MIC38300A

Ultra-Low Noise, 3A Power Module

Features

- 3A Continuous Operating Current
- Input Voltage Range: 3.0V to 5.5V
- Adjustable Output Voltage Down to 1.0V
- Output Noise Less Than 5 mV
- Ultra-Fast Transient Performance
- Unique Switcher Plus LDO Architecture
- Fully Integrated MOSFET Switches
- Micropower Shutdown
- Easy Upgrade from LDO as Power Dissipation Becomes an Issue
- Thermal Shutdown and Current-Limit Protection
- 4 mm × 6 mm × 1.55 mm LQFN Package

Applications

- Point-of-Load Applications
- Networking, Server, Industrial Power
- Wireless Base Stations
- Sensitive RF Applications

General Description

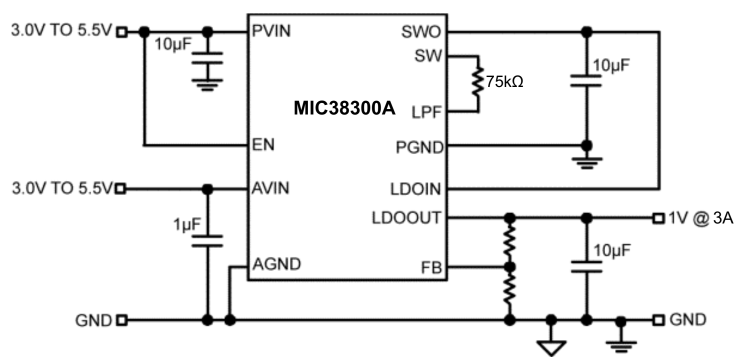
The MIC38300A is a 3A current step-down converter that provides the benefits of an LDO in respect to ease of use, fast transient performance, high PSRR, and low noise while offering the efficiency of a switching regulator.

As output voltages move lower, the output noise and transient response of a switching regulator become an increasing challenge for designers. By combining a switcher whose output is slaved to the input of a high-performance LDO, high efficiency is achieved with a clean low noise output. The MIC38300A is designed to provide less than 5 mV of peak to peak noise and over 70 dB of PSRR at 1 kHz. Furthermore, the architecture of the MIC38300A is optimized for fast load transients that allow maintenance of less than 30 mV of output voltage deviation even during ultra-fast load steps, making the MIC38300A an ideal choice for low-voltage ASICs and other digital ICs.

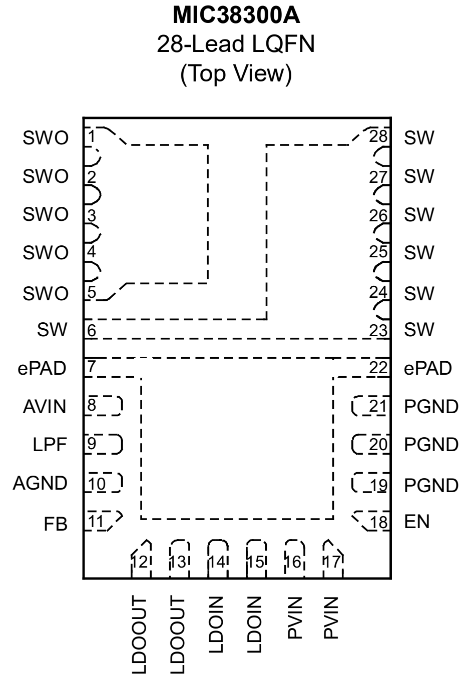
The MIC38300A features a fully integrated switching regulator and LDO combo, operates with input voltages from 3.0V to 5.5V input, and offers adjustable output voltages down to 1.0V.

The MIC38300A is offered in the small 28-lead 4 mm × 6 mm × 1.55 mm LQFN package and can operate from -40°C to +125°C.

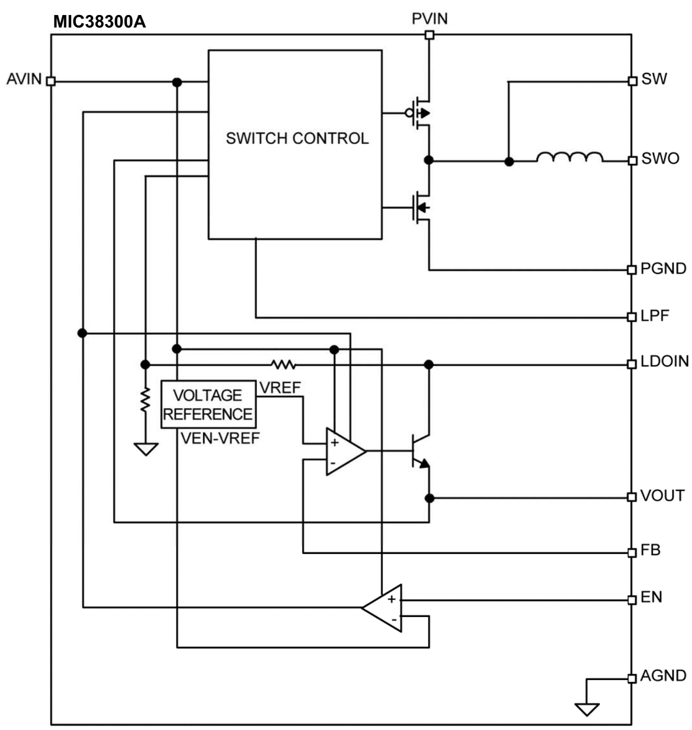
Typical Application Circuit



Package Type



Functional Block Diagram



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{IN}) .... +6V
Output Switch Voltage (V_{SW}) .... +6V
LDO Output Voltage (V_{OUT}) .... +6V
Logic Input Voltage (V_{EN}) .... -0.3V to V_{IN}
Power Dissipation (Note 1) .... Internally Limited
ESD Rating (Note 2) .... 1 kV

Operating Ratings ‡

Supply Voltage (V_{IN}) .... +3.0V to +5.5V
Enable Input Voltage (V_{EN}) .... 0V to V_{IN}

† 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.

2: Devices are ESD sensitive. Handling precautions recommended. Human body model, 1.5 kΩ in series with 100 pF.

ELECTRICAL CHARACTERISTICS

T_A = +25°C with V_{IN} = V_{EN} = 5V; I_{OUT} = 10 mA, V_{OUT} = 1.8V. **Bold** values valid for -40°C ≤ T_J ≤ +125°C, unless noted. Note 1

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Supply Voltage Range (AVIN, PVIN)	—	**3.0**	—	**5.5**	V	—
Undervoltage Lockout Threshold	—	—	2.85	—	V	Turn-on
UVLO Hysteresis	—	—	100	—	mV	—
Quiescent Current	I_Q	—	1	—	mA	I_{OUT} = 0A, Not switching, open loop
Turn-On Time	t_{ON}	—	200	500	µs	V_{OUT} to 95% of nominal
Shutdown Current	I_{SHDN}	—	30	**50**	µA	V_{EN} = 0V
Feedback Voltage	V_{FB}	**0.975**	1	**1.025**	V	±2.5%
Feedback Current	I_{FB}	—	5	—	nA	—
Dropout Voltage (VIN – VOUT)	V_{DO}	—	0.85	1.2	V	I_{LOAD} = 3A, V_{OUT} = 3V
Current Limit	I_{LIM}	—	5	—	A	V_{FB} = 0.9 × V_{NOM}
Output Voltage Load Regulation	—	—	0.3	1	%	V_{OUT} = 1.8V, 10 mA to 3A
Output Voltage Line Regulation	—	—	0.35	0.5	%/V	V_{OUT} = 1.8V, V_{IN} from 3.0V to 5.5V
Output Ripple	—	—	2	—	mV	I_{LOAD} = 1.5A, C_{OUTLDO} = 20 µF, C_{OUTSW} = 20 µF, R_{LPF} = 75 kΩ
Overtemperature Shutdown	—	—	150	—	°C	—
Overtemperature Shutdown Hysteresis	—	—	15	—	°C	—

ELECTRICAL CHARACTERISTICS (CONTINUED)

T_A = +25°C with V_{IN} = V_{EN} = 5V; I_{OUT} = 10 mA, V_{OUT} = 1.8V. **Bold** values valid for -40°C ≤ T_J ≤ +125°C, unless noted. Note 1

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Enable Input (Note 2)						
Enable Input Threshold	—	**0.90**	1	**1.1**	V	Regulator enable
Enable Hysteresis	—	**20**	100	**200**	mV	—
Enable Input Current	—	—	0.03	1	µA	—

Note 1: Specification for packaged product only.

2: Enable pin should not be left open.

TEMPERATURE SPECIFICATIONS

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Storage Temperature Range	T_S	-65	—	+150	°C	—
Junction Temperature Range	T_J	-40	—	+125	°C	—
Package Thermal Resistances						
Thermal Resistance, LQFN 28-Ld	θ_{JA}	—	24	—	°C/W	—

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.

V_{IN} = 3.3V, V_{OUT} = 1.8V, C_{OUT} = 20 µF, R_{LPF} = 75 kΩ, I_{OUT} = 100 mA, unless noted.

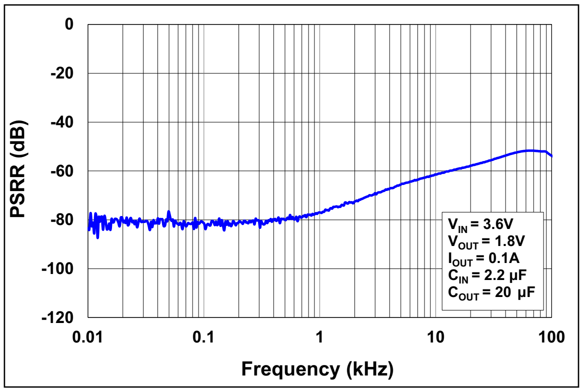


FIGURE 2-1: *Power Supply Ripple Rejection.*

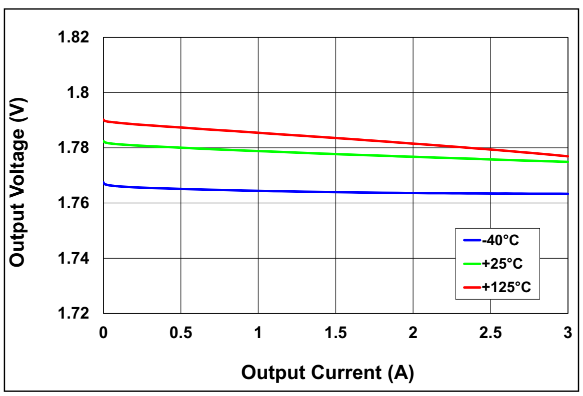


FIGURE 2-2: *Load Regulation.*

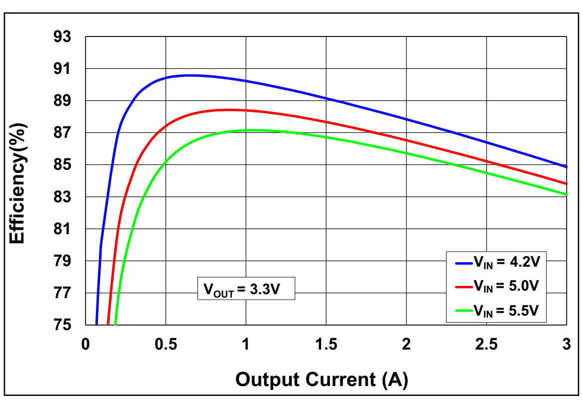


FIGURE 2-3: *Efficiency (V_{OUT} = 3.3V).*

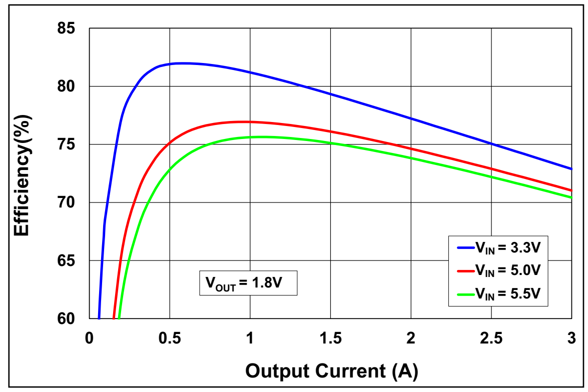


FIGURE 2-4: *Efficiency (V_{OUT} = 1.8V).*

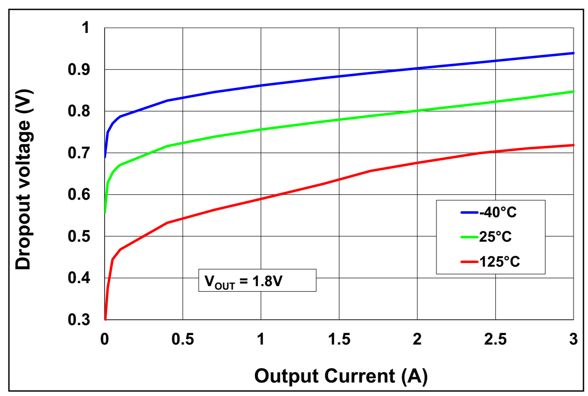


FIGURE 2-5: *Dropout Voltage.*

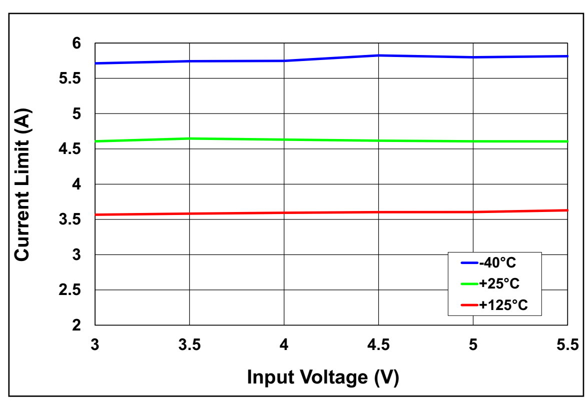


FIGURE 2-6: *Current Limit.*

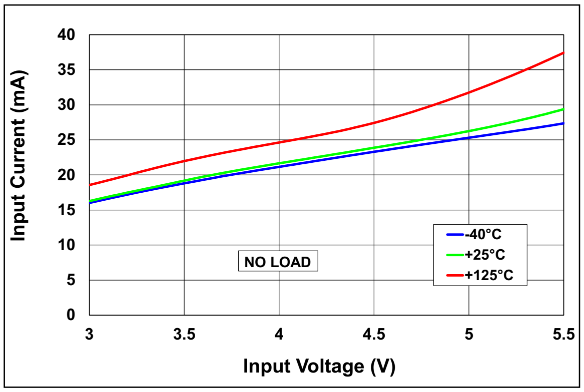


FIGURE 2-7: *No-Load Input Current.*

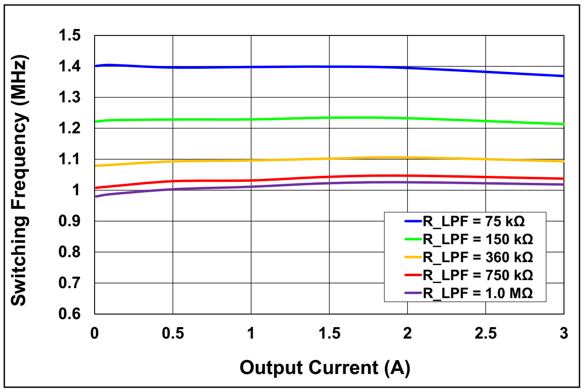


FIGURE 2-8: *Switching Frequency (V_{IN} = 3.3V, V_{OUT} = 1.0V).*

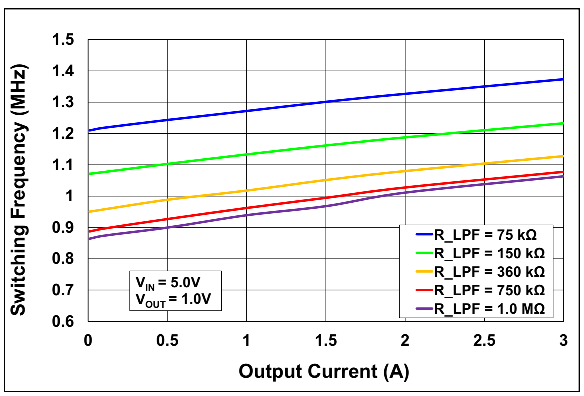


FIGURE 2-9: *Switching Frequency (V_{IN} = 5.0V, V_{OUT} = 1.0V).*

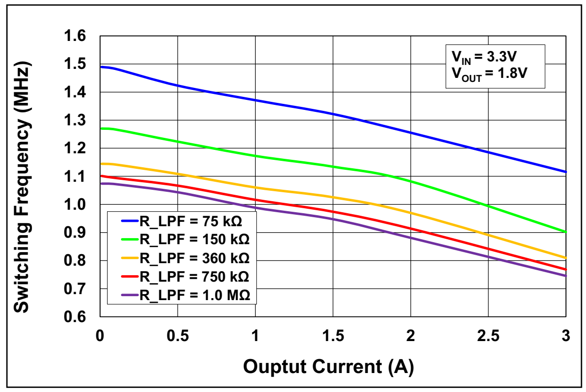


FIGURE 2-10: *Switching Frequency (V_{IN} = 3.3V, V_{OUT} = 1.8V).*

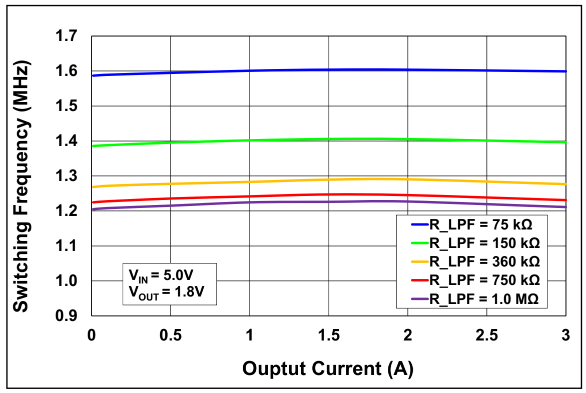


FIGURE 2-11: *Switching Frequency (V_{IN} = 5.0V, V_{OUT} = 1.8V).*

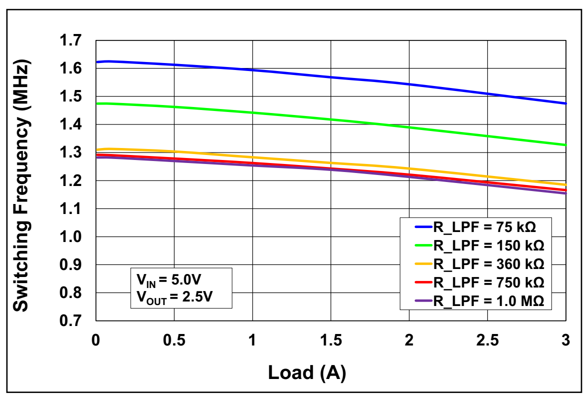


FIGURE 2-12: *Switching Frequency (V_{IN} = 5.0V, V_{OUT} = 2.5V).*

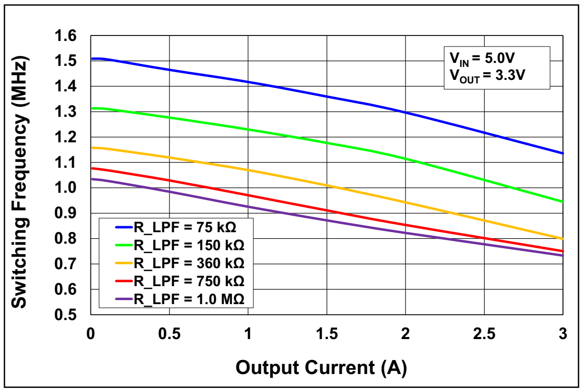


FIGURE 2-13: *Switching Frequency (V_{IN} = 5.0V, V_{OUT} = 3.3V).*

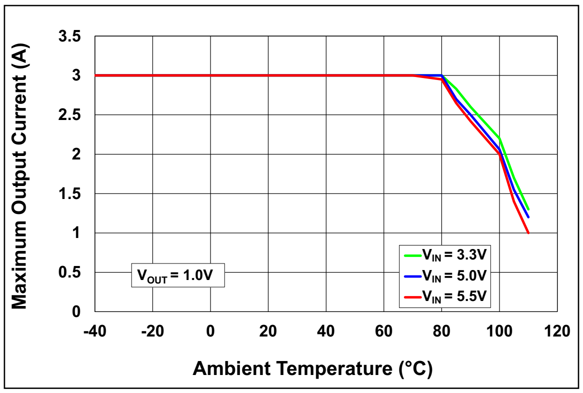


FIGURE 2-14: *Current Derating (V_{OUT} = 1.0V).*

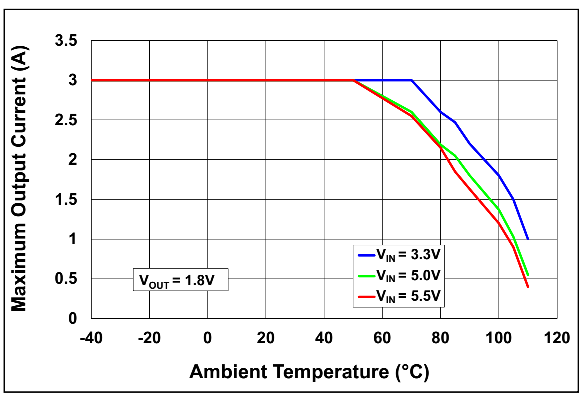


FIGURE 2-15: *Current Derating (V_{OUT} = 1.8V).*

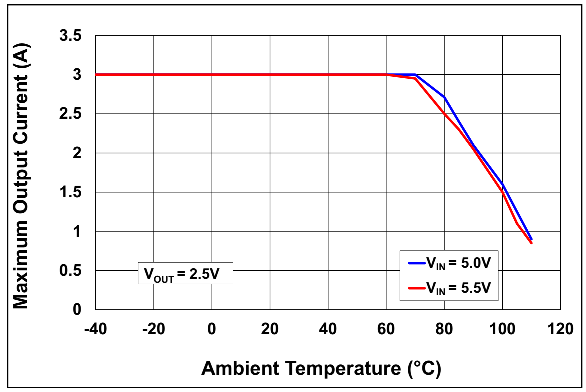


FIGURE 2-16: *Current Derating (V_{OUT} = 2.5V).*

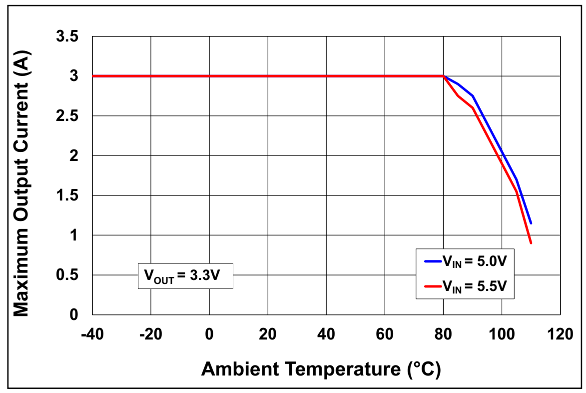


FIGURE 2-17: *Current Derating (V_{OUT} = 3.3V).*

Note: For Figure 2-14 through Figure 2-17, the following condition applies: Tested on Microchip Evaluation Board in thermal chamber, with approximately 20 to 30 LFM airflow. Case temperature is limited to 120°C.

V_{IN} = 3.3V, V_{OUT} = 1.8V, C_{OUT} = 10 µF, R_{LPF} = 75 kΩ, I_{OUT} = 100 mA, unless noted.

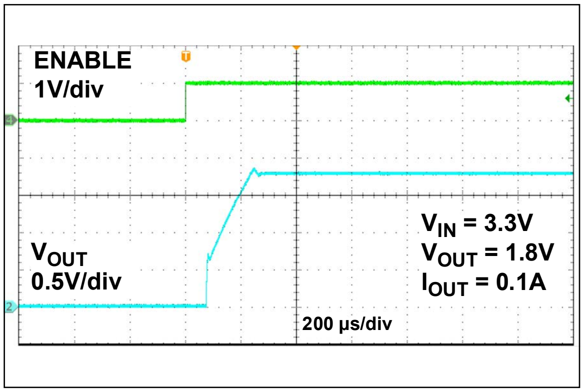


FIGURE 2-18: *Start-Up from Enable.*

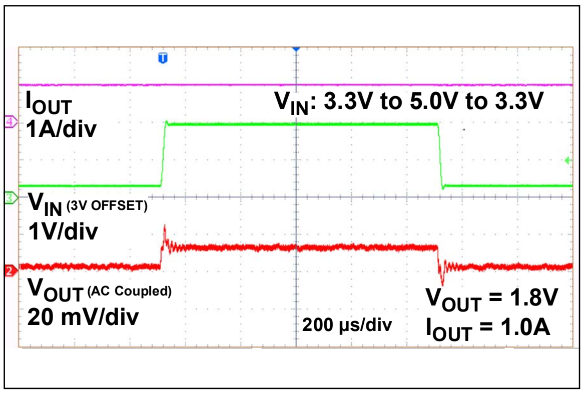


FIGURE 2-19: *Line Transient Response.*

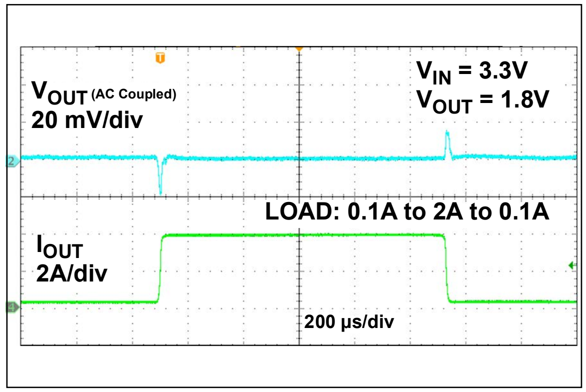


FIGURE 2-20: *Load Transient Response.*

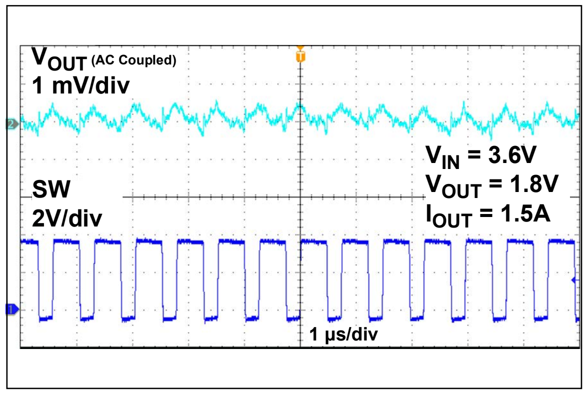


FIGURE 2-21: *Output Voltage Ripple.*

3.0 EMI PERFORMANCE

V_{OUT} = 1.8V, I_{OUT} = 1.2A.

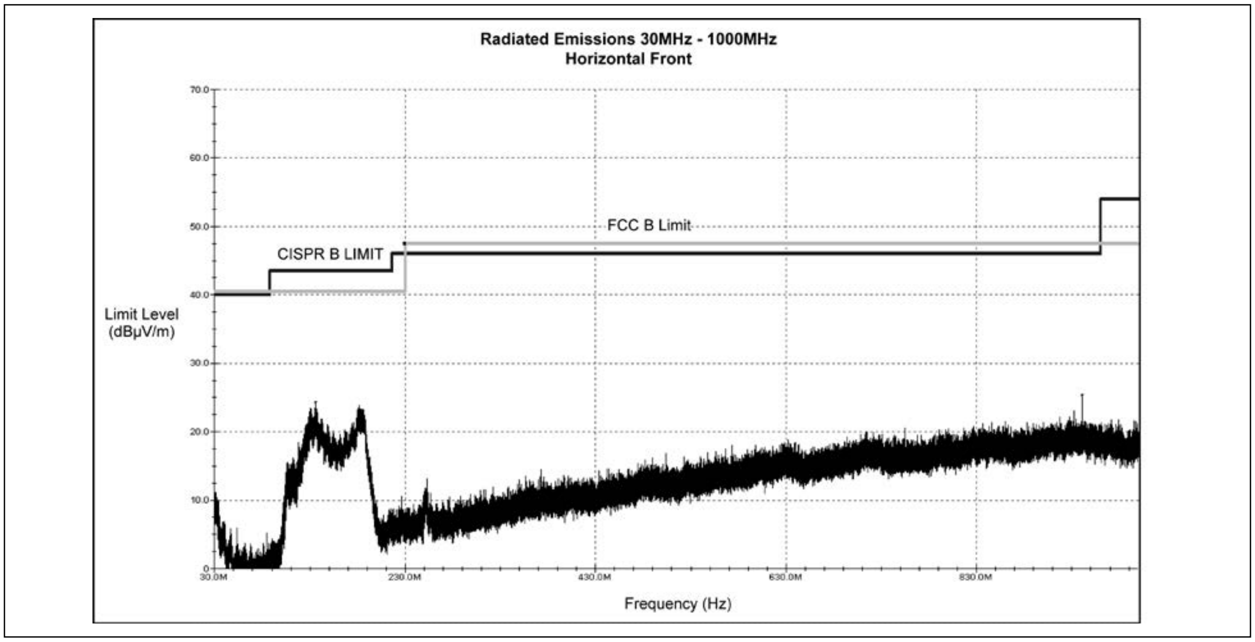


FIGURE 3-1: *EMI Test: Horizontal Front.*

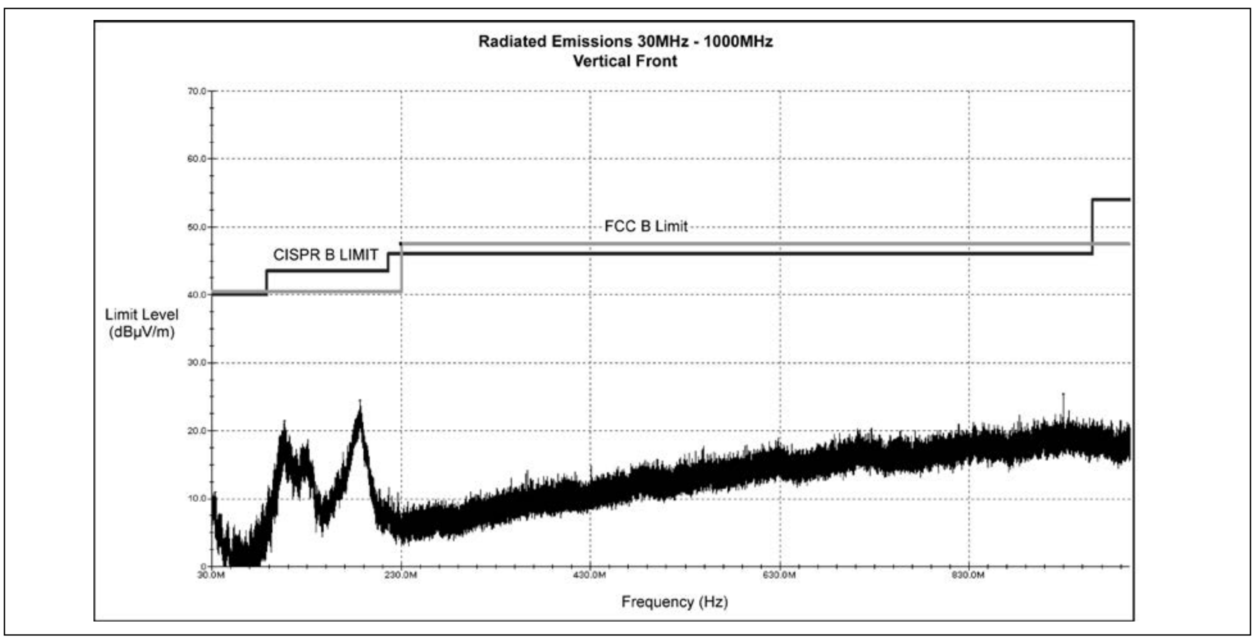


FIGURE 3-2: *EMI Test: Vertical Front.*

Additional components to MIC38150 Evaluation Board (Performance similar to MIC38300A):

1. Input Ferrite Bead Inductor. Part number: BLM21AG102SN1D.
2. 0.1 µF and 0.01 µF ceramic bypass capacitors on PVIN, SWO, and LDOOUT pins.

4.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 4-1.

TABLE 4-1: PIN FUNCTION TABLE

Pin Number	Pin Name	Description
1, 2, 3, 4, 5	SWO	Switch (Output): This is the output of the PFM Switcher.
6, 23, 24, 25, 26, 27, 28	SW	Switch Node: Attach external resistor from LPF to increase hysteretic frequency.
7, 22	ePAD	Exposed heat-sink pad. Connect externally to PGND.
8	AVIN	Analog Supply Voltage: Supply for the analog control circuitry. Requires bypass capacitor to ground. Nominal bypass capacitor is 1 µF.
9	LPF	Low Pass Filter: Attach external resistor from SW to increase hysteretic frequency. Use a minimum value of 75 kΩ to maintain converter stability.
10	AGND	Analog Ground.
11	FB	Feedback: Input to the error amplifier. Connect to the external resistor divider network to set the output voltage.
12, 13	LDOOUT	LDO Output: Output of voltage regulator. Place capacitor to ground to bypass the output voltage. Nominal bypass capacitor is 10 µF.
14, 15	LDOIN	LDO Input: Connect to SW output. Requires a bypass capacitor to ground. Nominal bypass capacitor is 10 µF.
16, 17	PVIN	Input Supply Voltage (Input): Requires bypass capacitor to GND. Nominal bypass capacitor is 10 µF.
18	EN	Enable (Input): Logic low will shut down the device, reducing the quiescent current to less than 50 µA. This pin can also be used as an undervoltage lockout function by connecting a resistor divider from EN/UVLO pin to VIN and GND. It should be not left open.
19, 20, 21	PGND	Power Ground.

5.0 APPLICATION INFORMATION

5.1 Enable Input

The MIC38300A features a TTL/CMOS compatible positive logic enable input for on/off control of the device. High enables the regulator, while low disables the regulator. In shutdown, the regulator consumes very little current (only a few microamperes of leakage). For simple applications, the enable (EN) can be connected to VIN (IN).

5.2 Input Capacitor

PVIN provides power to the MOSFETs for the switch mode regulator section and the gate drivers. Due to the high switching speeds, a 10 µF capacitor is recommended close to PVIN and the power ground (PGND) pin for bypassing.

Analog V_{IN} (AVIN) provides power to the analog supply circuitry. Careful layout should be considered to ensure high-frequency switching noise caused by PVIN is reduced before reaching AVIN. A 1 µF capacitor as close to AVIN as possible is recommended.

5.3 Output Capacitor

The MIC38300A requires an output capacitor for stable operation. As a µCap LDO, the MIC38300A can operate with ceramic output capacitors of 10 µF or greater. Values of greater than 10 µF improve transient response and noise reduction at high frequency. 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.

For less than 5 mV noise performance at higher current loads, 20 µF capacitors are recommended at LDOIN and LDOOUT.

5.4 Low Pass Filter Pin

The MIC38300A features a Low Pass Filter (LPF) pin for adjusting the switcher frequency. By tuning the frequency, the user can further improve output ripple without losing efficiency. Adjusting the frequency is accomplished by connecting a resistor between the LPF and SW pins. A small value resistor would increase the frequency while a larger value resistor decreases the frequency. Recommended R_{LPF} value is 75 kΩ. Please see the Typical Performance Curves section for more details.

5.5 Adjustable Regulator Design

The adjustable MIC38300A output voltage can be programmed from 1V to 5.0V using a resistor divider from output to the FB pin. Resistors can be quite large, up to 100 kΩ because of the very high input impedance and low bias current of the sense amplifier. For large value resistors (>50 kΩ) R1 should be bypassed by a small capacitor (C_{FF} = 0.1 µF bypass capacitor) to avoid instability due to phase lag at the ADJ/SNS input.

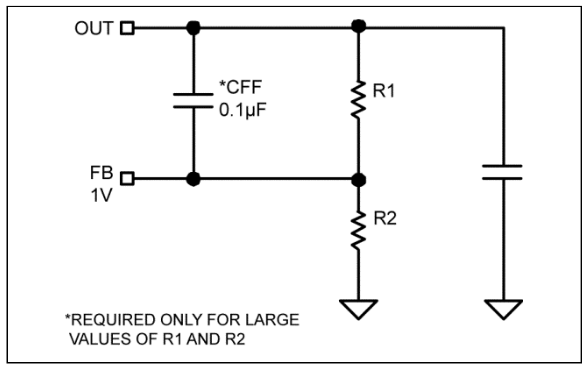


FIGURE 5-1: Adjustable Regulator with Resistors.

The output resistor divider values are calculated by Equation 5-1.

EQUATION 5-1:

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

5.6 Efficiency Considerations

Efficiency is defined as the amount of useful output power, divided by the amount of power supplied.

EQUATION 5-2:

$$\text{Efficiency } \% = \left(\frac{V_{OUT} \times I_{OUT}}{V_{IN} \times I_{IN}}\right) \times 100$$

Maintaining high efficiency serves two purposes. It reduces power dissipation in the power supply, reducing the need for heat sinks and thermal design considerations and it reduces consumption of current for battery-powered applications. Reduced current draw from a battery increases the devices operating time and is critical in handheld devices.

There are two types of losses in switching converters: DC losses and switching losses. DC losses are simply the power dissipation of I^2R. Power is dissipated in the high-side switch during the on cycle. Power loss is equal to the high-side MOSFET $R_{DS(ON)}$ multiplied by the switch current. During the off cycle, the low-side N-channel MOSFET conducts, also dissipating power. Device operating current also reduces efficiency. The product of the quiescent (operating) current and the supply voltage is another DC loss.

Over 100 mA, efficiency loss is dominated by MOSFET $R_{DS(ON)}$ and inductor losses. Higher input supply voltages will increase the gate-to-source threshold on the internal MOSFETs, reducing the internal $R_{DS(ON)}$. This improves efficiency by reducing DC losses in the device. All but the inductor losses are inherent to the device. In which case, inductor selection becomes increasingly critical in efficiency calculations. As the inductors are reduced in size, the DC resistance (DCR) can become quite significant. The DCR losses can be calculated as in Equation 5-3.

EQUATION 5-3:

$$L\_P_D = I_{OUT}{}^2 \times DCR$$

From that, the loss in efficiency due to inductor resistance can be calculated as in Equation 5-4:

EQUATION 5-4:

$$Eff\_Loss = \left[1 - \left(\frac{V_{OUT} \times I_{OUT}}{V_{OUT} \times I_{OUT} + L\_P_D}\right)\right] \times 100$$

Efficiency loss due to DCR is minimal at light loads and gains significance as the load is increased. Inductor selection becomes a trade-off between efficiency and size in this case.

5.7 Current-Sharing Circuit

Figure 5-2 allows two MIC38300A regulators to share the load current equally. Regulator1 senses the output voltage at the load, on the other side of a current sense resistor. As the load changes, a voltage equal to the output voltage, plus the load current times the sense resistor, is developed at the V_{OUT} terminal of Regulator1. The op-amp (MIC7300) inverting pin senses this voltage and compares it to the voltage on the V_{OUT} terminal of Regulator2.

If the current through the current sense of Regulator2 is less than the current through the current sense of Regulator1, the inverting pin will be at a higher voltage than the non-inverting pin and the op-amp will drive the FB of Regulator2 low. The low voltage sensed on Regulator2's FB pin will drive the output up until the output voltage of Regulator2 matches the output voltage of Regulator1. Because V_{OUT} will remain constant and both Regulators' V_{OUT} terminals and sense resistances are matched, the output currents will be shared equally.

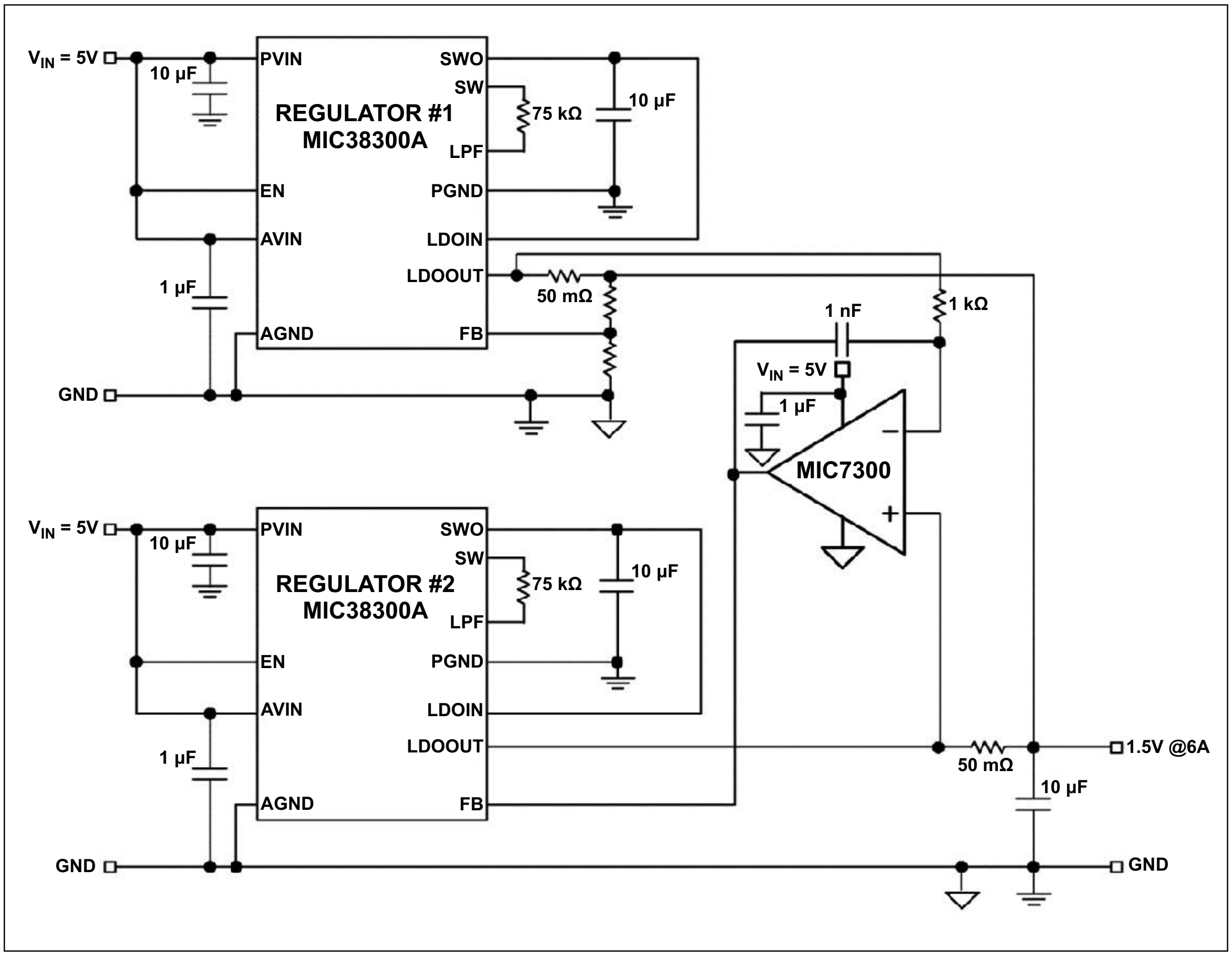
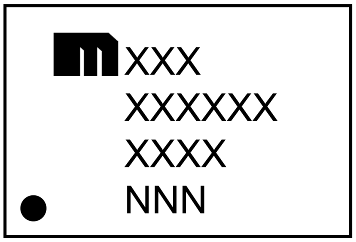


FIGURE 5-2: *Current-Sharing Circuit for 6A Output.*

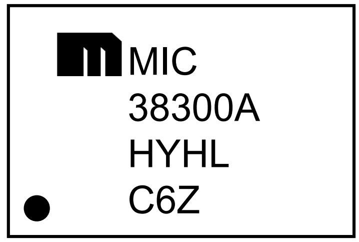
6.0 PACKAGING INFORMATION

6.1 Package Marking Information

28-Lead LQFN*



Example



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
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package.
	●, ▲, ▼	Pin one index is identified by a dot, delta up, or delta down (triangle mark).

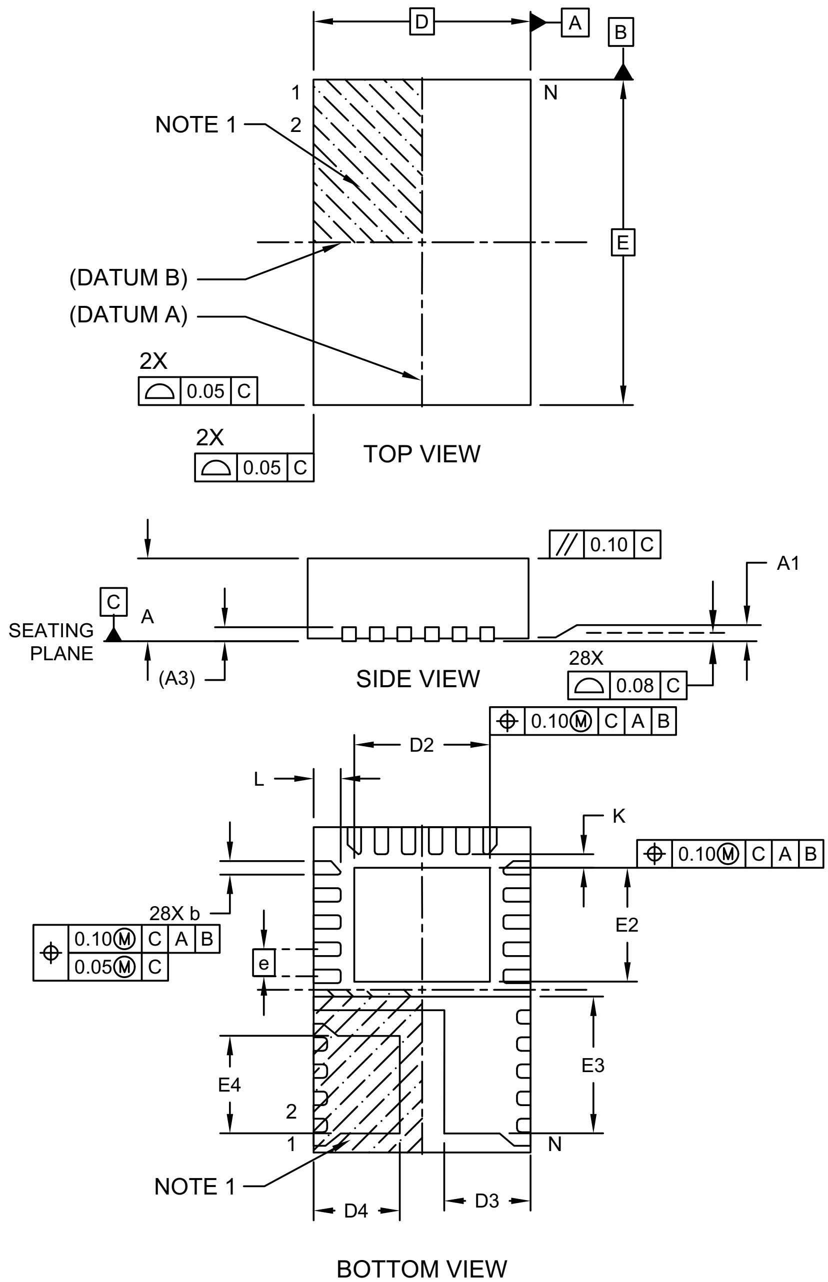
Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.

Underbar (_) and/or Overbar (‾) symbol may not be to scale.

Note: If the full seven-character YYWWNNN code cannot fit on the package, the following truncated codes are used based on the available marking space:
6 Characters = YWWNNN; 5 Characters = WWNNN; 4 Characters = WNNN; 3 Characters = NNN;
2 Characters = NN; 1 Character = N

28-Lead Thick Plastic Quad Flat, No Lead Package (LYA) - 4x6 mm Body [LQFN] With Multiple Fused Exposed Pads

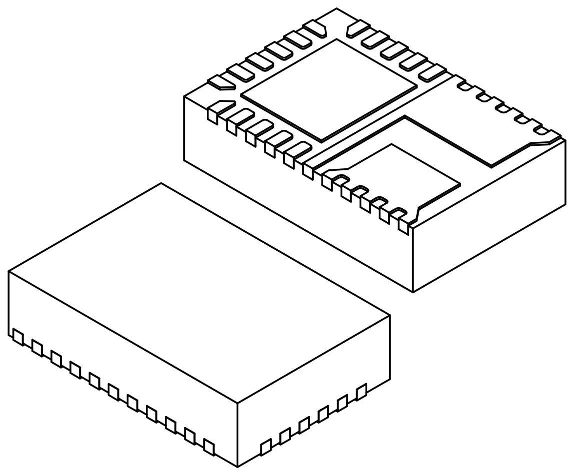
Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Microchip Technology Drawing C04-1294 Rev A Sheet 1 of 2

28-Lead Thick Plastic Quad Flat, No Lead Package (LYA) - 4x6 mm Body [LQFN] With Multiple Fused Exposed Pads

Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Terminals	N		28	
Pitch	e		0.50 BSC	
Overall Height	A	1.45	1.50	1.55
Standoff	A1	0.00	0.02	0.05
Terminal Thickness	A3		0.203 REF	
Overall Length	D		4.00 BSC	
Exposed Pad Length	D2	2.45	2.50	2.55
Exposed Pad Length	D3	1.57	1.62	1.67
Exposed Pad Length	D4	1.57	1.62	1.67
Overall Width	E		6.00 BSC	
Exposed Pad Width	E2	2.05	2.10	2.15
Exposed Pad Width	E3	2.47	2.52	2.57
Exposed Pad Width	E4	1.75	1.80	1.85
Terminal Width	b	0.20	0.25	0.30
Terminal Length	L	0.45	0.50	0.55

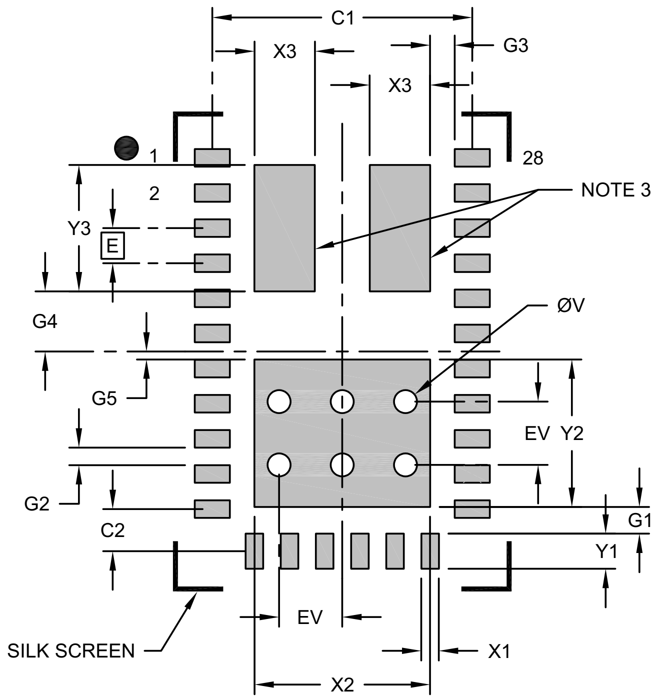
Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Package is saw singulated
3. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.
   REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-1294 Rev A Sheet 2 of 2

28-Lead Thick Plastic Quad Flat, No Lead Package (LYA) - 4x6 mm Body [LQFN] With Multiple Fused Exposed Pads

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E		0.50 BSC	
Center Pad Width	X2			2.52
Center Pad Length	Y2			2.10
Center Pad Width	X3			0.86
Center Pad Length (X2)	Y3			1.80
Contact Pad Spacing	C1		3.70	
Contact Pad Spacing	C2		0.60	
Contact Pad Width (X28)	X1			0.27
Contact Pad Length (X28)	Y1			0.52
Contact Pad to Center Pad (X6)	G1	0.38		
Contact Pad to Contact Pad (X25)	G2	0.25		
Contact Pad to Contact Pad (X2)	G3	0.35		
Package Center to Center Pad (X2)	G4		0.86	
Package Center to Center Pad	G5		0.12	
Thermal Via Diameter	V		0.33	
Thermal Via Pitch	EV		0.90	

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.
2. For best soldering results, thermal vias, if used, should be filled or tented to avoid solder loss during reflow process
3. These center pads have different electrical potentials. DO NOT CONNECT TO GROUND.

Microchip Technology Drawing C04-3294 Rev A

APPENDIX A: REVISION HISTORY

Revision B (April 2024)

- Updated Typical Performance Curves section to better describe the device.
- Updated Figure 5-2 to improve clarity.

Revision A (November 2023)

- Initial release of MIC38300A as Microchip data sheet DS20006831A.

PRODUCT IDENTIFICATION SYSTEM

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

PART NO.	X	X	XX	-XX
Device	Output Current	Temperature Range	Package	Media Type

Device:	MIC38300A:		3A High Efficiency Low Dropout Regulator
Output Current:	H	=	3A
Temperature Range:	Y	=	-40°C to +125°C
Package:	HL	=	28-Lead LQFN
Media Type:	TR	=	1,000/Reel

Examples:

a) MIC38300AHYHL-TR: MIC38300A, 3A Output Current, -40°C to +125°C Temp. Range, 28-Lead LQFN, 1,000/Reel

Note: 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.

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