MIC5304

Single 150 mA Low Operating Current LDO with Dual Voltage Pin Select

Features

- 150 mA Output Current
- Logic-Controlled Selectable Output Voltage
- Fast Transition Time Between Selected Output Voltages
- Input Voltage Range: 2.3V to 5.5V
- Low 24 µA Operating Current
- Stable with 1 µF Ceramic Capacitors
- Low Dropout Voltage of 85 mV at 150 mA
- Thermal Shutdown and Current Limit Protection
- Tiny 6-pin 1.6 mm x 1.6 mm UDFN Package

Applications

- Mobile Phones, PDAs, PMPs, PNDs
- Digital Still and Video Cameras
- Dual Voltage Levels for Power Saving Mode
- Portable Electronics

General Description

The MIC5304 is a low quiescent current, low dropout regulator with selectable output voltage designed for applications that require two levels of output voltage regulation. The MIC5304 is an ideal solution for programming memory cards as well as for conserving power in portable applications. The MIC5304 is capable of sourcing 150 mA of output current while only consuming 24 µA of operating current. This high performance LDO offers fast transient response while still maintaining low quiescent current levels.

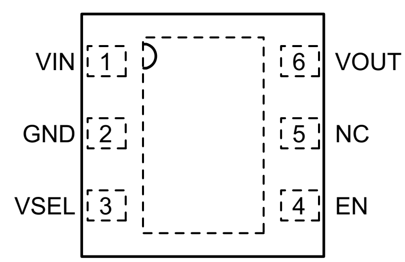
The MIC5304 is an ideal solution for battery-operated applications due to ultra low operating current and extremely low dropout voltage of 85 mV at 150 mA. Equipped with a TTL logic compatible enable pin, the MIC5304 can be put into a zero off-mode current state, drawing virtually no current when disabled.

Board space and component cost is minimized because the MIC5304 operates with very small 1 µF ceramic capacitors. The MIC5304 provides fixed output voltages, and is available in the tiny 1.6 mm x 1.6 mm UDFN package ideal for portable electronics.

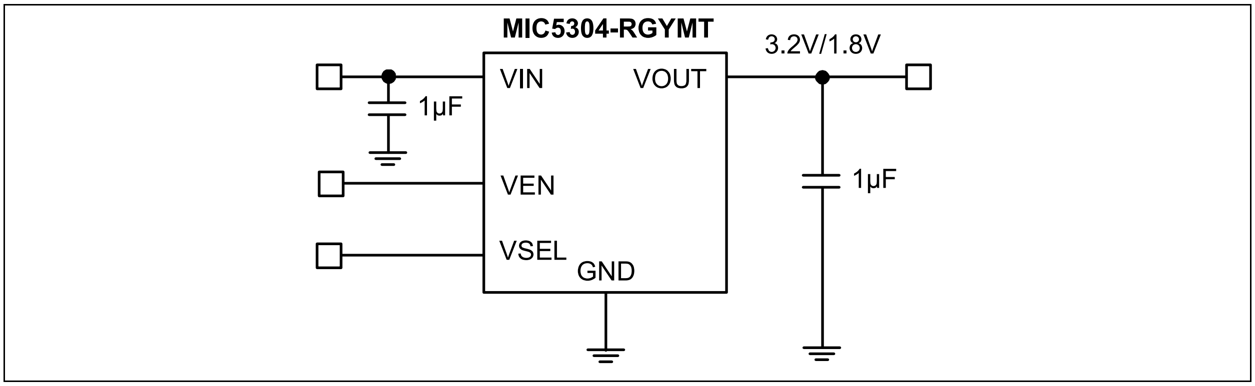
MIC5304 also features thermal shutdown and current limit protection.

Package Type

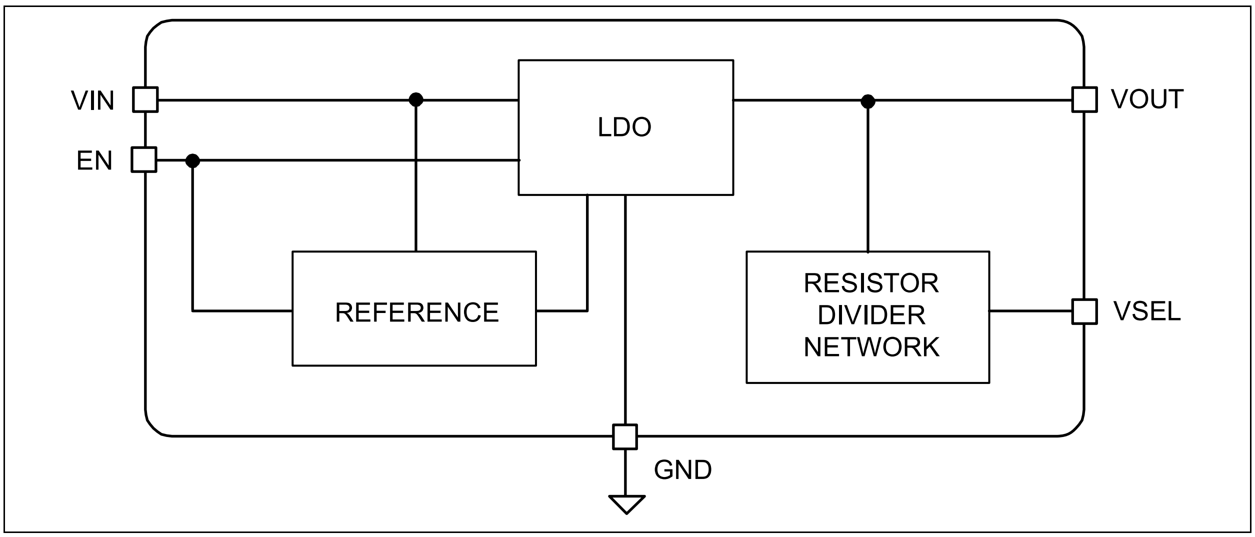
MIC5304
6-Pin UDFN (MT)
(Top View)



Typical Application Circuit



Functional Block Diagram



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{IN}) .... –0.3V to +6V
Enable/Select Voltage (V_{EN}/V_{SEL}) .... –0.3V to V_{IN}
Power Dissipation (P_D, Note 1) .... Internally Limited
ESD Rating (Note 2) .... 2 kV

Operating Ratings ‡

Supply Voltage .... +2.3V to +5.5V
Enable/Select Voltage (V_{EN}/V_{SEL}) .... 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 $P_{D(MAX)} = (T_{J(MAX)} – T_A)/θ_{JA}$. 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

Electrical Characteristics: $V_{IN} = V_{EN} = V_{OUT}$ + 1V; $C_{IN} = C_{OUT}$ = 1 µF; I_{OUT} = 100 µA; T_A = +25°C. **Bold** values valid for –40ºC to +125°C; unless otherwise specified. Note 1

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Output Voltage Accuracy		–1.5	—	1.5	%	Variation from nominal V_{OUT}
		–2.0	—	**2.0**		
Line Regulation	$ΔV_{OUT}/(V_{OUT}$ x $ΔV_{IN})$	—	0.01	0.3	%/V	$V_{IN} = V_{OUT}$ + 1V to 5.5V, I_{OUT} = 100 µA
Load Regulation (Note 2)	$ΔV_{OUT}/V_{OUT}$	—	0.05	**1**	%	I_{OUT} = 100 µA to 150 mA
Dropout Voltage (Note 3)	V_{DO}	—	25	—	mV	I_{OUT} = 50 mA
		—	55	—		I_{OUT} = 100 mA
		—	85	**150**		I_{OUT} = 150 mA
Ground Pin Current (Note 4)	I_{GND}	—	24	**35**	µA	I_{OUT} = 100 µA to 150 mA
Ground Pin Current in Shutdown	I_{SD}	—	0.01	1	µA	V_{EN} = 0V
Ripple Rejection	PSRR	—	65	—	dB	f = 1 kHz; C_{OUT} = 1 µF; I_{OUT} = 150 mA
		—	50	—		f = 20 kHz; C_{OUT} = 1 µF; I_{OUT} = 150 mA
Current Limit	I_{LIM}	275	475	750	mA	V_{OUT} = 0V
Output Voltage Noise	e_n	—	90	—	$µV_{RMS}$	C_{OUT} = 1 µF, 10 Hz to 100 kHz
Enable/Select Input						
Enable/Select Input Voltage	V_{IL}	—	—	**0.2**	V	Logic Low
	V_{IH}	**1.2**	—	—		Logic High

ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: $V_{IN} = V_{EN} = V_{OUT} + 1V$; $C_{IN} = C_{OUT} = 1\ \mu F$; $I_{OUT} = 100\ \mu A$; $T_A = +25°C$. **Bold** values valid for –40ºC to +125°C; unless otherwise specified. Note 1

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Enable/Select Input Current	I_{IL}	—	0.01	**1**	µA	$V_{IL} \le 0.2V$
	I_{IH}	—	0.01	**1**		$V_{IH} \ge 1.2V$
Turn-On Time	t_{ON}	—	150	**500**	µs	$C_{OUT} = 1\ \mu F$; $I_{OUT} = 150$ mA
Transition Time	t_{TRANS}	—	35	**100**	µs	V_{EN} = High; V_{SEL} = Transition from 0V to 1.2V; V_{OUT} change from 1.8V to (3.2V – 10%)
		—	45	**100**		V_{EN} = High; V_{SEL} = Transition from 1.2V to 0V; V_{OUT} change from 3.2V to (1.8V + 10%)

Note 1: Specification for packaged product only.

2: Regulation is measured at constant junction temperature using low duty cycle pulse testing; changes in output voltage due to heating effects are covered by the thermal regulation specification.

3: Dropout voltage is defined as the input-to-output differential at which the output voltage drops 2% below its nominal V_{OUT}. For outputs below 2.3V, the dropout voltage is the input-to-output differential with the minimum input voltage 2.3V.

4: Ground pin current is the regulator quiescent current. The total current drawn from the supply is the sum of the load current plus the ground pin current.

TEMPERATURE SPECIFICATIONS

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Junction Temperature Range	T_J	–40	—	+125	°C	—
Storage Temperature	T_S	–65	—	+150	°C	—
Lead Temperature	T_{LEAD}	—	—	+260	°C	Soldering, 5 sec.
Package Thermal Resistances						
Thermal Resistance, UDFN 6-Ld	θ_{JA}	—	92	—	°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.

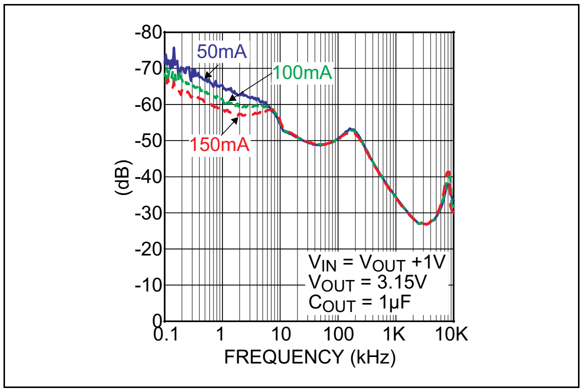


FIGURE 2-1: *Power Supply Rejection Ratio (V_{SEL} = High).*

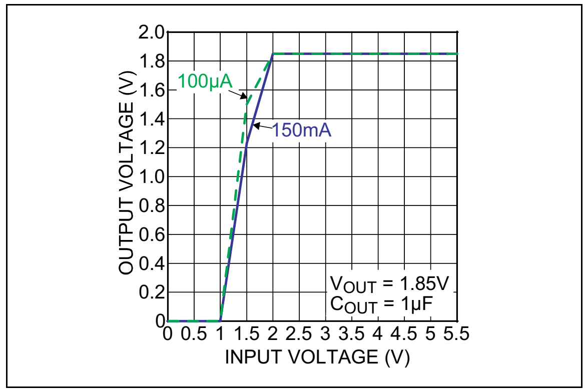


FIGURE 2-4: *Output Voltage vs. Input Voltage (V_{SEL} = Low).*

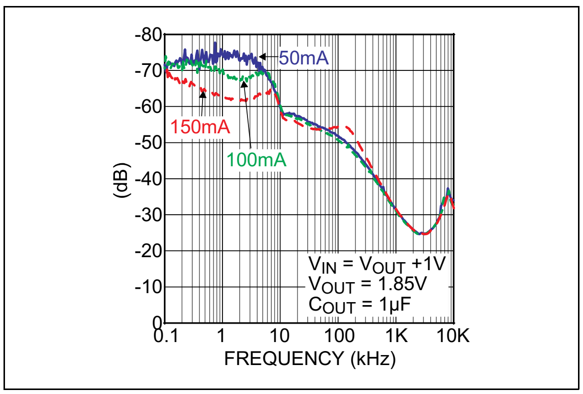


FIGURE 2-2: *Power Supply Rejection Ratio (V_{SEL} = Low).*

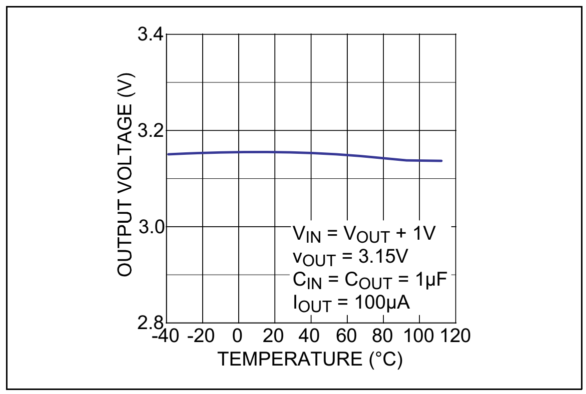


FIGURE 2-5: *Output Voltage vs. Temperature (V_{SEL} = High).*

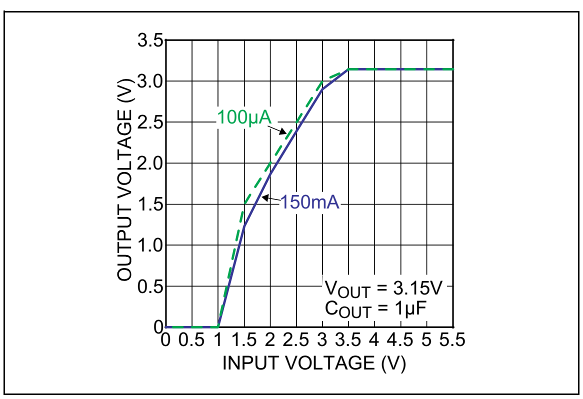


FIGURE 2-3: *Output Voltage vs. Input Voltage (V_{SEL} = High).*

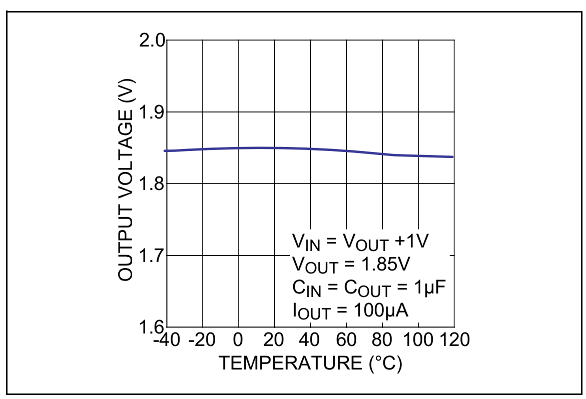


FIGURE 2-6: *Output Voltage vs. Temperature (V_{SEL} = Low).*

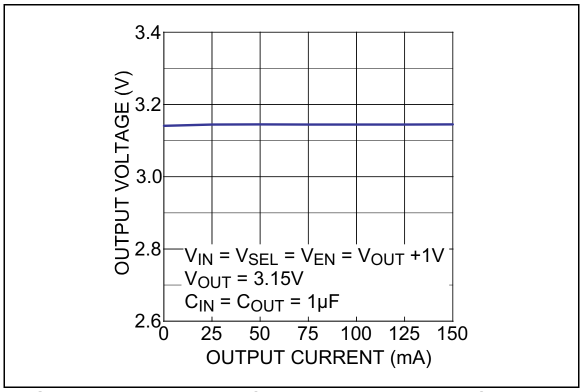


FIGURE 2-7: *Output Voltage vs. Output Current (V_{SEL} = High).*

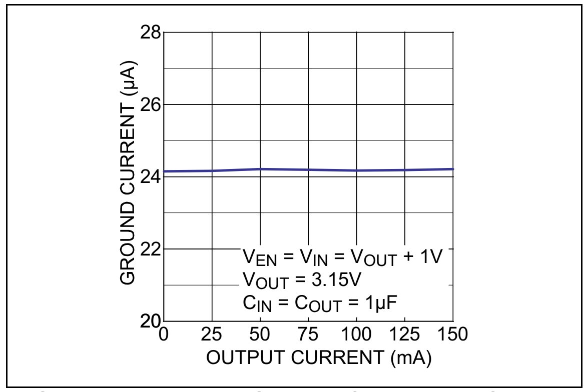


FIGURE 2-10: *Ground Current vs. Output Current.*

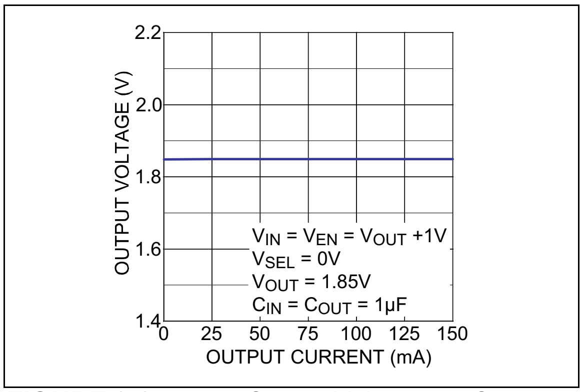


FIGURE 2-8: *Output Voltage vs. Output Current (V_{SEL} = Low).*

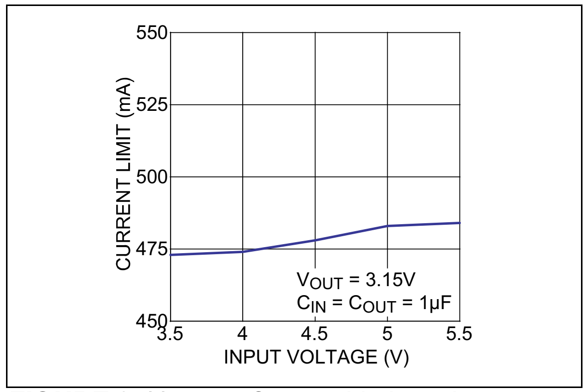


FIGURE 2-11: *Current Limit vs. Input Voltage (V_{SEL} = High).*

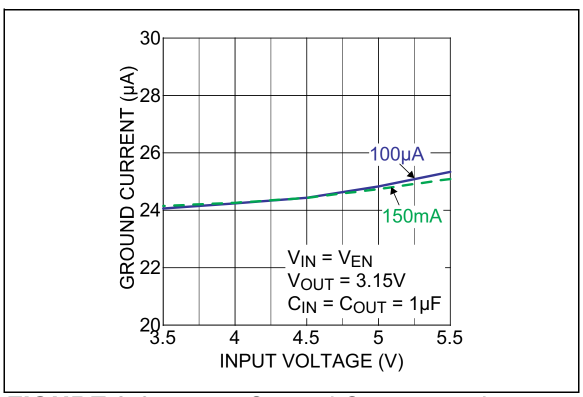


FIGURE 2-9: *Ground Current vs. Input Voltage.*

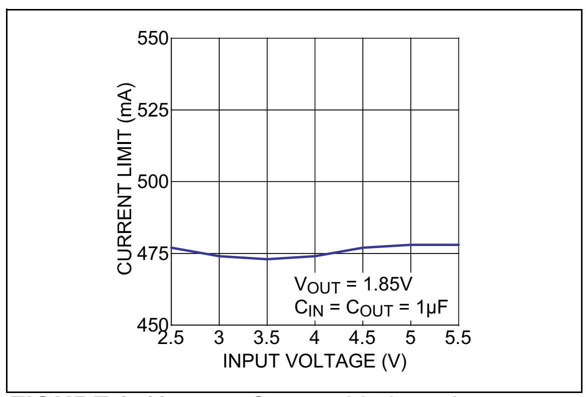


FIGURE 2-12: *Current Limit vs. Input Voltage (V_{SEL} = Low).*

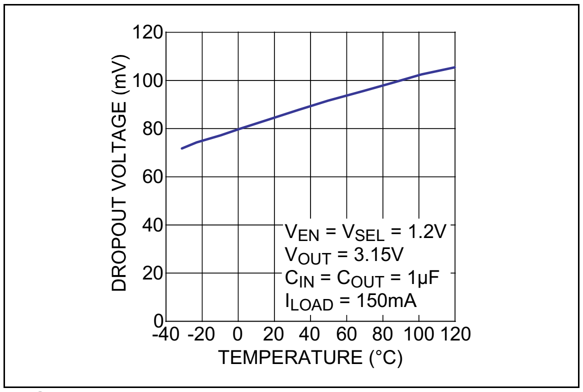


FIGURE 2-13: *Dropout Voltage vs. Temperature (V_{SEL} = High).*

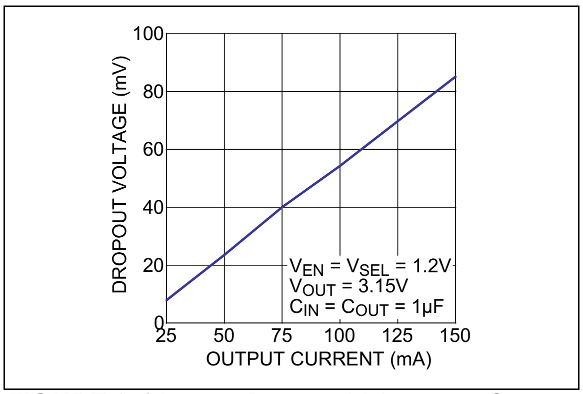


FIGURE 2-14: *Dropout Voltage vs. Output Current (V_{SEL} = High).*

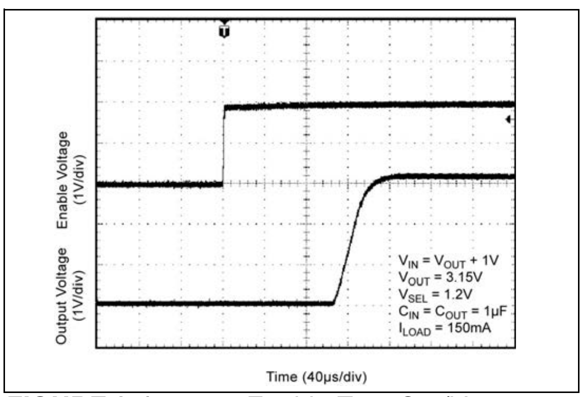


FIGURE 2-15: *Enable Turn-On (V_{SEL} = High).*

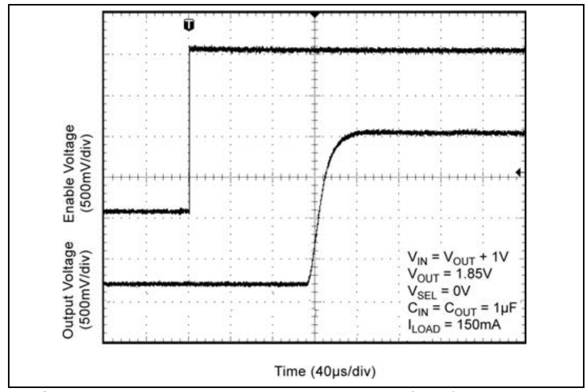


FIGURE 2-16: *Enable Turn-On (V_{SEL} = Low).*

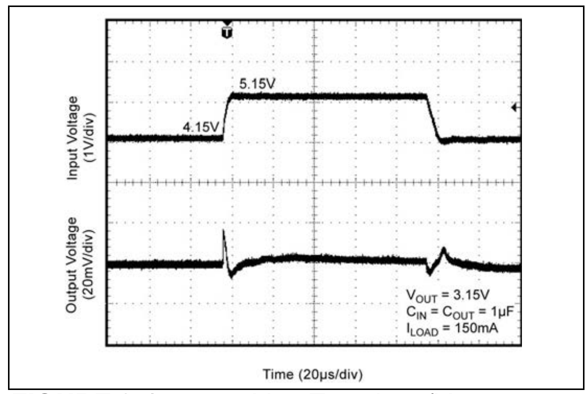


FIGURE 2-17: *Line Transient (V_{SEL} = High).*

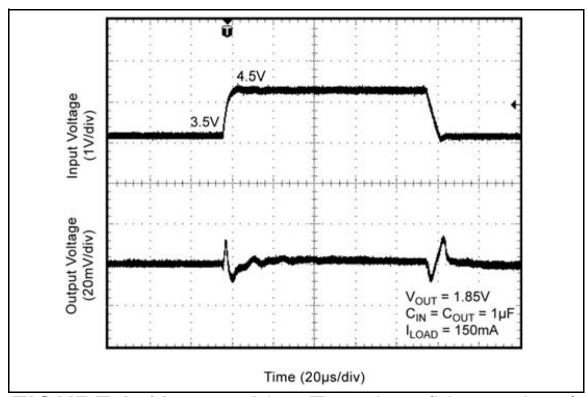


FIGURE 2-18: *Line Transient (V_{SEL} = Low).*

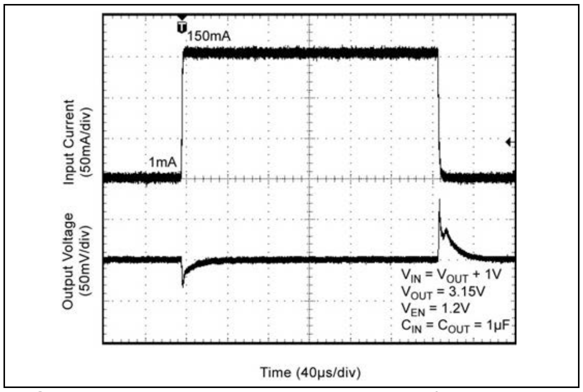


FIGURE 2-19: *Load Transient (V_{SEL} = High).*

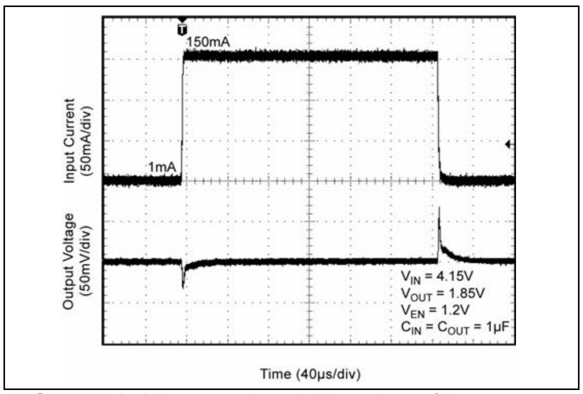


FIGURE 2-20: *Load Transient (V_{SEL} = Low).*

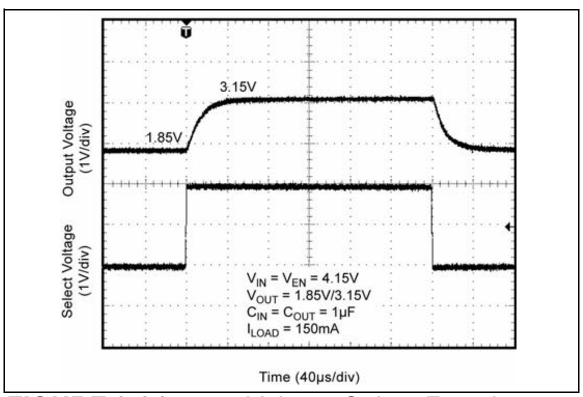


FIGURE 2-21: *Voltage Select Function.*

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	VIN	Supply Input.
2	GND	Ground.
3	VSEL	Voltage Select Input. Logic high = higher output voltage; Logic low = lower output voltage. Do not leave floating.
4	EN	Enable Input: Active High Input. Logic High = On; Logic Low = Off. Do not leave floating.
5	NC	Not internally connected.
6	VOUT	Output Voltage.
HS Pad	ePad	Exposed heatsink pad connected to ground internally.

4.0 APPLICATION INFORMATION

The MIC5304 is a low quiescent current, voltage-selectable LDO. The regulator is capable of sourcing 150 mA of output current with a low quiescent current of 24 µA. A logic input signal selects the output between two preset voltages. The MIC5304 regulator is fully protected from damage due to fault conditions, offering linear current limiting and thermal shutdown.

4.1 Input Capacitor

The MIC5304 is a high-performance, high bandwidth device. Therefore, it requires a well-bypassed input supply for optimal performance. An input capacitor of 1 µF is required from the input to ground to provide stability. Low-ESR ceramic capacitors provide optimal performance at a minimum of space. Additional high-frequency capacitors, such as small-valued NPO dielectric-type capacitors, help filter out high-frequency noise and are good practice in any RF-based circuit. X5R or X7R dielectrics are recommended for the input capacitor. Y5V dielectrics lose most of their capacitance over temperature and are therefore, not recommended.

4.2 Output Capacitor

The MIC5304 requires an output capacitor of 1 µF or greater to maintain stability. The design is optimized for use with low-ESR ceramic chip capacitors. High ESR capacitors may cause high frequency oscillation. The output capacitor can be increased, but performance has been optimized for a 1 µF ceramic output capacitor and does not improve significantly with larger capacitance.

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 an X7R ceramic capacitor to ensure the same minimum capacitance over the equivalent operating temperature range.

4.3 Enable/Shutdown

The MIC5304 is provided with an active-high enable pin that allows the regulator to be enabled. Forcing the enable pin low disables the regulator and sends it into a “zero” off-mode current state. In this state, current consumed by the regulator goes nearly to zero. The active-high enable pin uses CMOS technology and the enable pin cannot be left floating; a floating enable pin may cause an indeterminate state on the output.

4.4 Voltage Select

The voltage select pin is used to select the output voltage between two voltages. A logic high signal sets the output to the higher voltage; while a logic low signal selects the lower output voltage. The voltage select pin cannot be left floating; a floating pin may cause an indeterminate state on the output.

4.5 Thermal Considerations

The MIC5304 is designed to provide 150 mA of continuous current in a very small package. Maximum ambient operating temperature can be calculated based on the output current and the voltage drop across the part. For example if the input voltage is 3.6V, the output voltage is 3.15V with V_{SEL} set high and 1.85V with V_{SEL} low, and the output current equals 150 mA. The lower output voltage should be used for power dissipation calculations as this is the worst case situation. The actual power dissipation of the regulator circuit can be determined using the equation:

EQUATION 4-1:

$$P_D = (V_{IN} - V_{OUT}) \times I_{OUT} + V_{IN} \times I_{GND}$$

Because this device is CMOS and the ground current is typically <100 µA over the load range, the power dissipation contributed by the ground current is <1% and can be ignored for this calculation.

EQUATION 4-2:

$$P_D = (3.6V - 1.85V) \times 150mA = 0.2625W$$

To determine the maximum ambient operating temperature of the package, use the junction-to-ambient thermal resistance of the device and the following basic equation:

EQUATION 4-3:

$$P_{D(MAX)} = \frac{T_{J(MAX)} - T_A}{\theta_{JA}}$$

Where:

$T_{J(MAX)}$ = 125°C, the max. junction temp. of the die.

θ_{JA} = 92°C/W

Substituting P_D for $P_{D(MAX)}$ and solving for the ambient operating temperature will give the maximum operating conditions for the regulator circuit. The junction-to-ambient thermal resistance for the minimum footprint is 92°C/W.

The maximum power dissipation must not be exceeded for proper operation.

For example, when operating the MIC5304-XDYMT at an input voltage of 3.6V and 150 mA load with a minimum footprint layout, the maximum ambient operating temperature T_A can be determined as follows:

EQUATION 4-4:

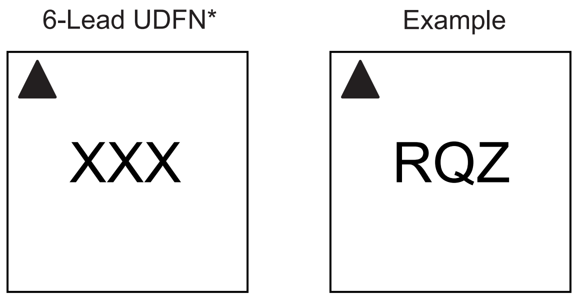
$$0.2625W = \frac{125°C - T_A}{92°C/W}$$

$$T_A = 100°C$$

Therefore, a 3.15/1.85V application with a 150 mA output current can accept an ambient operating temperature of 100°C in a 1.6 mm x 1.6 mm UDFN package. For a full discussion of heat sinking and thermal effects on voltage regulators, refer to the "Regulator Thermals" section of Microchip's Designing with Low-Dropout Voltage Regulators handbook.

5.0 PACKAGING INFORMATION

5.1 Package Marking Information

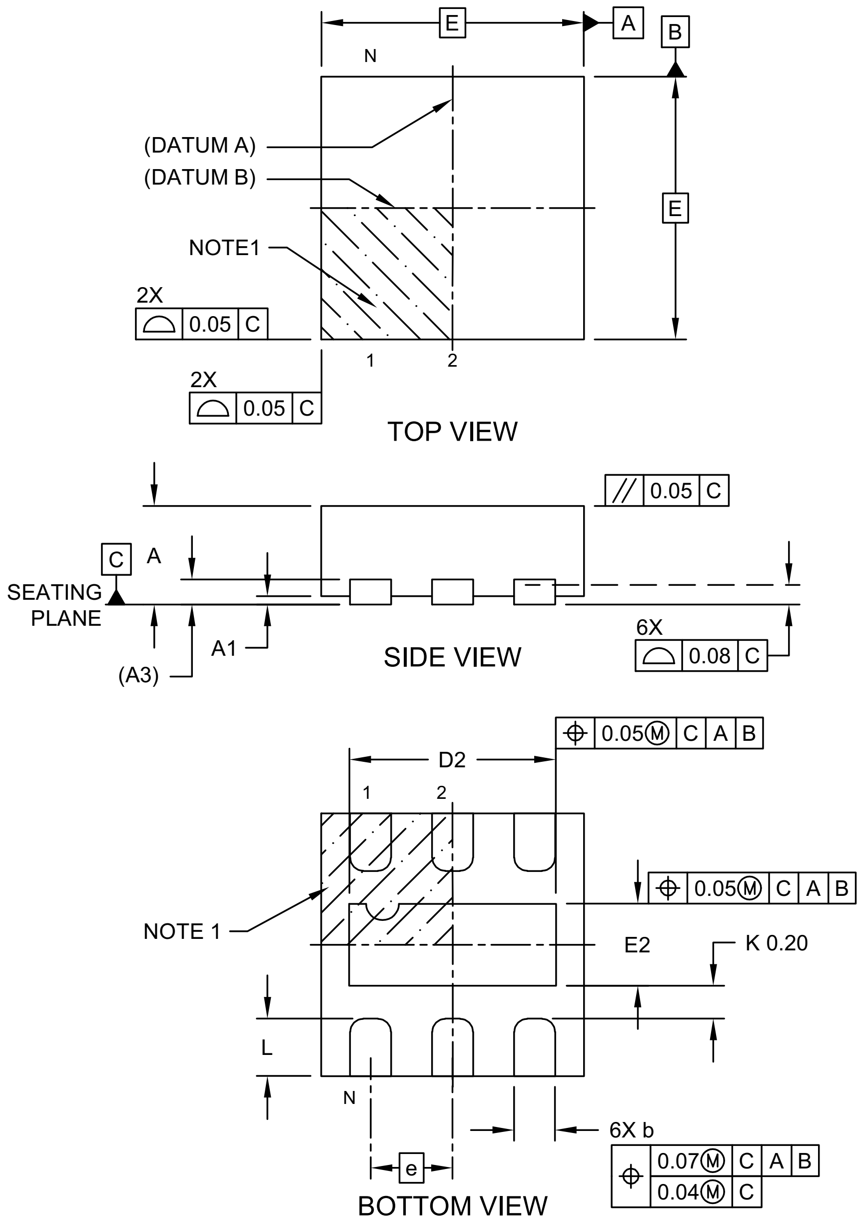


Legend:	XX...X	Product code or customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package 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 (_) 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

6-Lead Ultra Thin Plastic Dual Flat, No Lead (HKA) - 1.6x1.6x0.6 mm Body [UDFN] With 1.26x0.50 mm Exposed Pad; Micrel Legacy Package TDFN1616-6LD-PL-1

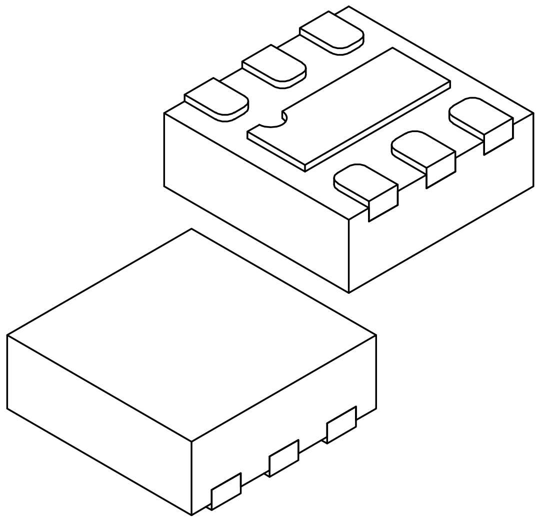
Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Microchip Technology Drawing C04-1154 Rev A Sheet 1 of 2

6-Lead Ultra Thin Plastic Dual Flat, No Lead (HKA) - 1.6x1.6x0.6 mm Body [UDFN] With 1.26x0.50 mm Exposed Pad; Micrel Legacy Package TDFN1616-6LD-PL-1

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		6	
Pitch	e		0.50 BSC	
Overall Height	A	0.50	0.55	0.60
Standoff	A1	0.00	0.02	0.05
Terminal Thickness	A3		0.152 REF	
Overall Length	D		1.60 BSC	
Exposed Pad Length	D2	1.21	1.26	1.31
Overall Width	E		1.60 BSC	
Exposed Pad Width	E2	0.45	0.50	0.55
Terminal Width	b	0.20	0.25	0.30
Terminal Length	L	0.30	0.35	0.40
Terminal-to-Exposed-Pad	K	0.20	–	–

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 C04-1154 Rev A Sheet 2 of 2

6-Lead Ultra Thin Plastic Dual Flat, No Lead (HKA) - 1.6x1.6x0.6 mm Body [UDFN] With 1.26x0.50 mm Exposed Pad; Micrel Legacy Package TDFN1616-6LD-PL-1

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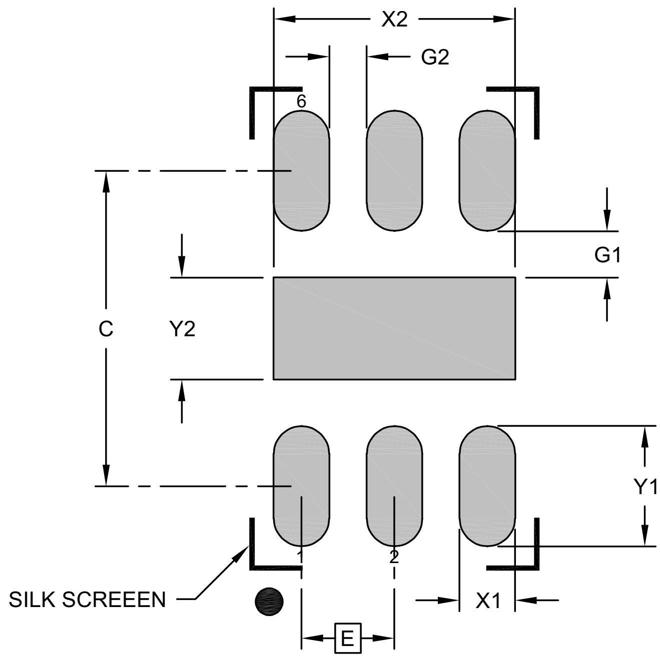

RECOMMENDED LAND PATTERN

	Units	MILLIMETERS		
	Dimension Limits	MIN	NOM	MAX
Contact Pitch	E		0.50 BSC	
Center Pad Width	X2			1.30
Center Pad Length	Y2			0.55
Contact Pad Spacing	C		1.70	
Contact Pad Width (X6)	X1			0.30
Contact Pad Length (X6)	Y1			0.65
Contact Pad to Center Pad (X6)	G1	0.25		
Contact Pad to Contact Pad (X4)	G2	0.20		

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-3154 Rev A

NOTES:

APPENDIX A: REVISION HISTORY

Revision A (March 2023)

- Converted Micrel document MIC5304 to Microchip data sheet DS20006720A.
- Minor text changes throughout.
- Schematic, Bill of Materials, and PCB Layout Recommendations removed from the data sheet because that information is found in the MIC5304 User's Guide.

NOTES:

PRODUCT IDENTIFICATION SYSTEM

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

Part Number	-XXX	X	XX	-XX
Device	Output Voltage	Temp. Range	Package	Media Type

Device:	MIC5304:		Single 150 mA Low Operating Current LDO with Dual Voltage Pin Select
Output Voltage:	RG	=	3.2V (V_{SEL} High)/1.8V (V_{SEL} Low)
	XD	=	3.15V (V_{SEL} High)/1.85V (V_{SEL} Low)
	XGH	=	3.15V (V_{SEL} High)/1.875V (V_{SEL} Low)
Temperature Range:	Y	=	–40°C to +125°C
Package:	MT	=	6-Lead 1.6 mm x 1.6 mm UDFN
Media Type:	TR	=	5,000/Reel

Note: The marking code for the RG option is **RQZ**; the marking code for the XD option is **XQD**; the marking code for the XGH option is **XGH**.

Examples:

a) MIC5304-RGYMT-TR: MIC5304, 3.2V/1.8V, –40°C to +125°C Temp. Range, 6-Lead UDFN, 5,000/Reel

b) MIC5304-XDYMT-TR: MIC5304, 3.15V/1.85V, –40°C to +125°C Temp. Range, 6-Lead UDFN, 5,000/Reel

c) MIC5304-XGHYMT-TR: MIC5304, 3.15V/1.875V, –40°C to +125°C Temp. Range, 6-Lead UDFN, 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.

NOTES:

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