{EN} = V_{IN}$; CRC = Open
Enable Input						
Enable Input Threshold		1	—	—	V	Regulator enable
		—	—	0.2		Regulator shutdown
Enable Hysteresis		20	120	200	mV	—

TABLE 1-1: ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: $T_A = +25^\circ\text{C}$ with $V_{IN} = V_{OUT} + 1\text{V}$; $V_{EN} = V_{IN}$; $I_{OUT} = 10\text{ mA}$; **bold** values indicate $-40^\circ\text{C} \leq T_J \leq +125^\circ\text{C}$, unless noted. [Note 1](#)

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Enable Input Current		—	0.02	—	μA	$V_{IL} \leq 0.2\text{V}$ (Regulator shutdown)
		—	3	—		$V_{IH} \geq 1\text{V}$ (Regulator enable)
POR Output						
POR Leakage Current	$I_{\text{POR(LEAK)}}$	—	—	1	μA	$V_{\text{POR}} = 5.5\text{V}$; POR = High
		—	—	2		
	$V_{\text{POR(LO)}}$	—	60	90	mV	Output Logic-Low Voltage (undervoltage condition), $I_{\text{POR}} = 1\text{ mA}$
	V_{POR}	7.5	10	12.5	%	V_{OUT} Ramping Up, Threshold, Percent of V_{OUT} below nominal
		10	12.5	15		V_{OUT} Ramping Down, Threshold, Percent of V_{OUT} below nominal
		—	3	—		Hysteresis
Delay Current	I_{DELAY}	0.7	1	1.3	μA	$V_{\text{DELAY}} = 0.75\text{V}$
Delay Voltage (Note 2)	V_{DELAY}	1.185	1.235	1.285	V	$V_{\text{POR}} = \text{High}$
Ramp Control						
Ramp Control Current	I_{RC}	0.7	1	1.3	μA	$V_{\text{RC}} = 0.75\text{V}$
Output Discharge Current (Note 3)	$I_{\text{DC(OUT)}}$	25	45	70	mA	$V_{\text{OUT}} = 0.5V_{\text{NOM}}$, $V_{\text{RAMP}} = 0\text{V}$
Fixed Tracking Accuracy (Note 4)		-50	25	100	mV	$200\text{ mV} < V_{\text{RC}} < V_{\text{TARGET}}$; Measure $(V_{\text{OUT}} - V_{\text{RC}})$
Adjustable Tracking Accuracy (Note 4)		-10	15	50	mV	Measure $(V_{\text{OUT}} - V_{\text{RC}} \times (V_{\text{TARGET}}/500\text{ mV}))$

Note 1: Specification for packaged product only.

- 2: Timer High Voltage along with Delay pin current ($1\ \mu\text{A}$ nom.) determines the delay per μF of capacitance. Typical delay is $1.1\text{ sec}/\mu\text{F}$.
- 3: Discharge current is the current drawn from the output to ground to actively discharge the output capacitor during the shutdown process.
- 4: V_{TARGET} is the output voltage of an adjustable with customer resistor divider installed between V_{OUT} and ADJ/SNS pin, or the rated output voltage of a fixed device.

MIC68400

TEMPERATURE SPECIFICATIONS (Note 1)

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Junction Temperature Range	T_J	-40	—	+125	°C	—
Storage Temperature Range	T_S	-65	—	+150	°C	—
Package Thermal Resistances						
Thermal Resistance 16-LD 4x4 QFN	θ_{JA}	—	30	—	°C/W	—

Note 1: The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature and the thermal resistance from junction to air (i.e., T_A , T_J , θ_{JA}). Exceeding the maximum allowable power dissipation will cause the device operating junction temperature to exceed the maximum +125°C rating. Sustained junction temperatures above +125°C can impact the device reliability.

2.0 TYPICAL PERFORMANCE CURVES

Note: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

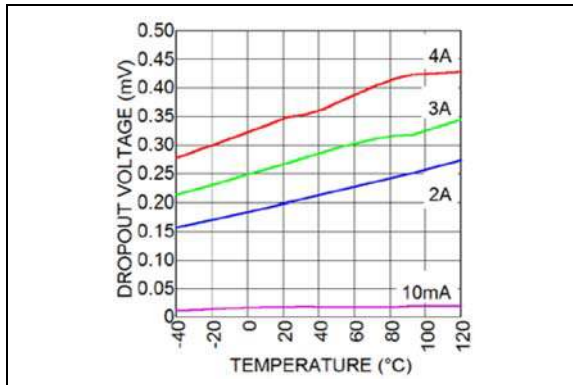


FIGURE 2-1: Dropout Voltage vs. Temperature.

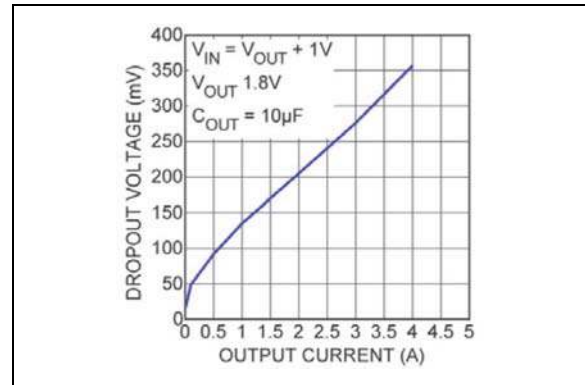


FIGURE 2-4: Dropout Voltage vs. Output Current.

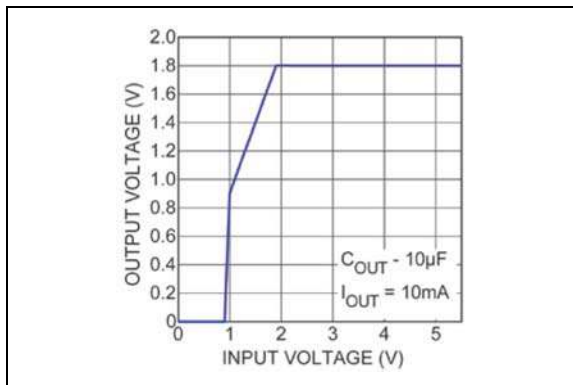


FIGURE 2-2: Output Voltage vs. Input Voltage.

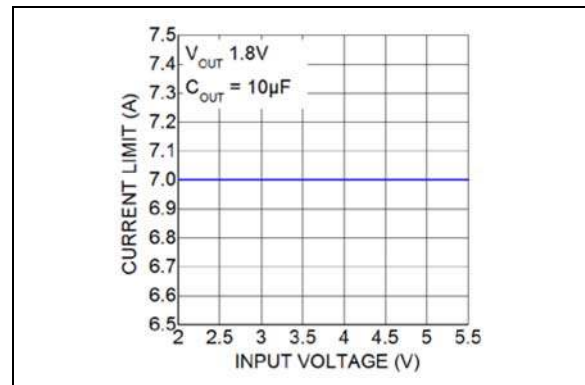


FIGURE 2-5: Current Limit vs. Input Voltage.

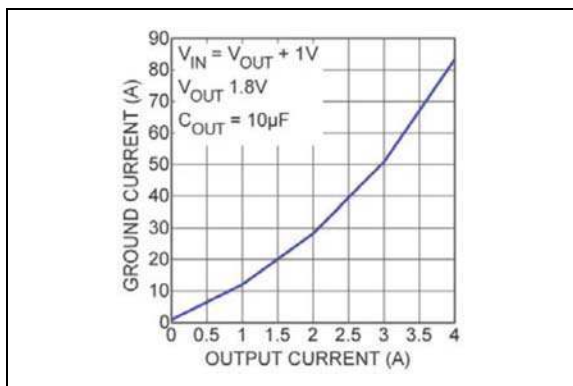


FIGURE 2-3: Ground Current vs. Output Current.

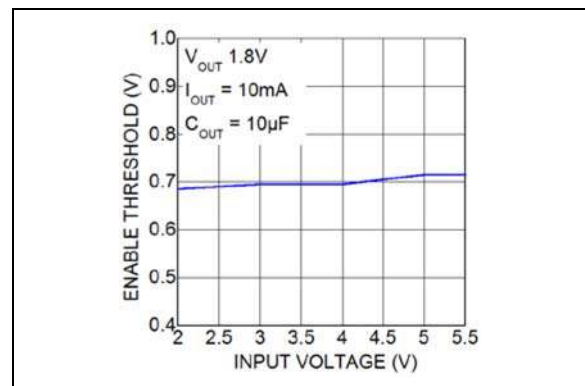


FIGURE 2-6: Enable Threshold vs. Input Voltage.

MIC68400

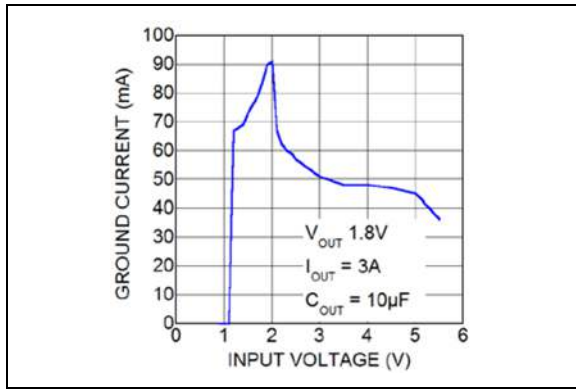


FIGURE 2-7: Ground Current vs. Input Voltage.

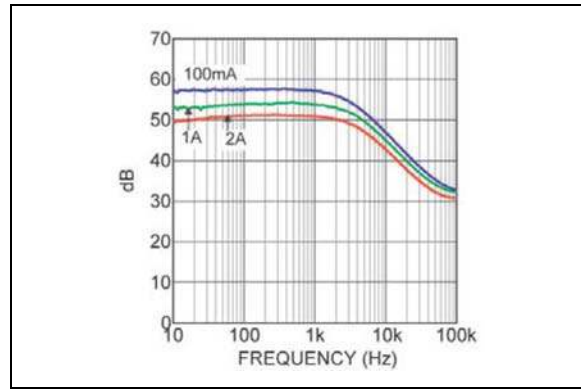


FIGURE 2-10: Power Supply Rejection Ratio.

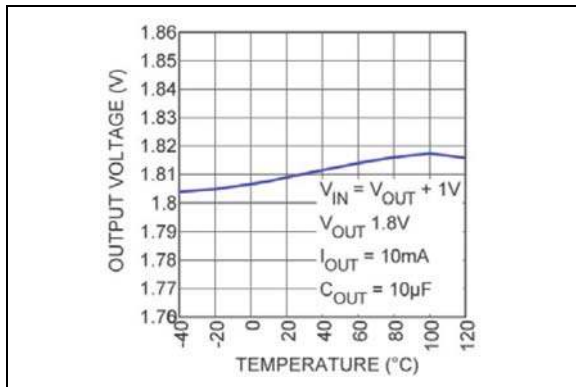


FIGURE 2-8: Output Voltage vs. Temperature.

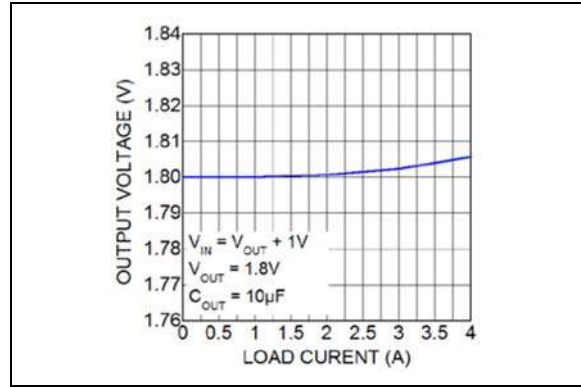


FIGURE 2-11: Load Regulation.

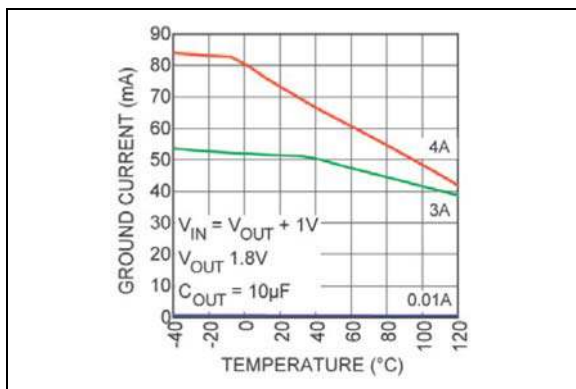


FIGURE 2-9: Ground Current vs. Temperature.

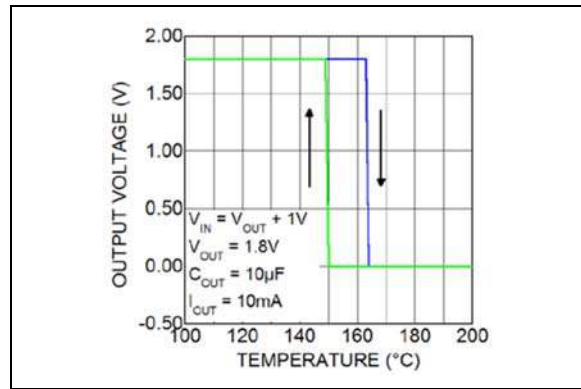


FIGURE 2-12: Thermal Shutdown.

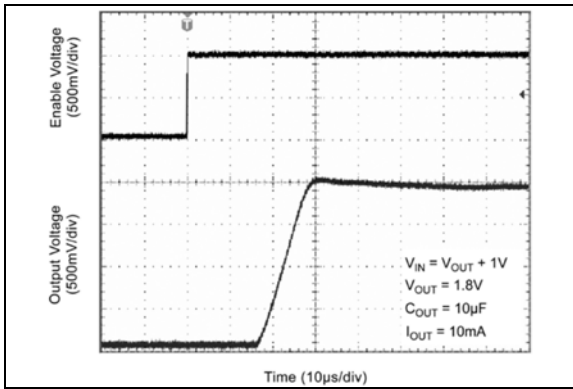


FIGURE 2-13: Enable Turn-On.

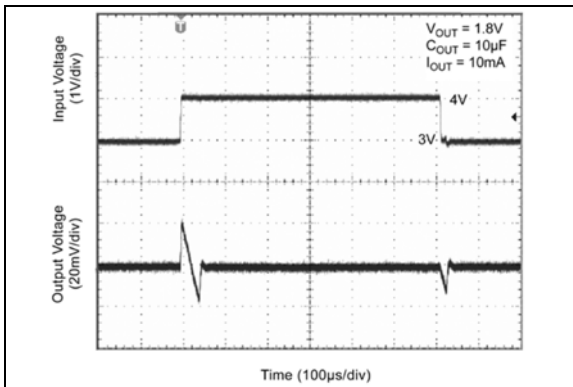


FIGURE 2-14: Line Transient.

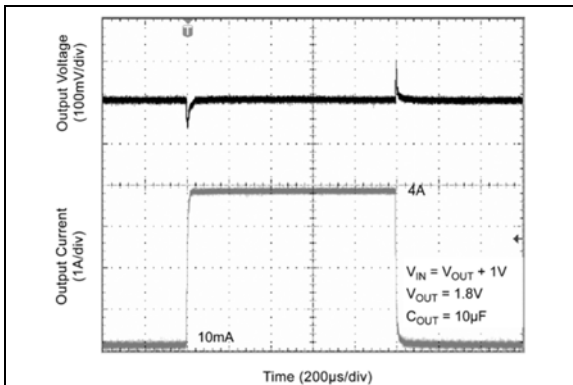


FIGURE 2-15: Load Transient.

MIC68400

3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in [Table 3-1](#).

TABLE 3-1: PIN FUNCTION TABLE

Pin Number	Pin Name	Description
1, 2, 15, 16	V _{IN}	Input: Input voltage supply pin. Place a capacitor to ground to bypass the input supply.
3	DELAY	Delay: Capacitor to ground sets internal delay timer. Timer delays power-on reset (POR) output at turn-on, and ramp down at turn-off.
4	RC	Ramp Control: May be voltage driven for tracking applications or a capacitor to ground will set the slew rate of output voltage during start-up.
5	EN	Enable (Input): CMOS compatible input. Logic-high = enable, logic-low = shutdown.
6, 14	NC	Not internally connected.
7, 8, Tab	GND	Ground.
9	POR	Power-on Reset: Open-drain output device indicates when the output is in regulation. High (open) means device is regulating within 10%. POR onset can be delayed using a single capacitor from Delay to ground.
10 (Fixed)	SNS	Output Voltage Sense Pin: Connect directly to output pin.
10 (Adj.)	ADJ	Adjustable regulators: Feedback input. Connect to resistor voltage divider.
11, 12, 13	V _{OUT}	Output Voltage: Output of voltage regulator. Place capacitor to ground to bypass the output voltage. Minimum load current is 100 μ A. Nominal bypass capacitor is 10 μ F.

4.0 APPLICATION INFORMATION

4.1 Enable Input

The MIC68400 features a TTL/CMOS-compatible positive logic enable input for on/off control of the device. High (>1V) enables the regulator while low (<0.2V) disables the regulator. In shutdown, the regulator consumes very little current (only a few microamps of leakage). For simple applications, the enable (EN) can be connected to V_{IN} (IN). While MIC68400 only requires a few microamps of enable current to turn on, the actual enable pin current will depend on the overdrive (enable voltage exceeding 1V) in each particular application.

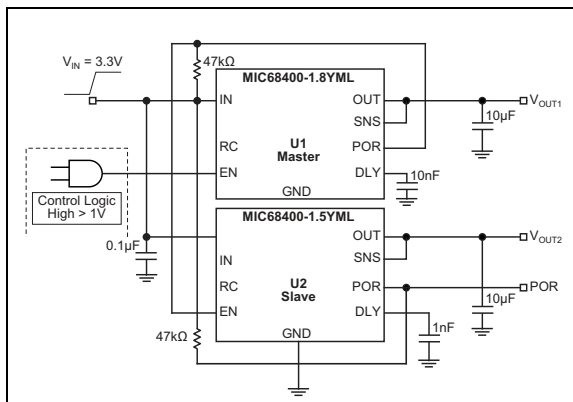


FIGURE 4-1: Enable Connections for Logic-Driven Input.

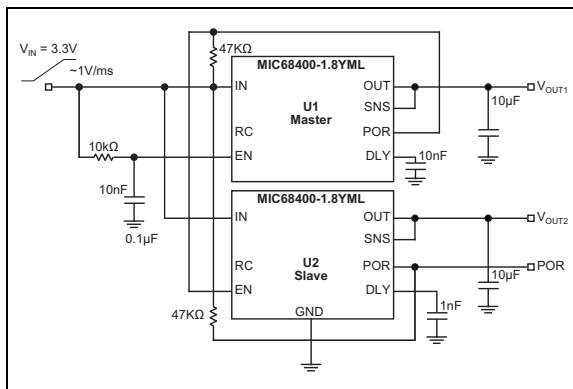


FIGURE 4-2: Enable Connection for V_{IN} -Driven and/or Slow Rise Time Inputs.

If MIC68400 is used in standalone mode, it is not recommended to connect the enable (EN) pin to the input voltage supply (IN). In this case, the enable (EN) input should be externally controlled, as indicated in the [Electrical Characteristics](#) section (regulator enable for $V_{EN} > 1.0V$ and regulator disable for $V_{EN} < 0.2V$).

4.2 Input Capacitor

An input capacitor of 0.1 μF or greater is recommended when the device is more than four inches away from the bulk supply capacitance, or when the supply is a battery. Small, surface-mount chip capacitors can be used for bypassing. The capacitor should be placed within one inch of the device for optimal performance. Larger values will help to improve ripple rejection by bypassing the regulator input, further improving the integrity of the output voltage.

4.3 Output Capacitor

The MIC68400 requires an output capacitor for stable operation. As a μCap LDO, the MIC68220 can operate with ceramic output capacitors of 10 μF or greater with ESR's ranging from 3 m Ω to over 300 m Ω . Values greater than 10 μF improve transient response and noise reduction at high frequencies. X7R/X5R dielectric-type ceramic capacitors are recommended because of their superior temperature performance. X7R-type capacitors change capacitance by 15% over their operating temperature range and are the most stable type of ceramic capacitors. Larger output capacitances can be achieved by placing tantalum or aluminum electrolytics in parallel with the ceramic capacitor. For example, a 100 μF electrolytic in parallel with a 10 μF ceramic can provide the transient and high frequency noise performance of a 100 μF ceramic at a significantly lower cost. Specific undershoot/overshoot performance will depend on both the values and ESR/ESL of the capacitors.

4.4 Adjustable Regulator Design

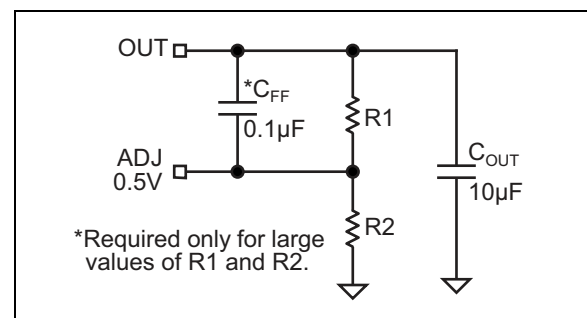


FIGURE 4-3: Adjustable Regulator with Resistors.

The adjustable MIC68400 output voltage can be programmed from 0.5V to 5.5V using a resistor divider from output to the SNS pin. Resistors can be quite large, up to 1 M Ω because of the very high input impedance and low bias current of the sense amplifier. Typical sense input currents are less than 30 nA which causes less than 0.3% error with R1 and R2 less than or equal to 100 k Ω . For large value resistors (>50 k Ω)

MIC68400

R1 should be bypassed by a small capacitor ($C_{FF} = 0.1 \mu\text{F}$ bypass capacitor) to avoid instability due to phase lag at the ADJ/SNS input.

The output resistor divider values are calculated by:

EQUATION 4-1:

$$V_{OUT} = 0.5V\left(\frac{R1}{R2} + 1\right)$$

4.5 Power on Reset (POR) and Delay (DLY)

The power-on reset output (POR) is an open-drain N-Channel device requiring a pull-up resistor to either the input voltage or output voltage for proper voltage levels. POR is driven by the internal timer so that the release of POR at turn-on can be delayed for as much as one second. POR is always pulled low when enable (EN) is pulled low or the output goes out of regulation by more than 10% due to loading conditions.

The internal timer is controlled by the DLY pin which has a bidirectional current source and two limiting comparators. A capacitor connected from DLY to GND sets the delay time for two functions. On start up, DLY sets the time from the nominal output voltage is reached to the release of the POR. At shut down, the delay sets the time from disable (EN pin driven low) to actual ramp down of the output voltage. The current source is $\pm 1 \mu\text{A}$, which charges the capacitor from $\sim 150 \text{ mV}$ (nominal disabled DLY voltage) to $\sim 1.25\text{V}$. At turn on, the DLY cap begins to charge when the output voltage reaches 90% of the target value. When the capacitor reaches 1.25V, the output of the POR is released to go high. At turn off, the DLY cap begins to discharge when the EN is driven low. When the cap reaches $\sim 150 \text{ mV}$ the output is ramped down. Both delays are nominally the same, and are calculated by the same formula:

EQUATION 4-2:

$$t_{DLY} = (1.1)\left(\frac{C_{DLY}}{1\mu\text{A}}\right)$$

The scale factor is 1.1 seconds/ μF , 1.1 ms/nF, or 1.1 $\mu\text{s/pF}$. t_{DLYOFF} is the time from lowering of EN to the start of ramp down on the off cycle. T_{POR} is the time from the rising of EN to the release (low to high edge) of the POR. This behavior means that a $\mu\text{Processor}$ or other complex logic system is guaranteed that the

nominal output voltage is stable for a known time before the POR is released, and they are further guaranteed that once POR is pulled low, they have a known time to 'tidy up' memory or other registers for a well-controlled shutdown. In Master/Slave configurations, the timers can be used to ensure that the Master is always accurately regulating when the Slave is on.

4.6 Ramp Control

The ramp control (RC) has a bidirectional current source and a sense amplifier, which together are used to control the voltage at the output. When RC is below the target voltage (nominal output voltage for fixed voltage parts, 0.5V for adjustable parts) the RC pin controls the output voltage. When RC is at or above the target voltage, the output is controlled by the internal regulator.

4.6.1 TRACKING APPLICATIONS: DRIVING RC FROM A VOLTAGE SOURCE

Fixed Parts: If RC is driven from another (Master) regulator the two outputs will track each other until the Master exceeds the target voltage of the Slave regulator. Typically the output of the MIC68400 will track above the RC input by 30 mV to 70 mV. This offset is designed to allow Master/Slave tracking of same-voltage regulators. Without the offset, same-voltage Master/Slave configurations could suffer poor regulation.

Adjustable Parts: The RC pin on adjustable versions operates from 0V to 0.5V. To implement tracking on an adjustable version, an external resistor divider must be used. This divider is the nearly same ratio as the voltage setting divider used to drive the SNS/ADJ pin. It is recommended that the ratio be adjusted to track $\sim 50 \text{ mV}$ (2% to 3%) above the target voltage if the Master and Slave are operating at the same target voltage.

4.6.2 RAMP UP: CAP-CONTROLLED SLEW RATE

If a capacitor is connected to RC, the bidirectional current source will charge the cap during startup and discharge the cap during shutdown. The size of the capacitor and the RC current ($1 \mu\text{A}$ nom.) control the slew rate of the output voltage during startup. For example, to ramp up a 1.8V regulator from zero to full output in 10 ms requires a 5.6 nF capacitor.

For Fixed Versions:

EQUATION 4-3:

$$t_{RC} = V_{OUT} \left(\frac{C_{RC}}{1\mu A} \right) \quad SR_{ON} = \left(\frac{1\mu A}{C_{RC}} \right)$$

Similarly, to slew an adjustable (any output voltage) from zero to full output in 10 ms requires a 20 nF cap.

For Adjustable Versions:

EQUATION 4-4:

$$t_{RC} = 0.5V \left(\frac{C_{RC}}{1\mu A} \right) \quad SR_{ON} = 2V_{OUT} \left(\frac{1\mu A}{C_{RC}} \right)$$

4.6.3 RAMP DOWN: TURN OFF SLEW RATE

When EN is lowered and the DLY pin has discharged, the RC pin and the OUT pin slew toward zero. For fixed voltage devices, the RC pin slew rate is 2 to 3 times the SR_{ON} defined above. For adjustable voltage devices, the RC pin slew is much higher. In both cases, turn off slew rate may be determined by the RC pin for low values of output capacitor, or by the maximum discharge current available at the output for large values of output capacitor. Turn off slew rate is not a specified characteristic of the MIC68400.

4.7 Sequencing Configurations

Sequencing refers to timing-based Master/Slave control between regulators. It allows a Master device to control the start and stop timing of a single or multiple Slave devices. In typical sequencing the Master POR drives the Slave EN. The sequence begins with the Master EN driven high. The Master output ramps up and triggers the Master DLY when the Master output reaches 90%. The Master DLY then determines when the POR is released to enable the Slave device. When the Master EN is driven low, the Master POR is immediately pulled low causing the Slave to ramp down. However, the Master output will not ramp down until the Master DLY has fully discharged. In this way, the Master power can remain good after the Slave has been ramped down.

In sequencing configurations the Master DLY controls the turn-on time of the Slave and the Slave DLY controls the turn-off time of the Slave.

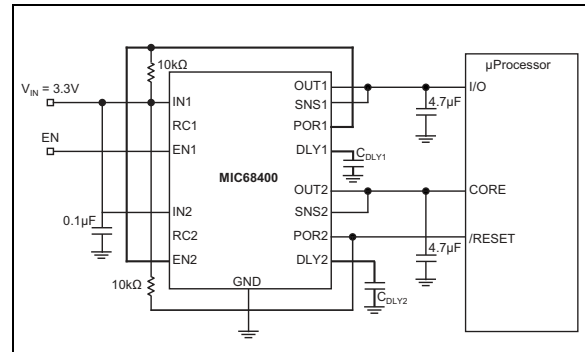


FIGURE 4-4: Sequencing Connections.

In the figure below, $C_{DLYS} > C_{DLYM}$. $C_{DLYS} = 2\text{ nF}$, $C_{DLYM} = 1\text{ nF}$.

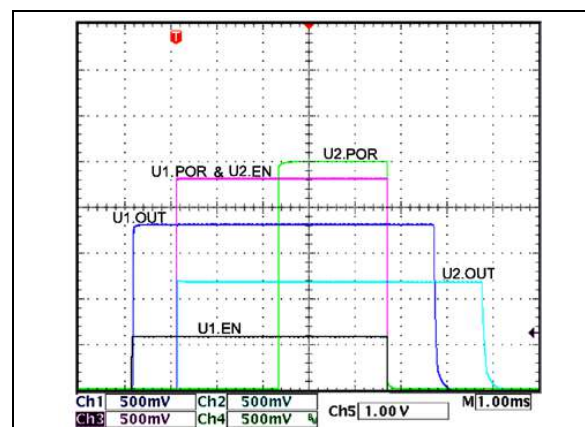


FIGURE 4-5: Delayed Sequencing.

In the figure below, $C_{DLYS} < C_{DLYM}$. $C_{DLYS} = 1\text{ nF}$, $C_{DLYM} = 2\text{ nF}$.

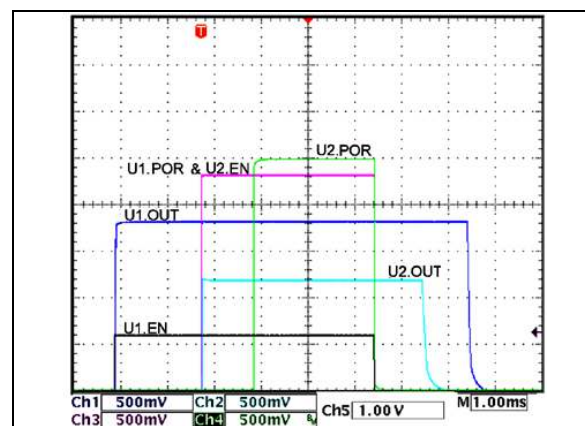


FIGURE 4-6: Windowed Sequencing.

4.8 Tracking Configurations

4.8.1 NORMAL TRACKING

In normal tracking, the Slave RC pin is driven from the Master output. The internal control buffering ensures that the output of the Slave is always slightly above the Master to guarantee that the Slave properly regulates

MIC68400

(based on its own internal reference) if Master and Slave are both fixed voltage devices of the same output voltage. The schematic and plot below show a 1.2V device tracking a 1.8V device through the entire turn-on/turn-off sequence. Note that because the RC pin will override the target voltage (to ensure proper regulation), the ramp down delay is longer than the POR delay during turn-on.

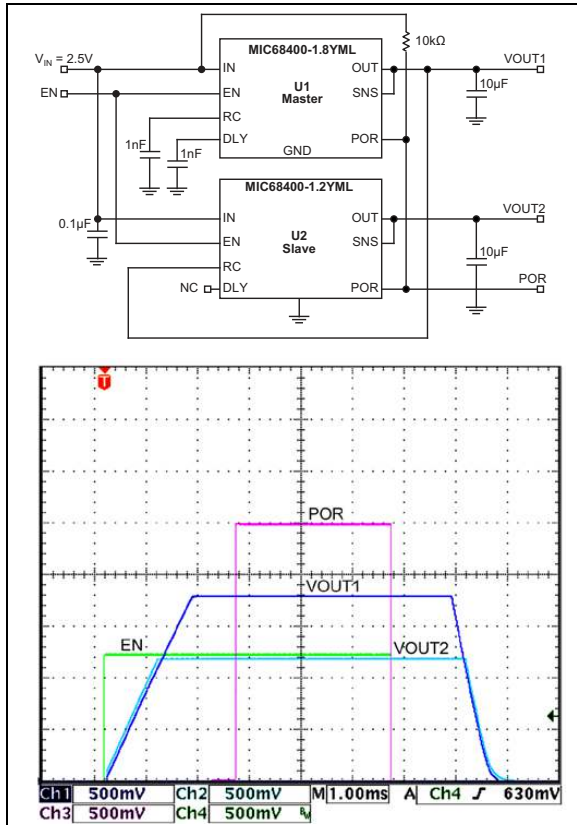


FIGURE 4-7: Fixed Voltage Devices.

Fixed voltage versions of MIC68400 have two internal voltage dividers: one for setting the output voltage and the other for driving the tracking circuitry. Adjustable parts have up to two external dividers: one from output to SNS (to set the output voltage) and one from the output to the Slave RC pin (in tracking configurations). Also, the RC pin in fixed parts operates at the same voltage as the output, whereas the RC pin in adjustable parts operates at the 0.5V reference. To set up a normal tracking configuration, the divider driving the Slave RC pin is the same ratio (or nearly the same – if both Master and Slave are set to the same output voltage, the Slave RC divider should be adjusted 2% to 4% higher) as the divider driving the Slave SNS pin. This is shown in Figure 4-8.

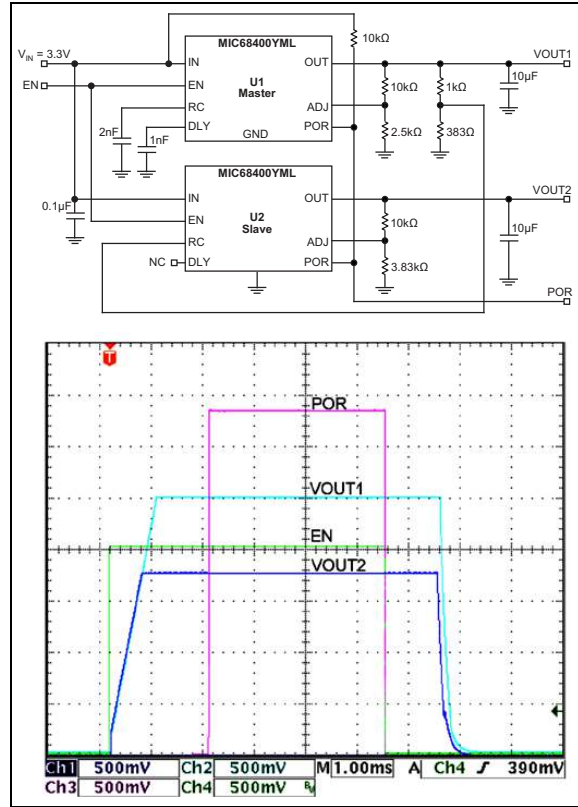


FIGURE 4-8: Adjustable Voltage Devices.

4.8.2 RATIOMETRIC TRACKING

Ratiometric tracking allows independent ramping speeds for both regulators so that the regulation voltage is reached at the same time. This is accomplished by adding a resistor divider between the Master output pin and the Slave RC pin. The divider should be scaled such that the Slave RC pin reaches or exceeds the target output voltage of the Slave as the Master reaches its target voltage.

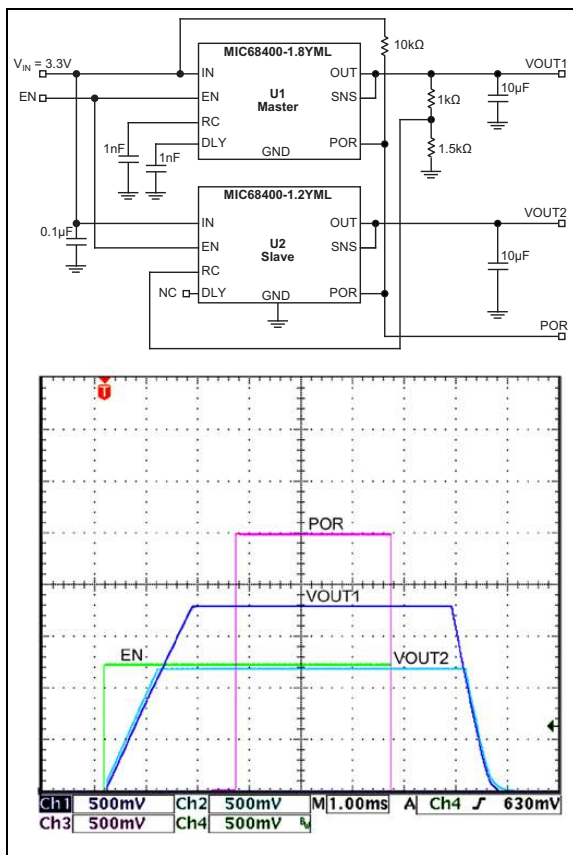


FIGURE 4-9: Fixed Voltage Devices.

Ratiometric tracking may be used with adjustable parts by simply connecting the RC pins of the Master and Slave. Use a single RC capacitor of twice the normal value (because twice the current is injected into the single RC cap). Alternatively, fixed parts may use ratiometric tracking in a manner similar to adjustable normal tracking, with the tracking divider changed to the same resistor ratio driving the Master ADJ/SNS pin.

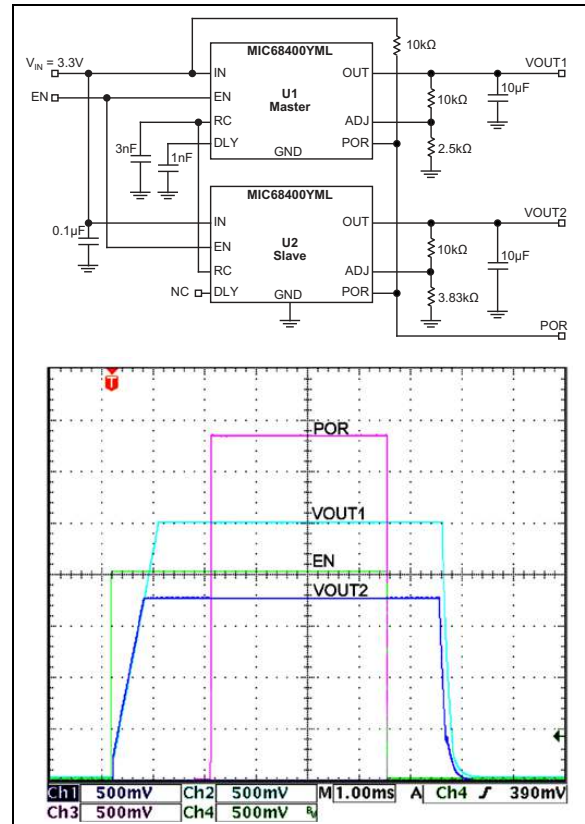


FIGURE 4-10: Adjustable Voltage Devices.

4.9 Final Note on Tracking

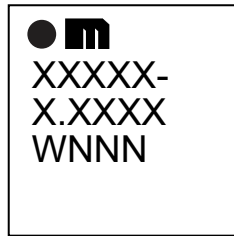
The MIC68400 does not fully shut down until the output load is discharged to near zero. If RC is driven from an external source in a tracking configuration, and the external source does not go to zero on shutdown, it may prevent complete shutdown of the MIC68400. This will cause no damage, but some Q current will remain and may cause concern in battery operated portable equipment. Also, when RC is driven in tracking mode, pulling EN low will not cause the output to drop. Maintaining low EN in tracking mode simply means that the MIC68400 will shutdown when the tracking voltage gets near zero. In no case can the MIC68400 enter the tracking mode unless EN is pulled high.

MIC68400

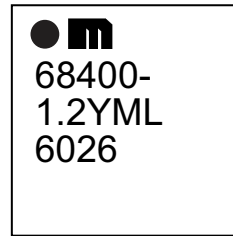
5.0 PACKAGING INFORMATION

5.1 Package Marking Information

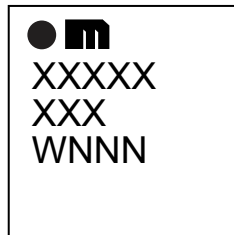
16-Lead QFN*
(Fixed)



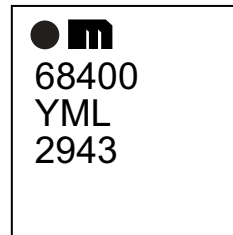
Example



16-Lead QFN*
(Adjustable)

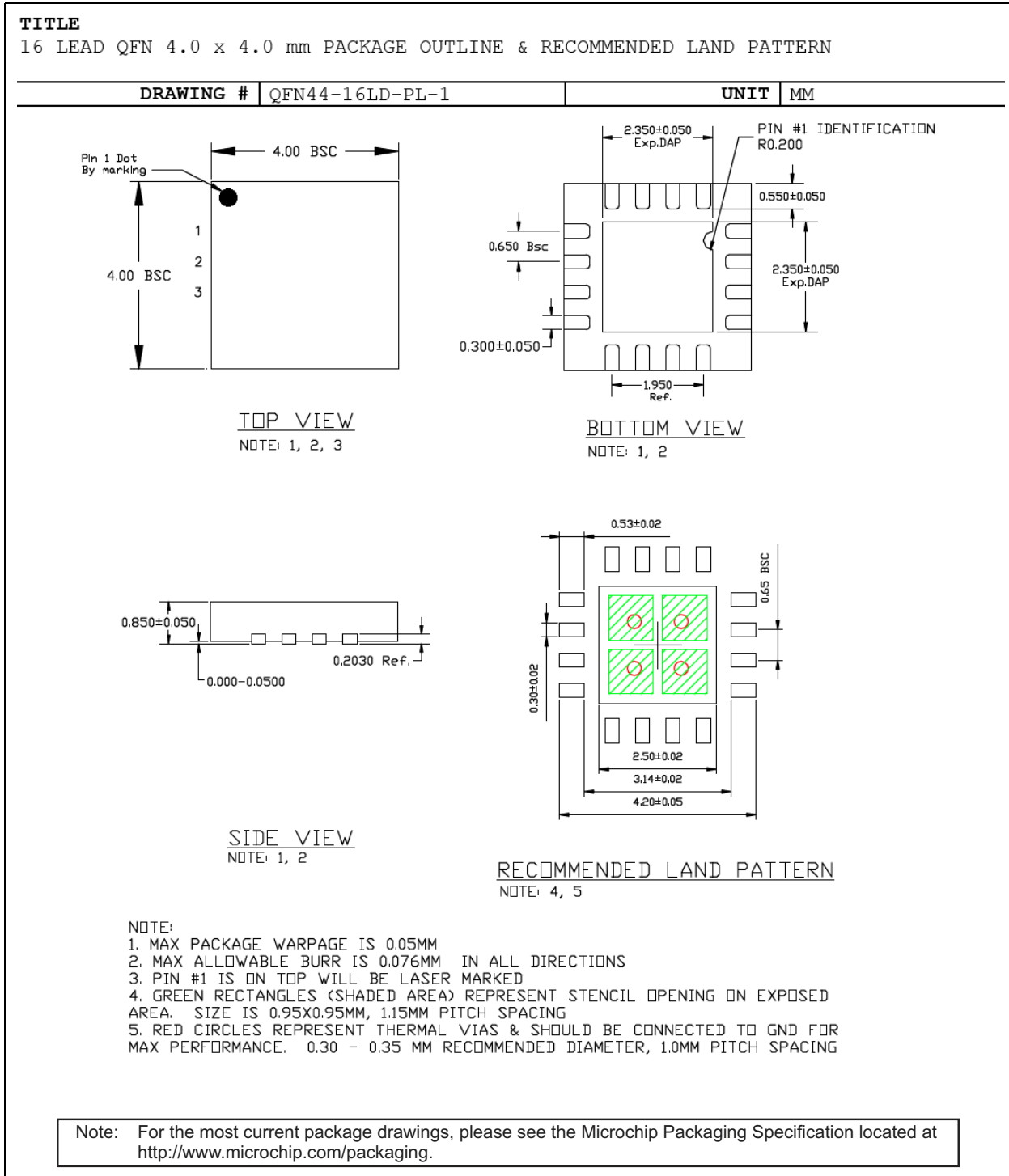


Example



<p>Legend: XX...X Product code or customer-specific information Y Year code (last digit of calendar year) YY Year code (last 2 digits of calendar year) WW Week code (week of January 1 is week '01') NNN Alphanumeric traceability code ⓔ3 Pb-free JEDEC® designator for Matte Tin (Sn) * This package is Pb-free. The Pb-free JEDEC designator (ⓔ3) can be found on the outer packaging for this package.</p> <p>●, ▲, ▼ Pin one index is identified by a dot, delta up, or delta down (triangle mark).</p>
<p>Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.</p> <p>Underbar (¯) and/or Overbar (¯) symbol may not be to scale.</p>

16-Lead 4 mm x 4 mm QFN Package Outline and Recommended Land Pattern



MIC68400

NOTES:

APPENDIX A: REVISION HISTORY

Revision A (August 2017)

- Converted Micrel document MIC68400 to Microchip data sheet DS20005824A.
- Minor text changes throughout.
- Paragraph added after [Figure 4-2](#) in [Section 4.2](#) “**Input Capacitor**”.

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

<u>PART NO.</u>	<u>-X.X</u>	<u>X</u>	<u>XX</u>	<u>-XX</u>
Device	Voltage	Temperature	Package	Media Type
Device:	MIC68400:	4A Sequencing LDO with Tracking and Ramp Control		
Voltage:	1.2 =	1.2V		
	1.8 =	1.8V		
	blank=	Adjustable		
Temperature:	Y =	-40°C to +125°C		
Package:	ML =	16-Lead 4 mm x 4 mm QFN		
Media Type:	TR =	5,000/Reel		

Examples:

- a) MIC68400-1.2YML-TR: 4A Sequencing LDO with Tracking and Ramp Control, 1.2V, -40°C to +125°C, 16-Lead QFN, 5,000/Reel
- b) MIC68400-1.8YML-TR: 4A Sequencing LDO with, Tracking and Ramp Control 1.8V, -40°C to +125°C, 16-Lead QFN, 5,000/Reel
- c) MIC68400YML-TR: 4A Sequencing LDO with, Tracking and Ramp Control Adjustable Voltage, -40°C to +125°C, 16-Lead QFN, 5,000/Reel

Note 1: Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is not printed on the device package. Check with your Microchip Sales Office for package availability with the Tape and Reel option.

MIC68400

NOTES:

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as “unbreakable.”

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights unless otherwise stated.

Microchip received ISO/TS-16949:2009 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC® MCUs and dsPIC® DSCs, KEELoC® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.

**QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
= ISO/TS 16949 =**

Trademarks

The Microchip name and logo, the Microchip logo, AnyRate, AVR, AVR logo, AVR Freaks, BeaconThings, BitCloud, CryptoMemory, CryptoRF, dsPIC, FlashFlex, flexPWR, Helder, JukeBlox, KEELoC, KEELoC logo, Klear, LANCheck, LINK MD, maXStylus, maXTouch, MediaLB, megaAVR, MOST, MOST logo, MPLAB, OptoLyzer, PIC, picoPower, PICSTART, PIC32 logo, Prochip Designer, QTouch, RightTouch, SAM-BA, SpyNIC, SST, SST Logo, SuperFlash, tinyAVR, UNI/O, and XMEGA are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

ClockWorks, The Embedded Control Solutions Company, EtherSynch, Hyper Speed Control, HyperLight Load, IntelliMOS, mTouch, Precision Edge, and Quiet-Wire are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Adjacent Key Suppression, AKS, Analog-for-the-Digital Age, Any Capacitor, AnyIn, AnyOut, BodyCom, chipKIT, chipKIT logo, CodeGuard, CryptoAuthentication, CryptoCompanion, CryptoController, dsPICDEM, dsPICDEM.net, Dynamic Average Matching, DAM, ECAN, EtherGREEN, In-Circuit Serial Programming, ICSP, Inter-Chip Connectivity, JitterBlocker, KlearNet, KlearNet logo, Mindi, MiWi, motorBench, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, MultiTRAK, NetDetach, Omniscient Code Generation, PICDEM, PICDEM.net, PICKit, PICTail, PureSilicon, QMatrix, RightTouch logo, REAL ICE, Ripple Blocker, SAM-ICE, Serial Quad I/O, SMART-I.S., SQI, SuperSwitcher, SuperSwitcher II, Total Endurance, TSHARC, USBCheck, VariSense, ViewSpan, WiperLock, Wireless DNA, and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

Silicon Storage Technology is a registered trademark of Microchip Technology Inc. in other countries.

GestIC is a registered trademark of Microchip Technology Germany II GmbH & Co. KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.

© 2017, Microchip Technology Incorporated, All Rights Reserved.
ISBN: 978-1-5224-2075-0



Worldwide Sales and Service

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
<http://www.microchip.com/support>
Web Address:
www.microchip.com

Atlanta
Duluth, GA
Tel: 678-957-9614
Fax: 678-957-1455

Austin, TX
Tel: 512-257-3370

Boston
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

Chicago
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

Dallas
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

Detroit
Novi, MI
Tel: 248-848-4000

Houston, TX
Tel: 281-894-5983

Indianapolis
Noblesville, IN
Tel: 317-773-8323
Fax: 317-773-5453
Tel: 317-536-2380

Los Angeles
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608
Tel: 951-273-7800

Raleigh, NC
Tel: 919-844-7510

New York, NY
Tel: 631-435-6000

San Jose, CA
Tel: 408-735-9110
Tel: 408-436-4270

Canada - Toronto
Tel: 905-695-1980
Fax: 905-695-2078

ASIA/PACIFIC

Asia Pacific Office
Suites 3707-14, 37th Floor
Tower 6, The Gateway
Harbour City, Kowloon

Hong Kong
Tel: 852-2943-5100
Fax: 852-2401-3431

Australia - Sydney
Tel: 61-2-9868-6733
Fax: 61-2-9868-6755

China - Beijing
Tel: 86-10-8569-7000
Fax: 86-10-8528-2104

China - Chengdu
Tel: 86-28-8665-5511
Fax: 86-28-8665-7889

China - Chongqing
Tel: 86-23-8980-9588
Fax: 86-23-8980-9500

China - Dongguan
Tel: 86-769-8702-9880

China - Guangzhou
Tel: 86-20-8755-8029

China - Hangzhou
Tel: 86-571-8792-8115
Fax: 86-571-8792-8116

China - Hong Kong SAR
Tel: 852-2943-5100
Fax: 852-2401-3431

China - Nanjing
Tel: 86-25-8473-2460
Fax: 86-25-8473-2470

China - Qingdao
Tel: 86-532-8502-7355
Fax: 86-532-8502-7205

China - Shanghai
Tel: 86-21-3326-8000
Fax: 86-21-3326-8021

China - Shenyang
Tel: 86-24-2334-2829
Fax: 86-24-2334-2393

China - Shenzhen
Tel: 86-755-8864-2200
Fax: 86-755-8203-1760

China - Wuhan
Tel: 86-27-5980-5300
Fax: 86-27-5980-5118

China - Xian
Tel: 86-29-8833-7252
Fax: 86-29-8833-7256

ASIA/PACIFIC

China - Xiamen
Tel: 86-592-2388138
Fax: 86-592-2388130

China - Zhuhai
Tel: 86-756-3210040
Fax: 86-756-3210049

India - Bangalore
Tel: 91-80-3090-4444
Fax: 91-80-3090-4123

India - New Delhi
Tel: 91-11-4160-8631
Fax: 91-11-4160-8632

India - Pune
Tel: 91-20-3019-1500

Japan - Osaka
Tel: 81-6-6152-7160
Fax: 81-6-6152-9310

Japan - Tokyo
Tel: 81-3-6880-3770
Fax: 81-3-6880-3771

Korea - Daegu
Tel: 82-53-744-4301
Fax: 82-53-744-4302

Korea - Seoul
Tel: 82-2-554-7200
Fax: 82-2-558-5932 or
82-2-558-5934

Malaysia - Kuala Lumpur
Tel: 60-3-6201-9857
Fax: 60-3-6201-9859

Malaysia - Penang
Tel: 60-4-227-8870
Fax: 60-4-227-4068

Philippines - Manila
Tel: 63-2-634-9065
Fax: 63-2-634-9069

Singapore
Tel: 65-6334-8870
Fax: 65-6334-8850

Taiwan - Hsin Chu
Tel: 886-3-5778-366
Fax: 886-3-5770-955

Taiwan - Kaohsiung
Tel: 886-7-213-7830

Taiwan - Taipei
Tel: 886-2-2508-8600
Fax: 886-2-2508-0102

Thailand - Bangkok
Tel: 66-2-694-1351
Fax: 66-2-694-1350

EUROPE

Austria - Wels
Tel: 43-7242-2244-39
Fax: 43-7242-2244-393

Denmark - Copenhagen
Tel: 45-4450-2828
Fax: 45-4485-2829

Finland - Espoo
Tel: 358-9-4520-820

France - Paris
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

France - Saint Cloud
Tel: 33-1-30-60-70-00

Germany - Garching
Tel: 49-8931-9700

Germany - Haan
Tel: 49-2129-3766400

Germany - Heilbronn
Tel: 49-7131-67-3636

Germany - Karlsruhe
Tel: 49-721-625370

Germany - Munich
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Germany - Rosenheim
Tel: 49-8031-354-560

Israel - Ra'anana
Tel: 972-9-744-7705

Italy - Milan
Tel: 39-0331-742611
Fax: 39-0331-466781

Italy - Padova
Tel: 39-049-7625286

Netherlands - Drunen
Tel: 31-416-690399
Fax: 31-416-690340

Norway - Trondheim
Tel: 47-7289-7561

Poland - Warsaw
Tel: 48-22-3325737

Romania - Bucharest
Tel: 40-21-407-87-50

Spain - Madrid
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

Sweden - Gothenberg
Tel: 46-31-704-60-40

Sweden - Stockholm
Tel: 46-8-5090-4654

UK - Wokingham
Tel: 44-118-921-5800
Fax: 44-118-921-5820