MIC5524

High Performance 500 mA LDO

Features

- Input Voltage Range: 2.5V to 5.5V
- Fixed Output Voltages Down to 1.0V
- Ensured 500 mA Output Current
- High Output Initial Accuracy (±1%)
- High PSRR: 80 dB
- Low Quiescent Current: 38 µA
- Stable with 2.2 µF Ceramic Output Capacitors
- Low Dropout Voltage 260 mV at 500 mA
- Auto-Discharge and Internal Enable Pull-Down
- Thermal Shutdown and Current-Limit Protection
- 4-Lead 1 mm x 1 mm UDFN Package

Applications

- Portable Communication Equipment
- DSC, GPS, PMP, and PDAs
- Portable Medical Devices
- 5V POL Applications

General Description

The MIC5524 is a low-power, µCap, low dropout regulator designed for optimal performance in a very small footprint. It is capable of sourcing 500 mA of output current and only draws 38 µA of operating current to do so. The MIC5524 includes an auto-discharge feature on the output that is activated when the enable pin is low and it has an internal pull-down resistor on the enable pin that will disable the output when the enable pin is left floating. This is ideal for applications where the control signal is floating during processor boot up.

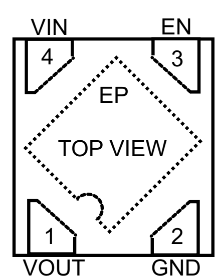
This high-performance LDO offers fast transient response and good PSRR in a 1 mm x 1 mm (0.55 mm ht.) UDFN package.

Ideal for battery-operated applications, the MIC5524 offers 2% accuracy, extremely low dropout voltage (260 mV at 500 mA), and can regulate output voltages down to 1.0V. Equipped with a TTL logic-compatible enable pin, the MIC5524 can be put into a zero off-mode current state, drawing no current when disabled.

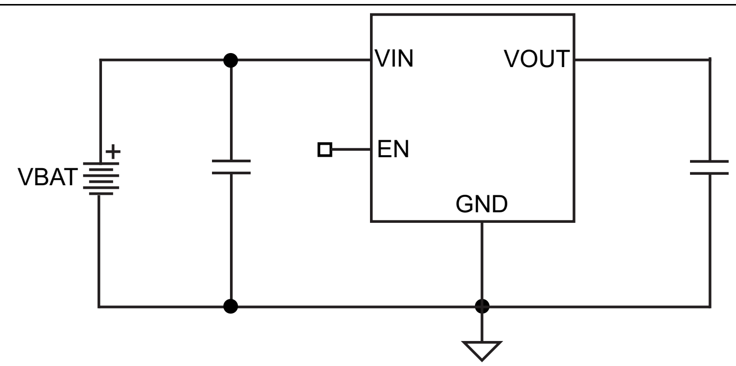
The MIC5524 is a µCap design, operating with very small ceramic output capacitors for stability, reducing required board space and component cost for space-critical applications. The MIC5524 has an operating junction temperature range of –40°C to 125°C.

Package Type

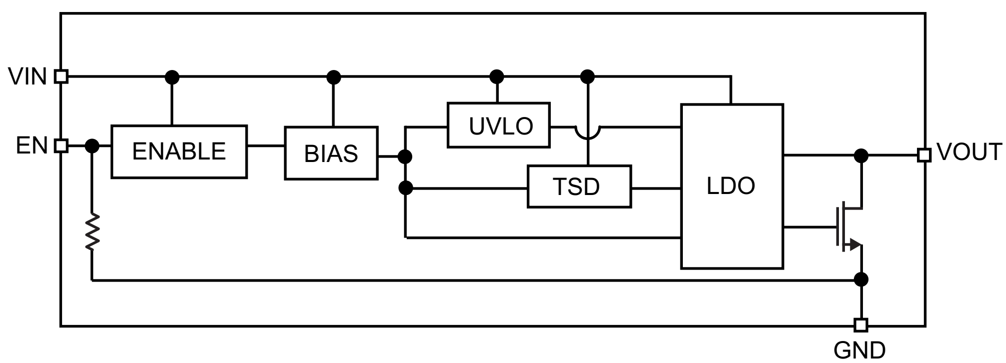
MIC5524
4-Lead UDFN (MT)
(Top View)



Typical Application Circuit



Functional Block Diagram



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{IN}) .... –0.3V to +6V
Enable Voltage (V_{EN}) .... –0.3V to V_{IN}
Power Dissipation (P_D, Note 1) .... Internally Limited
ESD Rating (Note 2) .... 3 kV

Operating Ratings ‡

Supply Voltage (V_{IN}) .... +2.5V to +5.5V
Enable 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 $P_{D(MAX)} = (T_{J(MAX)} – T_A)/θ_{JA}$. 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; $C_{IN} = C_{OUT}$ = 2.2 µF; I_{OUT} = 100 µA; T_J = +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	V_O	–2.0	±1	2.0	%	Variation from nominal V_{OUT}
		–3.0	—	**3.0**		Variation from nominal V_{OUT}
Line Regulation	$ΔV_{OUT}/(V_{OUT} \times ΔV_{IN})$	—	0.02	**0.3**	%/V	$V_{IN} = V_{OUT}$ +1V to 5.5V; I_{OUT} = 100 µA
Load Regulation	$ΔV_{OUT}$	—	10	—	mV	Note 2, I_{OUT} = 100 µA to 500 mA
Dropout Voltage (Note 3)	V_{DROP}	—	80	**175**	mV	I_{OUT} = 150 mA
		—	260	**500**		I_{OUT} = 500 mA
Ground Pin Current (Note 4)	I_{GND}	—	38	**55**	µA	I_{OUT} = 0 mA
		—	42	—		I_{OUT} = 500 mA
Ground Pin Current in Shutdown	$I_{GND(SHDN)}$	—	0.05	1	µA	V_{EN} = 0V
Ripple Rejection	PSRR	—	80	—	dB	f = 100 Hz
		—	65	—		f = 1 kHz
Current Limit	I_{LIM}	**525**	800	—	mA	V_{OUT} = 0V
Output Voltage Noise	e_N	—	80	—	$µV_{RMS}$	f =10 Hz to 100 kHz
Auto-Discharge NFET Resistance	R_{NFET}	—	25	—	Ω	V_{EN} = 0V; V_{IN} = 3.6V I_{OUT} = –3 mA

ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: V_{IN} = V_{EN} = V_{OUT} + 1V; C_{IN} = C_{OUT} = 2.2 µF; I_{OUT} = 100 µA; T_J = +25°C. **Bold** values valid for –40ºC to +125°C; unless otherwise specified. Note 1

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Enable Input						
Enable Pull-Down Resistor	$R_{EN(PD)}$	—	4	—	MΩ	
Enable Input Voltage	V_{EN}	—	—	**0.2**	V	Logic Low
		1.2	—	—		Logic High
Enable Input Current	I_{EN}	—	0.01	1	µA	V_{EN} = 0V
		—	1.4	2		V_{EN} = 5.5V
Turn-On Time	t_{ON}	—	50	**125**	µs	I_{OUT} = 150 mA

Note 1: Specification for packaged product only.

2: Regulation is measured at constant junction temperature using pulse testing with a low duty cycle. Changes in output voltage due to heating effects are covered by the speculation for thermal regulation.

3: Dropout voltage is defined as the input-to-output differential at which the output voltage drops 2% below its nominal value measured at V_{IN} = V_{OUT} + 1V.

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						
Absolute Maximum Junction Temperature Range	$T_{J(ABS)}$	–40	—	+150	°C	—
Junction Temperature Range	T_J	–40	—	+125	°C	—
Storage Temperature	T_S	–65	—	+150	°C	—
Lead Temperature	T_{LEAD}	—	—	+260	°C	Soldering, 10 sec.
Package Thermal Resistances						
Thermal Resistance, UDFN 4-Ld	θ_{JA}	—	250	—	°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.

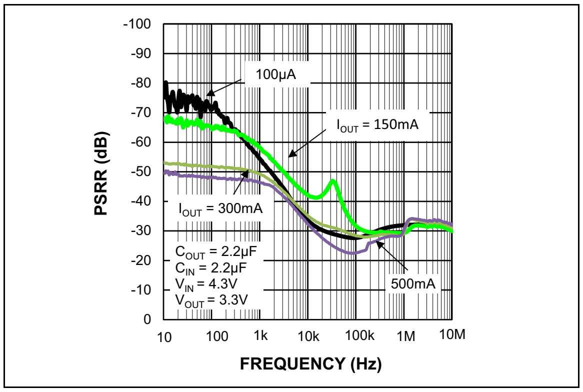


FIGURE 2-1: *Power Supply Rejection Ratio.*

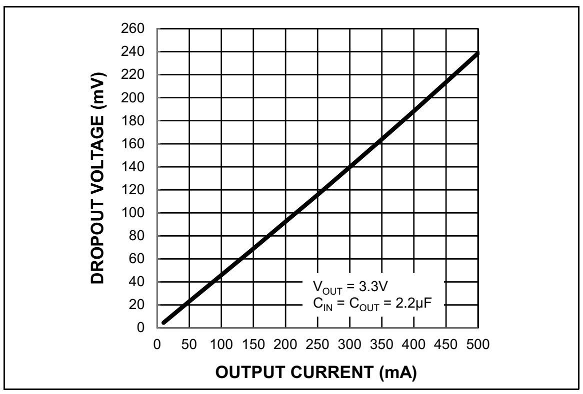


FIGURE 2-2: *Dropout Voltage vs. Output Current.*

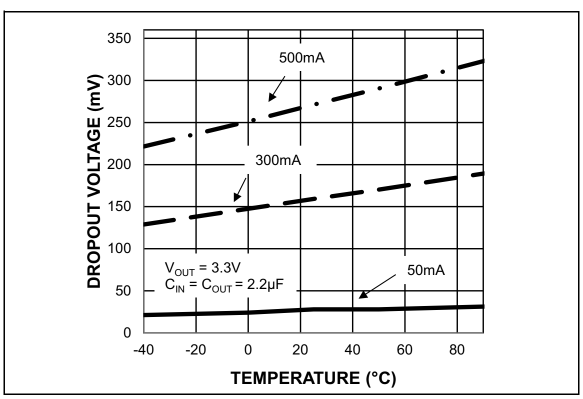


FIGURE 2-3: *Dropout Voltage vs. Temperature.*

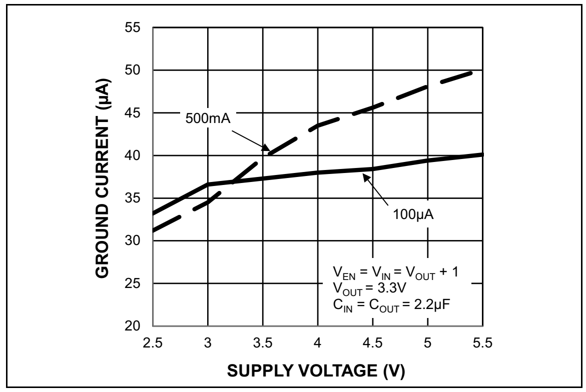


FIGURE 2-4: *Ground Current vs. Supply Voltage.*

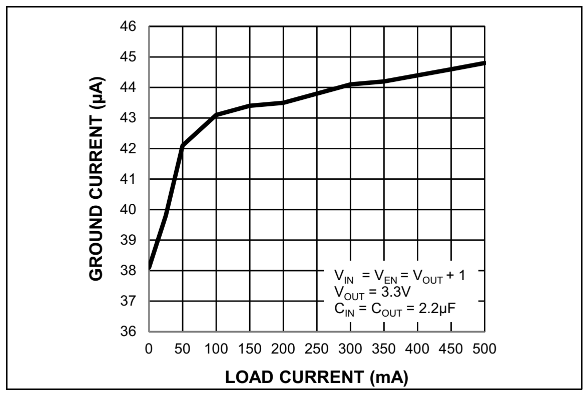


FIGURE 2-5: *Ground Current vs. Load Current.*

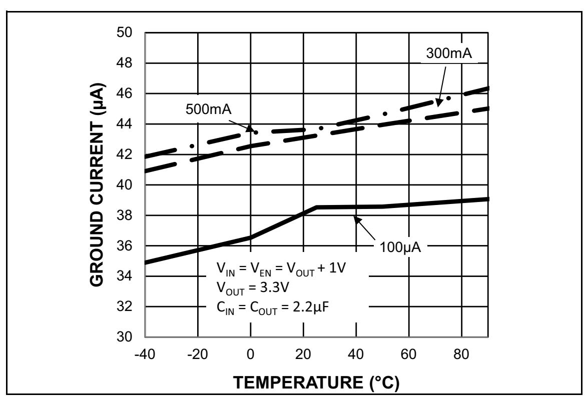


FIGURE 2-6: *Ground Current vs. Temperature.*

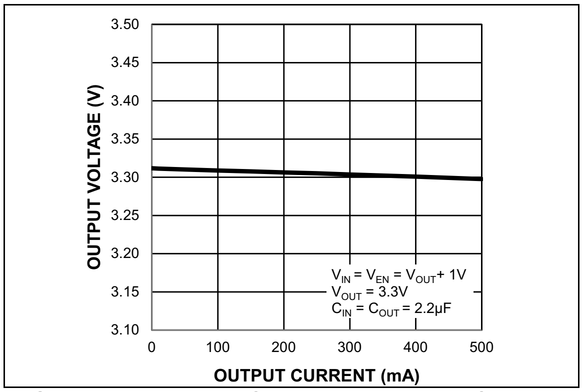


FIGURE 2-7: *Output Voltage vs. Output Current.*

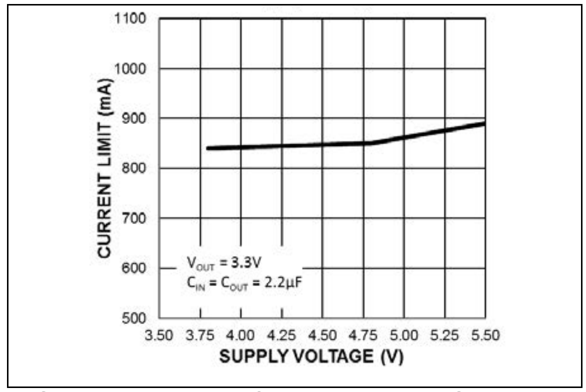


FIGURE 2-10: *Current Limit vs. Supply Voltage.*

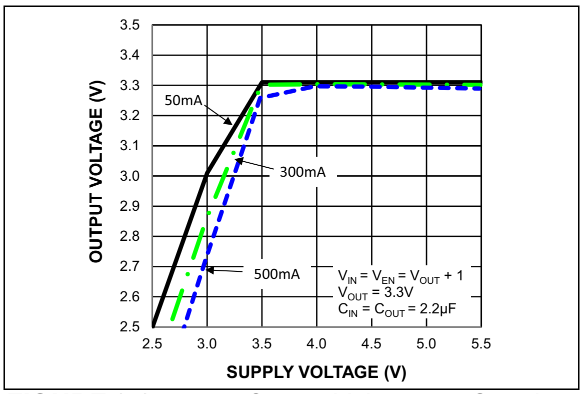


FIGURE 2-8: *Output Voltage vs. Supply Voltage.*

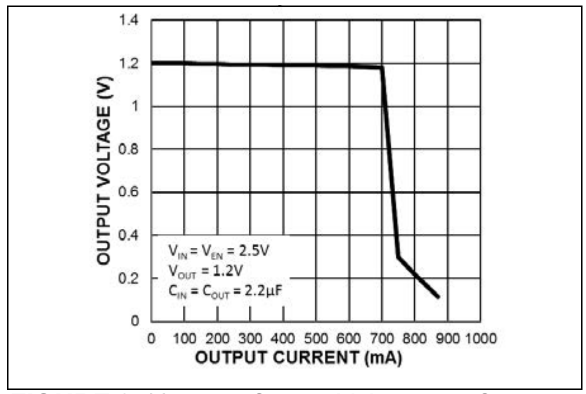


FIGURE 2-11: *Output Voltage vs. Output Current.*

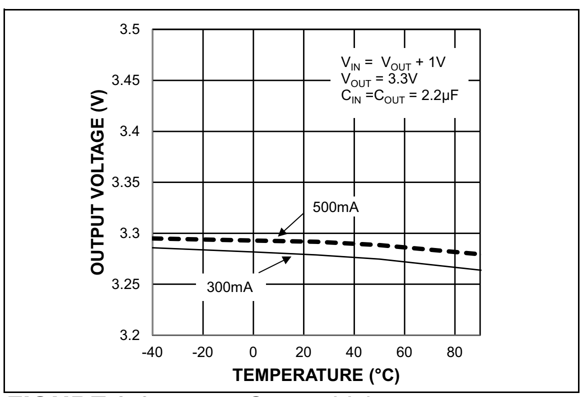


FIGURE 2-9: *Output Voltage vs. Temperature.*

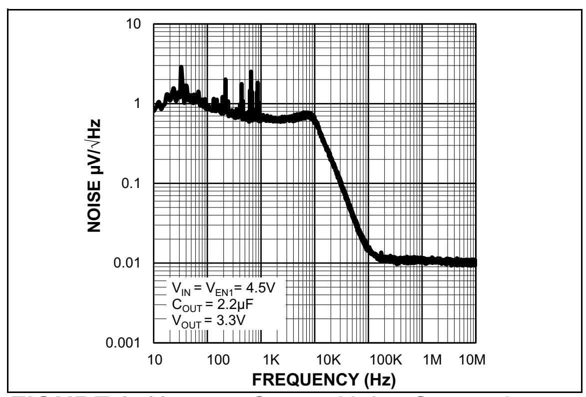


FIGURE 2-12: *Output Noise Spectral Density (MIC5524-3.3YMT).*

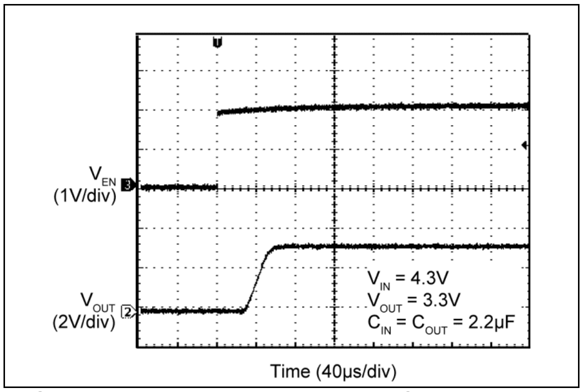


FIGURE 2-13: *Enable-Turn On.*

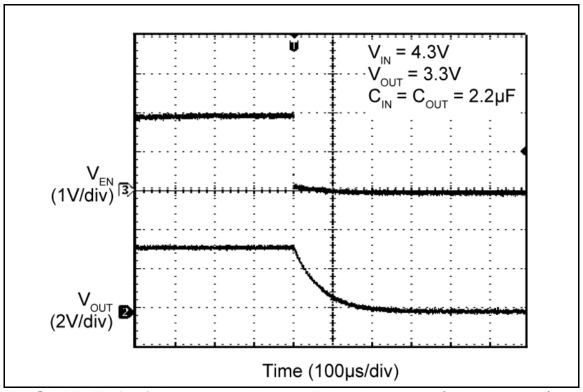


FIGURE 2-14: *Auto-Discharge (No Load).*

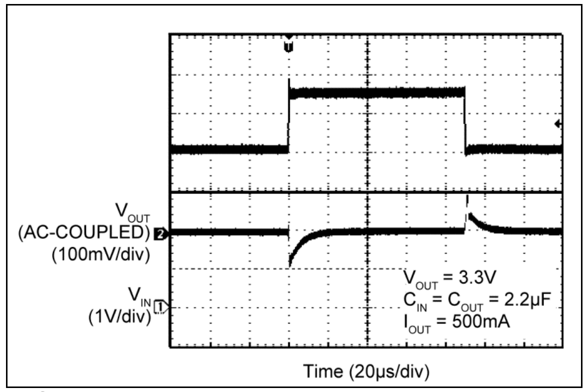


FIGURE 2-15: *Line Transient.*

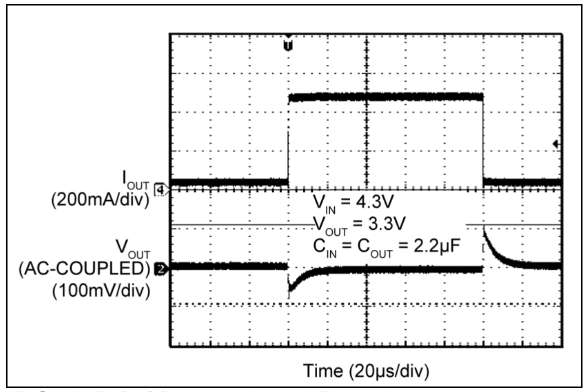


FIGURE 2-16: *Load Transient.*

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	VOUT	Output Voltage. When disabled, the MIC5524 switches in an internal 25Ω load to discharge the external capacitors.
2	GND	Ground.
3	EN	Enable Input. Active High. High = ON; Low = OFF. The MIC5524 has an internal 4 MΩ pull-down and this pin can be left floating.
4	VIN	Supply Input.
EP	ePad	Exposed Heatsink Pad. Connect to GND.

4.0 APPLICATION INFORMATION

The MIC5524 is a high-performance, low-power 500 mA LDO. The MIC5524 includes an auto-discharge circuit that is switched on when the regulator is disabled through the enable pin. The MIC5524 also offers an internal pull-down resistor on the enable pin to ensure the output is disabled if the control signal is tri-stated. The MIC5524 regulator is fully protected from damage due to fault conditions, offering linear current limiting and thermal shutdown.

4.1 Input Capacitor

The MIC5524 is a high-performance, high-bandwidth device. An input capacitor of 2.2 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 MIC5524 requires an output capacitor of 2.2 µF or greater to maintain stability. The design is optimized for use with low-ESR ceramic chip capacitors. High-ESR capacitors are not recommended because they may cause high-frequency oscillation. The output capacitor can be increased, but performance has been optimized for a 2.2 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 No-Load Stability

Unlike many other voltage regulators, the MIC5524 remains stable and in regulation with no load. This is especially important in CMOS RAM keep-alive applications.

4.4 Enable/Shutdown

The MIC5524 comes with an active-high enable pin that allows the regulator to be disabled. Forcing the enable pin low disables the regulator and sends it into an off-mode current state that draws virtually zero current. When disabled, the MIC5524 switches an internal 25Ω load on the regulator output to discharge the external capacitor.

Forcing the enable pin high enables the output voltage. The MIC5524 has an internal pull-down resistor on the enable pin to disable the output when the enable pin is floating.

4.5 Thermal Considerations

The MIC5524 is designed to provide 500 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 3.3V, and the output current is 500 mA. The actual power dissipation of the regulator circuit can be determined using Equation 4-1:

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 Equation 4-2:

EQUATION 4-2:

$$P_D = (3.6V - 3.3V) \times 500mA = 0.150W$$

To determine the maximum ambient operating temperature of the package, use the junction-to-ambient thermal resistance of the device Equation 4-3:

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} = Thermal resistance of 250°C/W for the UDFN package.

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 250°C/W.

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

For example, when operating the MIC5524-3.3YMT at an input voltage of 3.6V and a 500 mA load with a minimum footprint layout, the maximum ambient operating temperature T_A can be determined as in Equation 4-4:

EQUATION 4-4:

$$0.15W = (125°C - T_A) \div 250°C/W$$

$$T_A = 87.5°C$$

Therefore, the maximum ambient operating temperature allowed in a 1 mm x 1 mm UDFN package is 87.5°C. 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 TYPICAL APPLICATION SCHEMATIC

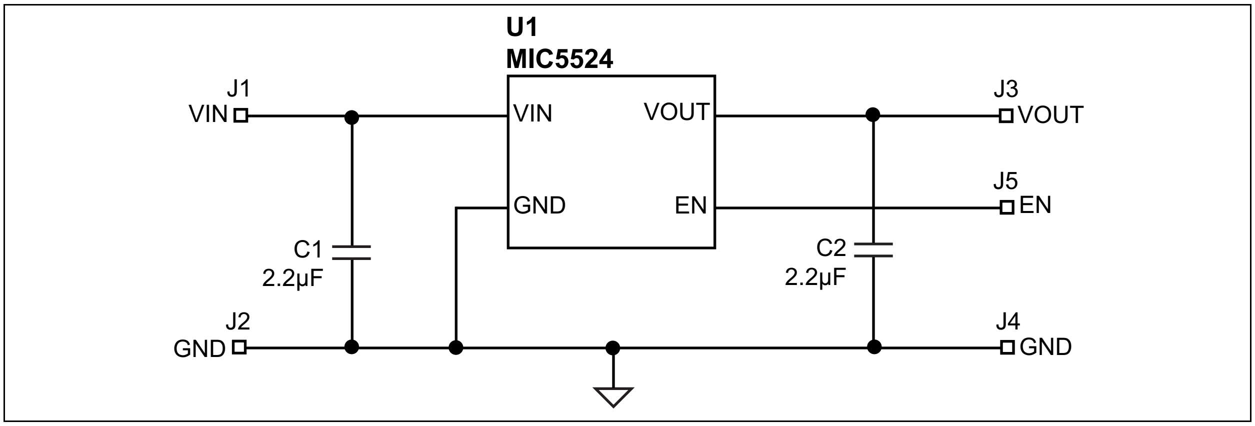


TABLE 5-1: BILL OF MATERIALS

Item	Part Number	Manufacturer	Description	Qty.
C1, C2	GRM188R71A225KE15D	Murata	Capacitor, 2.2 µF Ceramic, 10V, X5R, Size 0603	2
U1	MIC5524-x.xYMT	Microchip	High-Performance 500 mA LDO	1

6.0 PCB LAYOUT RECOMMENDATIONS

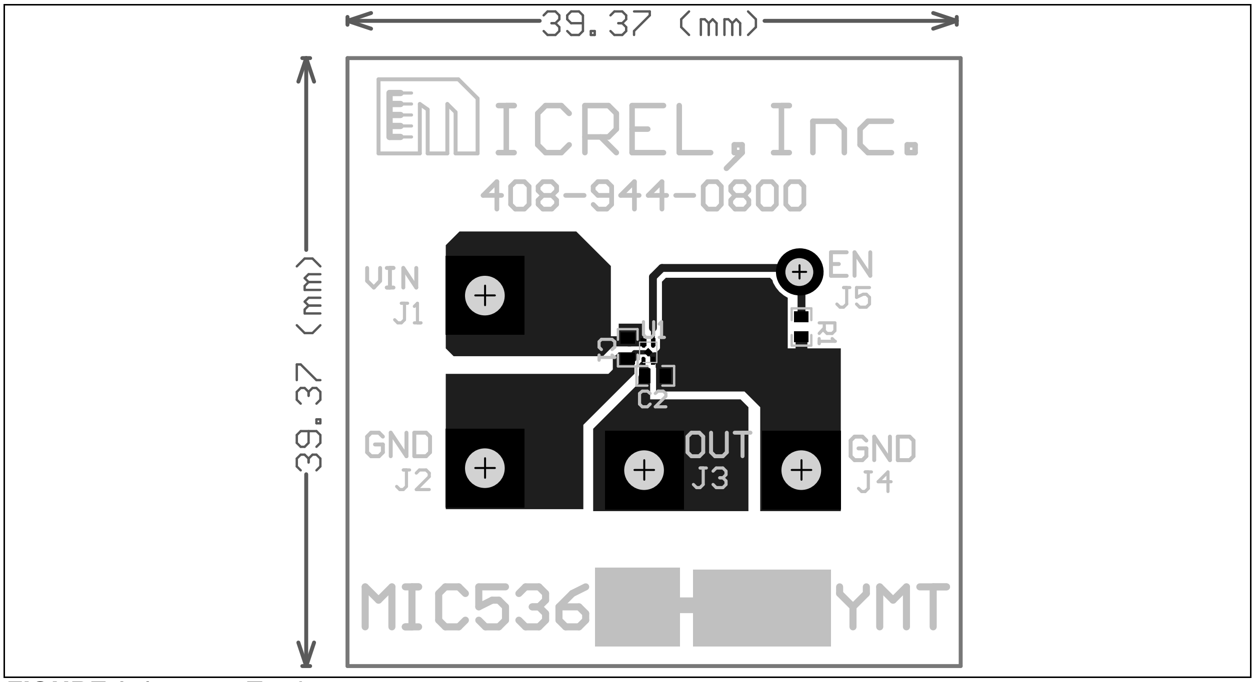


FIGURE 6-1: Top Layer.

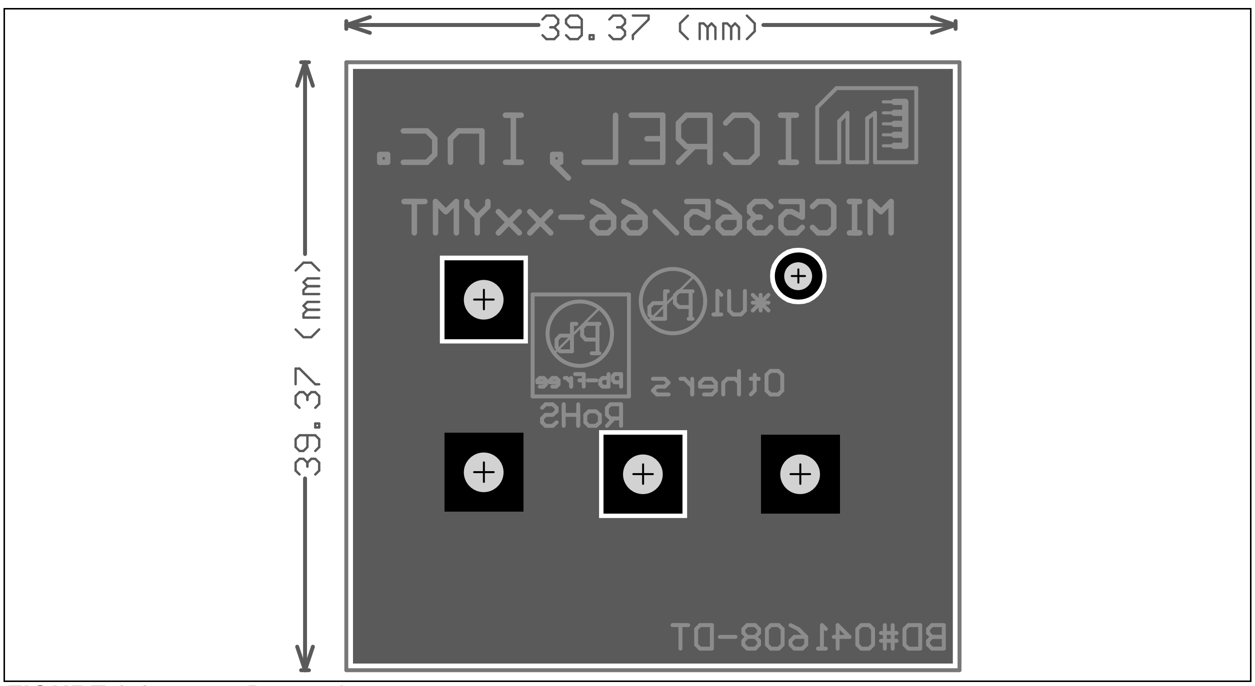
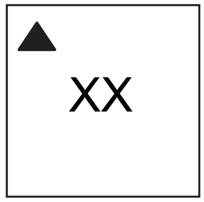


FIGURE 6-2: Bottom Layer.

7.0 PACKAGING INFORMATION

7.1 Package Marking Information

4-Lead UDFN*



Example

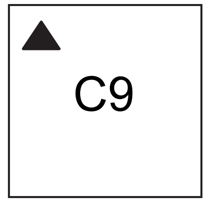


TABLE 7-1: MARKING CODES

Part Number	Marking Code	Output Voltage
MIC5524-1.2YMT	C9	1.2V
MIC5524-1.8YMT	C6	1.8V
MIC5524-2.5YMT	8C	2.5V
MIC5524-2.8YMT	4C	2.8V
MIC5524-3.0YMT	3C	3.0V
MIC5524-3.3YMT	C3	3.3V

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).

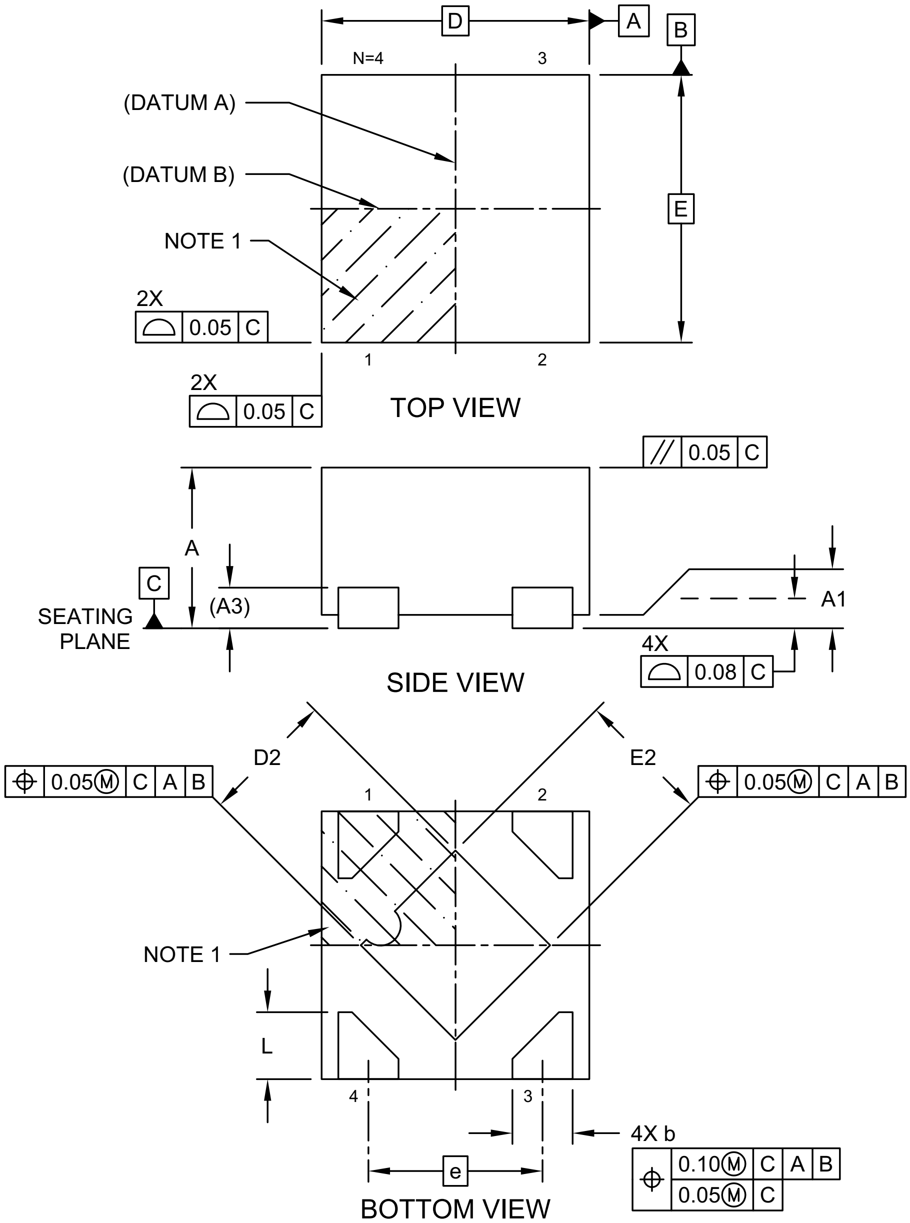
Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.

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

4-Lead Ultra Thin Plastic Dual Flat, No Lead Package (HCA) - 1x1 mm Body [UDFN]

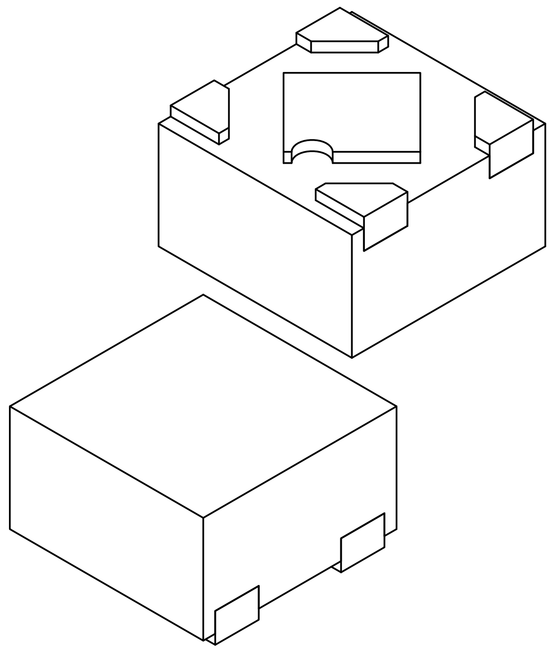
Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Microchip Technology Drawing C04-1149 Rev A Sheet 1 of 2

4-Lead Ultra Thin Plastic Dual Flat, No Lead Package (HCA) - 1x1 mm Body [UDFN]

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		4	
Pitch	e		0.65 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		1.00 BSC	
Exposed Pad Length	D2	0.45	0.50	0.55
Overall Width	E		1.00 BSC	
Exposed Pad Width	E2	0.45	0.50	0.55
Terminal Width	b	0.175	0.225	0.275
Terminal Length	L	0.20	0.25	0.30

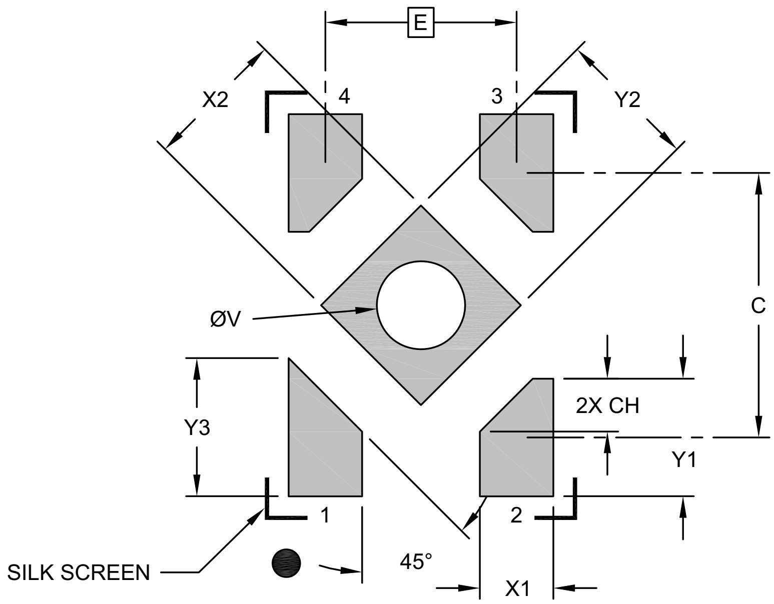
Notes:

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 C04-1149 Rev A Sheet 2 of 2

4-Lead Ultra Thin Plastic Dual Flat, No Lead Package (HCA) - 1x1 mm Body [UDFN]

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		0.65 BSC	
Center Pad Width	X2			0.48
Center Pad Length	Y2			0.48
Contact Pad Spacing	C		0.90	
Contact Pad Width (X4)	X1			0.25
Contact Pad Length (X3)	Y1			0.40
Terminal 1 Pad Length	Y3			0.47
Contact Pad Chamfer (X3)	CH		0.18	
Thermal Via Diameter	V		0.30	

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

Microchip Technology Drawing C04-3149 Rev A

APPENDIX A: REVISION HISTORY

Revision A (September 2022)

- Converted Micrel document MIC5524 to Microchip data sheet DS20006732A.
- Minor text changes throughout.

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	[X]	X	XX	-XX
Device	Output Voltage	Temp. Range	Package	Media Type

Device:	MIC5524:		High-Performance 500 mA LDO
Output Voltage:	1.2	=	1.2V
	1.8	=	1.8V
	2.5	=	2.5V
	2.8	=	2.8V
	3.0	=	3.0V
	3.3	=	3.3V
Temperature Range:	Y	=	–40°C to +125°C
Package:	MT	=	4-Lead 1 mm x 1 mm UDFN
Media Type:	TZ	=	10,000/Reel
	TR	=	5,000/Reel

Examples:

a) MIC5524-1.2YMT-TR: MIC5524, 1.2V Output Voltage, –40°C to +125°C Temp. Range, 4-Lead UDFN, 5,000/Reel

b) MIC5524-1.8YMT-TZ: MIC5524, 1.8V Output Voltage, –40°C to +125°C Temp. Range, 4-Lead UDFN, 10,000/Reel

c) MIC5524-2.5YMT-TR: MIC5524, 2.5V Output Voltage, –40°C to +125°C Temp. Range, 4-Lead UDFN, 5,000/Reel

d) MIC5524-2.8YMT-TZ: MIC5524, 2.8V Output Voltage, –40°C to +125°C Temp. Range, 4-Lead UDFN, 10,000/Reel

e) MIC5524-3.0YMT-TR: MIC5524, 3.0V Output Voltage, –40°C to +125°C Temp. Range, 4-Lead UDFN, 5,000/Reel

f) MIC5524-3.3YMT-TZ: MIC5524, 3.3V Output Voltage, –40°C to +125°C Temp. Range, 4-Lead UDFN, 10,000/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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