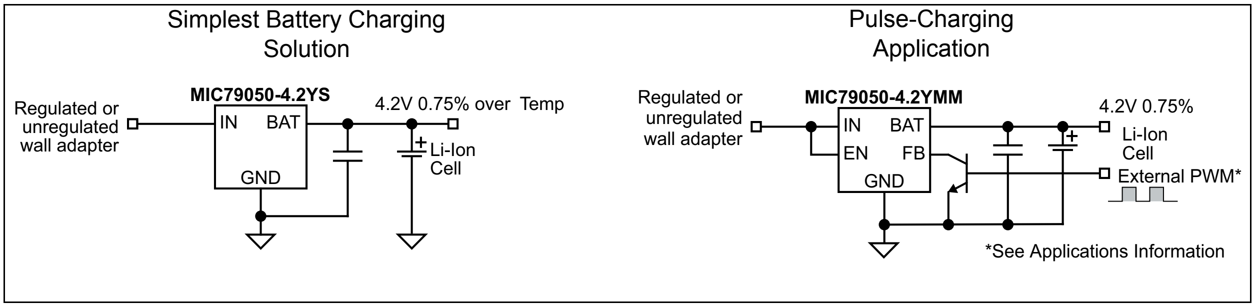
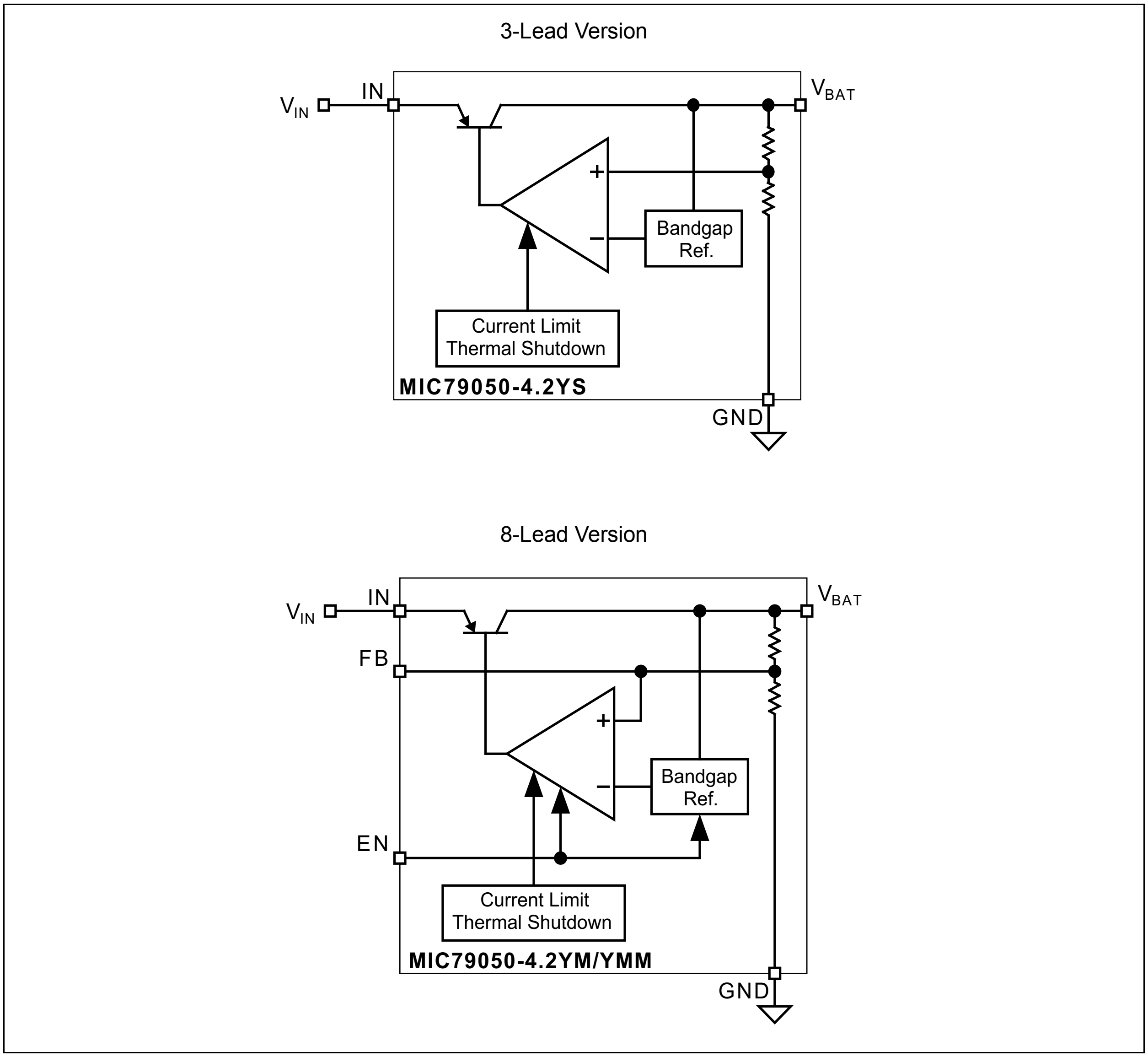
Typical Application Circuits



Functional Block Diagrams



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Input Voltage (V_{IN}) .... –20V to +20V
Power Dissipation (P_D) (Note 1) .... Internally Limited

Operating Ratings ‡

Supply Input Voltage (V_{IN}) .... +2.5V to +16V
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 at any T_A (ambient temperature) is calculated using: $P_{D(max)} = (T_{J(max)} – T_A) ÷ θ_{JA}$. Exceeding the maximum allowable power dissipation will result in excessive die temperature, and the regulator will go into thermal shutdown.

TABLE 1-1: ELECTRICAL CHARACTERISTICS

Electrical Characteristics: $V_{IN} = V_{BAT} + 1.0V$; $C_{OUT} = 4.7 μF$, $I_{OUT} = 100 μA$; $T_J = +25°C$, **bold** values indicate –40°C ≤ T_J ≤ +125°C; unless noted.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Battery Voltage Accuracy	V_{BAT}	–0.75	—	0.75	%	Variation from nominal V_{OUT}, –5°C to +60°C
Battery Voltage Temperature Coefficient	$ΔV_{BAT}/ΔT$	—	**40**	—	ppm/°C	Note 1
Line Regulation	$ΔV_{BAT}/V_{BAT}$	—	0.009	0.05	%/V	$V_{IN} = V_{BAT}$ + 1V to 16V
		—	—	**0.1**		
Load Regulation	$ΔV_{BAT}/V_{BAT}$	—	0.05	0.5	%	I_{OUT} = 100 μA to 500 mA, Note 2
		—	—	**0.7**		
Dropout Voltage (Note 3)	$V_{IN} – V_{BAT}$	—	380	500	mV	I_{OUT} = 500 mA
		—	—	**600**		
Ground Pin Current (Note 4, Note 5)	I_{GND}	—	85	130	μA	V_{EN} ≥ 3.0V, I_{OUT} = 100 μA
		—	—	**170**		
		—	11	20	mA	V_{EN} ≥ 3.0V, I_{OUT} = 500 mA
		—	—	**25**		
Ground Pin Quiescent Current (Note 5)	I_{GND}	—	0.05	**3**	μA	V_{EN} ≤ 0.4V (shutdown)
		—	0.10	**8**		V_{EN} ≤ 0.18V (shutdown)
Ripple Rejection	PSRR	—	75	—	dB	f = 120 Hz
Current Limit	I_{LIMIT}	—	**750**	900	mA	V_{BAT} = 0V
		—	—	**1000**		
Thermal Regulation	$ΔV_{BAT}/ΔP_D$	—	0.05	—	%/W	Note 6
ENABLE Input						
Enable Input Logic-Low Voltage	V_{ENL}	—	0.4	—	V	V_{EN} = logic-low (shutdown)
		—	—	**0.18**		
		2.0	—	—		V_{EN} = logic-high (enabled)

TABLE 1-1: ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: $V_{IN} = V_{BAT} + 1.0V$; $C_{OUT} = 4.7\ \mu F$, $I_{OUT} = 100\ \mu A$; $T_J = +25°C$, **bold** values indicate –40°C ≤ T_J ≤ +125°C; unless noted.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Enable Input Current	I_{ENL}	—	0.01	–1	µA	V_{ENL} ≤ 0.4V (shutdown)
		—	**0.01**	**–2**		V_{ENL} ≤ 0.18V (shutdown)
—	I_{ENH}	—	5	20	µA	V_{ENH} ≥ 2.0V (enabled)
		—	—	**25**		

Note 1: Battery voltage temperature coefficient is the worst case voltage change divided by the total temperature range.

2: Regulation is measured at constant junction temperature using low duty cycle pulse testing. Parts are tested for load regulation in the load range from 100 µA to 500 mA. Changes in output voltage due to heating effects are covered by the thermal regulation specification.

3: Dropout voltage is defined as the input to battery output differential at which the battery voltage drops 2% below its nominal value measured at 1V differential.

4: Ground pin current is the charger quiescent current plus pass transistor base current. The total current drawn from the supply is the sum of the load current plus the ground pin current.

5: V_{EN} is the voltage externally applied to devices with the EN (enable) input pin. MSOP-8 (MM) and SOIC-8 (M) packages only.

6: Thermal regulation is the change in battery voltage at a time "t" after a change in power dissipation is applied, excluding load or line regulation effects. Specifications are for a 500 mA load pulse at V_{IN} = 16V for t = 10 ms.

TEMPERATURE SPECIFICATIONS (Note 1)

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Junction Operating Temperature Range	T_J	–40	—	+125	°C	—
Storage Temperature Range	T_S	–65	—	+150	°C	—
Lead Temperature	—	—	—	+260	°C	Soldering, 5s
Package Thermal Resistances (Note 2)						
Thermal Resistance MSOP-8	θ_{JA}	—	80	—	°C/W	—
Thermal Resistance SOIC-8	θ_{JA}	—	63	—	°C/W	—
Thermal Resistance SOT-223	θ_{JC}	—	15	—	°C/W	—
	θ_{JA}	—	62	—	°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: The maximum allowable power dissipation at any T_A (ambient temperature) is calculated using: $P_{D(max)} = (T_{J(max)} - T_A) \div \theta_{JA}$. Exceeding the maximum allowable power dissipation will result in excessive die temperature, and the regulator will go into thermal shutdown.

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.

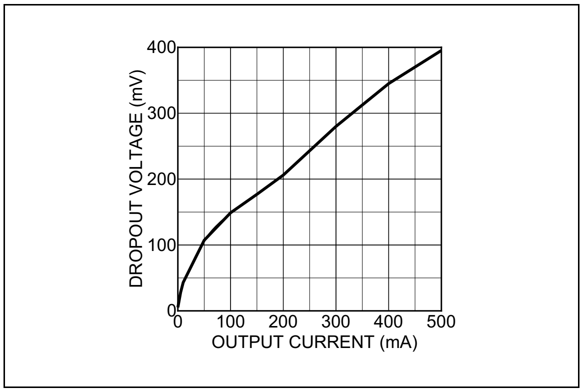


FIGURE 2-1: *Dropout Voltage vs. Output Current.*

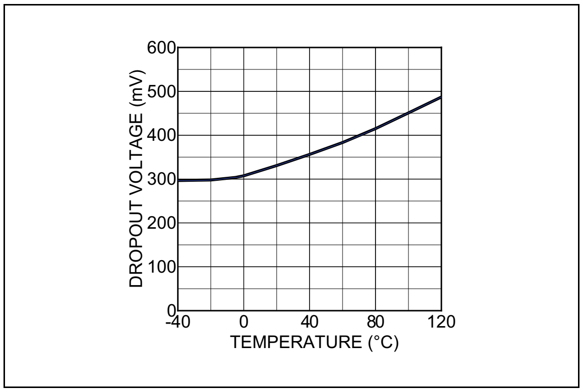


FIGURE 2-2: *Dropout Voltage vs. Temperature.*

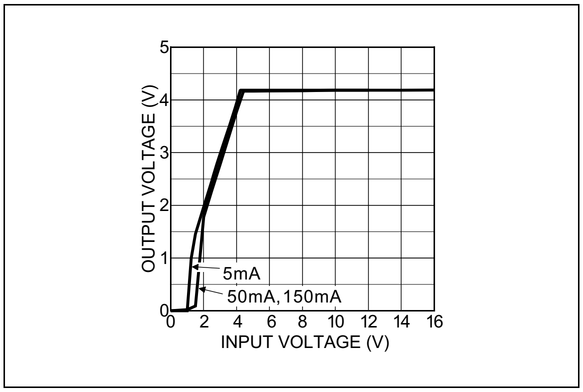


FIGURE 2-3: *Dropout Characteristics.*

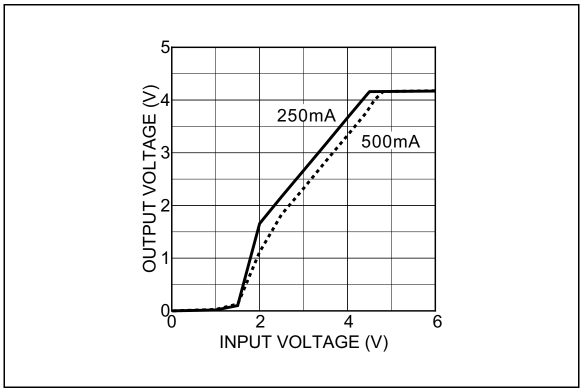


FIGURE 2-4: *Dropout Characteristics.*

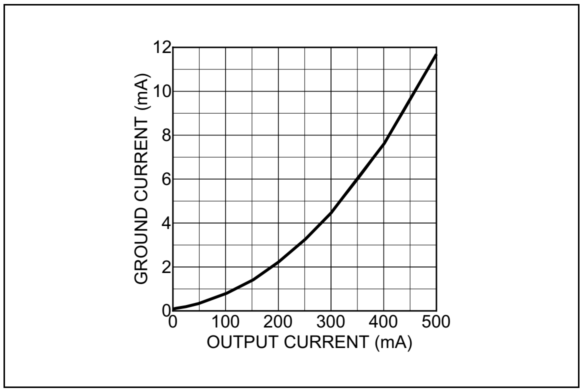


FIGURE 2-5: *Output Current vs. Ground Current.*

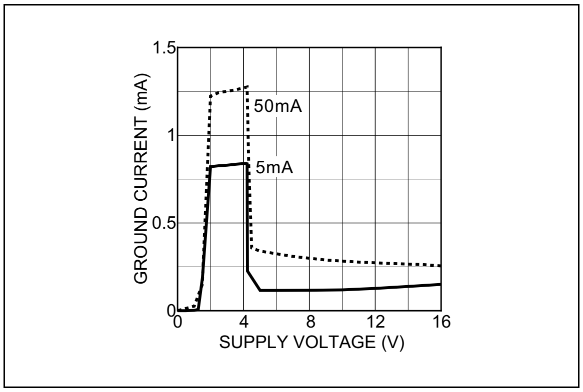


FIGURE 2-6: *Ground Current vs. Supply Voltage.*

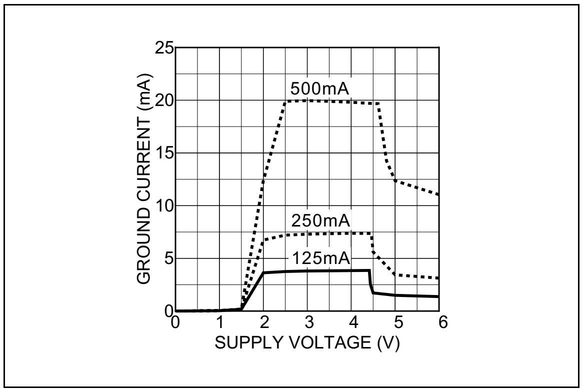


FIGURE 2-7: Ground Current vs. Supply Voltage.

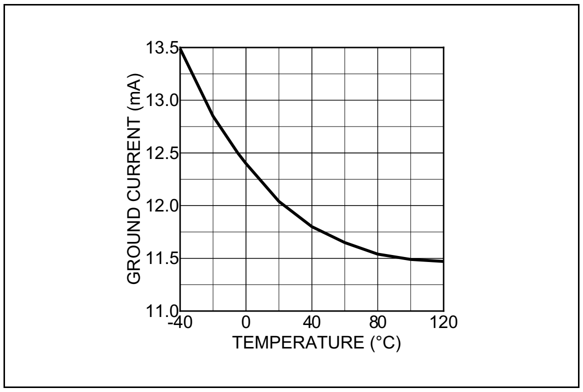


FIGURE 2-10: Ground Current vs. Temperature.

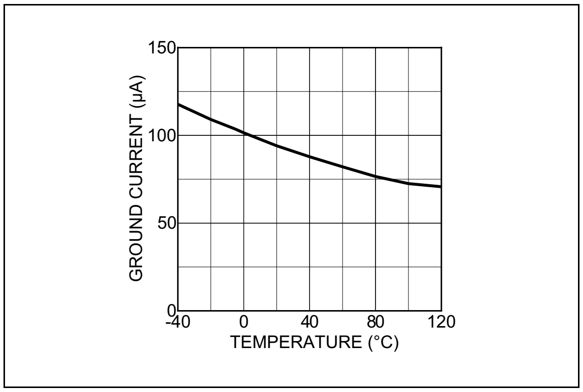


FIGURE 2-8: Ground Current vs. Temperature.

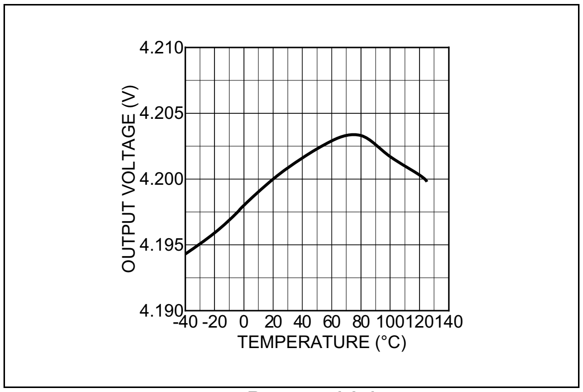


FIGURE 2-11: Battery Voltage vs. Temperature.

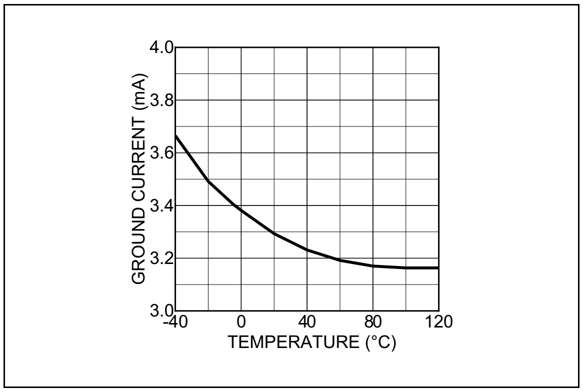


FIGURE 2-9: Ground Current vs. Temperature.

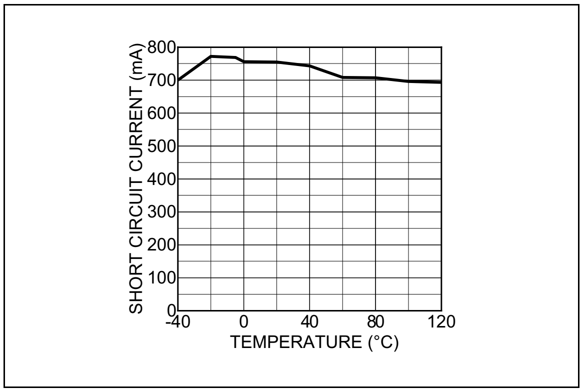


FIGURE 2-12: Short-Circuit Current vs. Temperature.

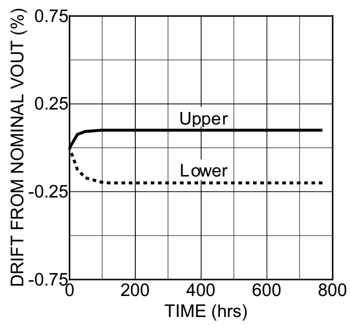


FIGURE 2-13: *Typical Voltage Drift Limits vs. Time.*

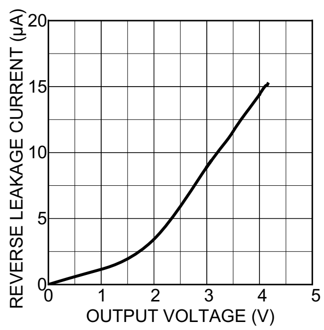


FIGURE 2-14: *Reverse Leakage Current vs. Output Voltage.*

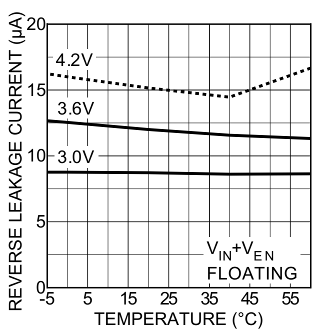


FIGURE 2-15: *Reverse Leakage Current vs. Output Voltage.*

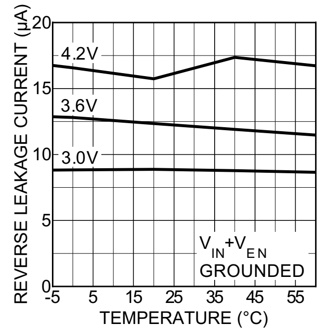


FIGURE 2-16: *Reverse Leakage Current vs. Temperature.*

3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 3-1.

TABLE 3-1: PIN FUNCTION TABLE

Pin Number SOT-223	Pin Number SOIC-8, MSOP-8	Pin Name	Description
1	2	IN	Supply input.
2, TAB	5, 6, 7, 8	GND	Ground: SOT-223 pin 2 and TAB are internally connected. SOIC-8 pins 5 through 8 are internally connected.
3	3	BAT	Battery voltage output.
—	1	EN	Enable (Input): TTL/CMOS-compatible control input. Logic-high = enable; logic-low or open = shutdown.
—	4	FB	Feedback node.

4.0 FUNCTIONAL DESCRIPTION

The MIC79050 is a high-accuracy, linear battery charging circuit designed for the simplest implementation of a single lithium-ion (Li-ion) battery charger. The part can operate from a regulated or unregulated power source, making it ideal for various applications. The MIC79050 can take an unregulated voltage source and provide an extremely accurate termination voltage. The output voltage varies only 0.75% from nominal over the standard temperature range for Li-ion battery charging (–5°C to +60°C). With a minimum of external components, an accurate constant-current charger can be designed to provide constant-current, constant-voltage charging for Li-ion cells.

4.1 Input Voltage

The MIC79050 can operate with an input voltage up to 16V (20V absolute maximum), ideal for applications where the input voltage can float high, such as an unregulated wall adapter that obeys a load-line. Higher voltages can be sustained without any performance degradation to the output voltage. The line regulation of the device is typically 0.009%/V; that is, a 10V change on the input voltage corresponds to a 0.09% change in output voltage.

4.2 Enable

The MIC79050 has an enable pin that allows the charger to be disabled when the battery is fully charged and the current drawn by the battery has approached a minimum and/or the maximum charging time has timed out. When disabled, the regulator output sinks a minimum of current with the battery voltage applied directly onto the output. This current is typically 12 µA or less.

4.3 Feedback

The feedback pin allows for external manipulation of the control loop. This node is connected to an external resistive divider network, which is connected to the internal error amplifier. This amplifier compares the voltage at the feedback pin to an internal voltage reference. The loop then corrects for changes in load current or input voltage by monitoring the output voltage and linearly controlling the drive to the large, PNP pass element. By externally controlling the voltage at the feedback pin the output can be disabled or forced to the input voltage. Pulling and holding the feedback pin low forces the output low. Holding the feedback pin high forces the pass element into saturation, where the output will be the input minus the saturation (dropout) voltage.

4.4 Battery Output

The BAT pin is the output of the MIC79050 and connects directly to the cell to provide charging current and voltage. When the input is left floating or grounded, the BAT pin limits reverse current to <12 µA to minimize battery drain.

5.0 APPLICATIONS INFORMATION

5.1 Simple Lithium-Ion Battery Charger

Figure 5-1 shows a simple, complete lithium-ion battery charger. The charging circuit comprises of a cheap wall adapter, with a load-line characteristic. This characteristic is always present with cheap adapters due to the internal impedance of the transformer windings. The load-line of the unregulated output should be less than 4.4V to 4.6V at somewhere between 0.5C to 1C of the battery under charge. This 4.4 to 4.6V value is an approximate number based on the headroom needed above 4.2V for the MIC79050 to operate correctly. In other words, for a 500 mAh battery, the output of the semi-regulated supply should be between 225 mA to 500 mA (0.5C to 1C). If it is below 225 mA no damage will occur but the battery will take longer to charge. Figure 5-2 shows a typical wall adapter characteristic with an output current of 350 mA at 4.5V. This natural impedance of the wall adapter will limit the maximum current into the battery, so no external circuitry is needed to accomplish this.

If extra impedance is needed to achieve the desired load-line, extra resistance can easily be added in series with the MIC79050 IN pin.

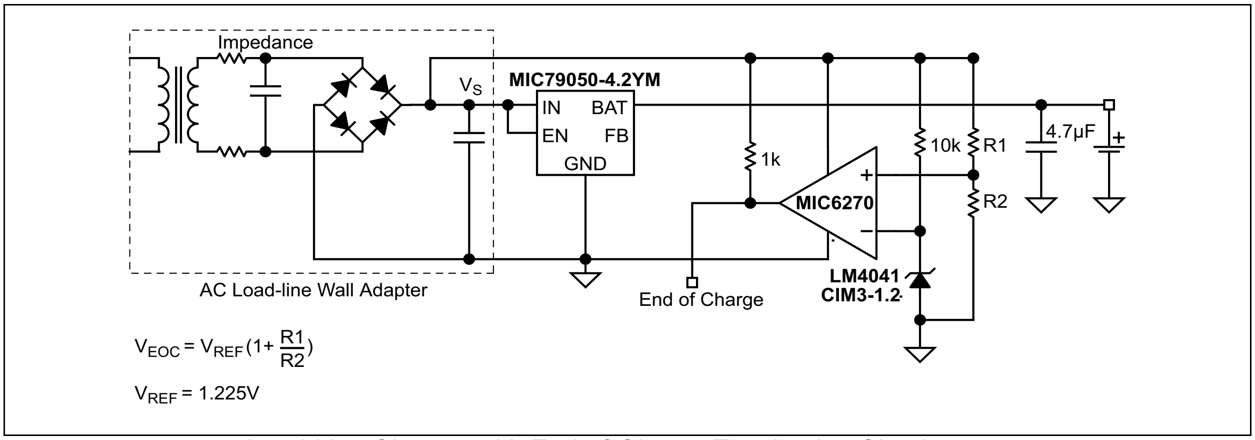


FIGURE 5-1: Load-Line Charger with End-of-Charge Termination Circuit.

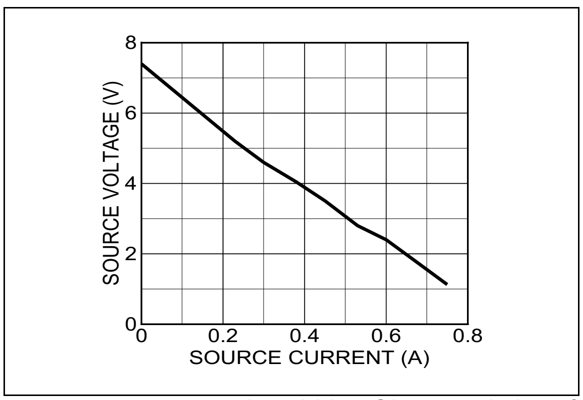


FIGURE 5-2: Load-Line Characteristics of AC Wall Adapter.

5.2 The Charging Cycle

See Figure 5-3.

State A: Initial charge. Here the battery's charging current is limited by the wall adapter's natural impedance. The battery voltage approaches 4.2V.

State B: Constant voltage charge. Here the battery voltage is at 4.2V ±0.75% and the current is decaying in the battery. When the battery has reached approximately 1/10th of its 1C rating, the battery is considered to have reached full charge. Because of the natural characteristic impedance of the cheap wall adapters, as the battery current decreases so the input voltage increases. The MIC6270 and the LM4041 are configured as a simple voltage monitor, indicating when the input voltage has reached such a level so the current in the battery is low, indicating full charge.

State C: End of charge cycle. When the input voltage, V_S reaches V_{EOC}, an end of charge signal is indicated.

State D: Top up charge. As soon as enough current is drawn out of the input source, which pulls the voltage lower than the V_{EOC}, the end of charge flag will be pulled low and charging will initiate.

Variations on this scheme can be implemented, such as the circuit shown in Figure 5-4.

For those designs that have a zero impedance source, see Figure 5-5.

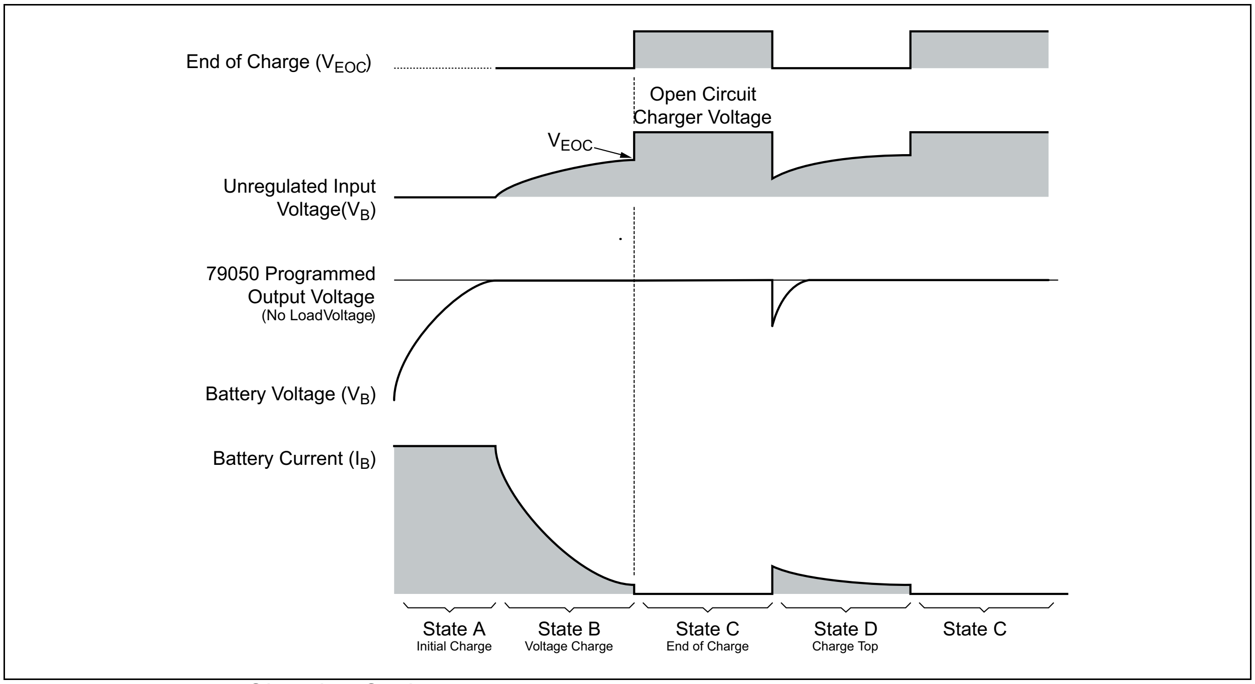


FIGURE 5-3: Charging Cycles.

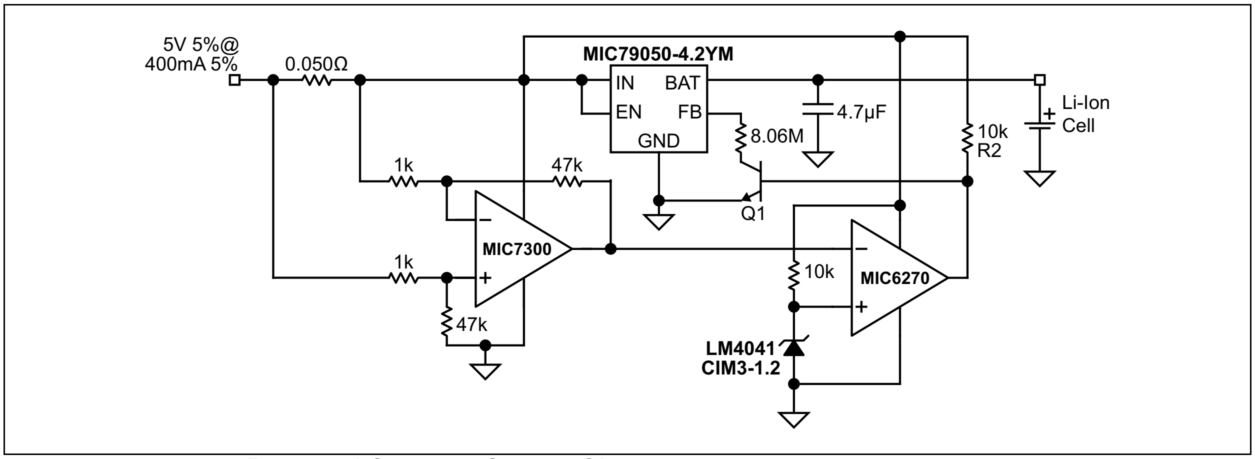


FIGURE 5-4: Protected Constant-Current Charger.

5.3 Protected Constant-Current Charger

Another form of charging is using a simple wall adapter that offers a fixed voltage at a controlled, maximum current rating. The output of a typical charger will source a fixed voltage at a maximum current unless that maximum current is exceeded. In the event that the maximum current is exceeded, the voltage will drop while maintaining that maximum current. Using an MIC79050 after this type of charger is ideal for lithium-ion battery charging. The only obstacle is end of charger termination. Using a simple differential amplifier and a similar comparator and reference circuit, similar to Figure 5-1, completes a single cell lithium-ion battery charger solution.

Figure 5-4 shows this solution in completion. The source is a fixed 5V source capable of a maximum of 400 mA of current. When the battery demands full current (fast charge), the source will provide only 400 mA and the input will be pulled down. The output of the MIC79050 will follow the input minus a small voltage drop. When the battery approaches full charge, the current will taper off. As the current across R_S approaches 50 mA, the output of the differential amplifier (MIC7300) will approach 1.225V, the reference voltage set by the LM4041. When it drops below the reference voltage, the output of the comparator (MIC6270) will allow the base of Q1 to be pulled high through R2.

5.4 Zero-Output Impedance Source Charging

Input voltage sources that have very low output impedances can be a challenge due to the nature of the source. Using the circuit in Figure 5-5 will provide a constant-current and constant voltage charging algorithm with the appropriate end-of-charge termination. The main loop consists of an op-amp controlling the feedback pin through the schottky diode, D1. The charge current through R_S is held constant by the op-amp circuit until the output draws less than the set charge-current. At this point, the output goes constant-voltage. When the current through R_S gets to less than 50 mA, the difference amp output becomes less than the reference voltage of the MIC834 and the output pulls low. This sets the output of the MIC79050 less than nominal, stopping current flow and terminating charge.

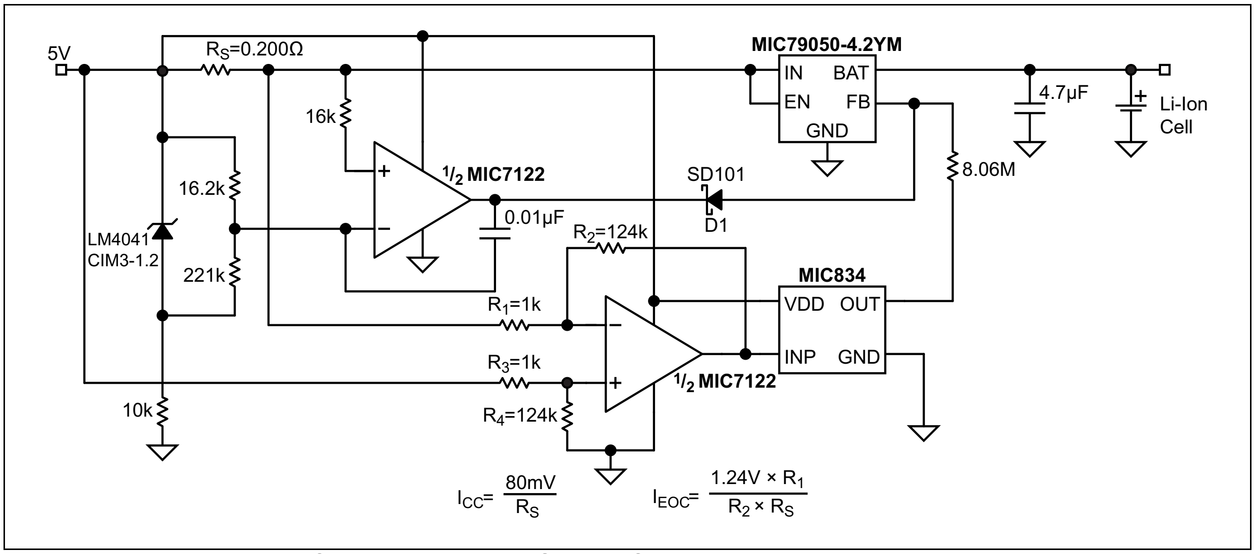


FIGURE 5-5: *Zero-Output Impedance Source Charging.*

5.5 Lithium-Ion Battery Charging

Single lithium-ion cells are typically charged by providing a constant current and terminating the charge with constant voltage. The charge cycle must be initiated by ensuring that the battery is not in deep discharge. If the battery voltage is below 2.5V, it is commonly recommended to trickle charge the battery with 5 mA to 10 mA of current until the output is above 2.5V. At this point, the battery can be charged with constant current until it reaches its top off voltage (4.2V for a typical single lithium-ion cell) or a time-out occurs.

For the constant-voltage portion of the charging circuit, an extremely accurate termination voltage is highly recommended. The higher the accuracy of the termination circuit, the more energy the battery will store. Because lithium-ion cells do not exhibit a memory effect, less accurate termination does not harm the cell, but simply stores less usable energy in the battery. The charge cycle is completed by disabling the charge circuit after the termination current drops below a minimum recommended level, typically 50 mA or less, depending on the manufacturer's recommendation, or if the circuit times out.

5.6 Time-Out

The time-out aspect of lithium-ion battery charging can be added as a safety feature of the circuit. Often times this function is incorporated in the software portion of an application using a real-time clock to count out the maximum amount of time allowed in the charging cycle. When the maximum recommended charge time for the specific cell has been exceeded, the enable pin of the MIC79050 can be pulled low, and the output will float to the battery voltage, no longer providing current to the output.

As a second option, the feedback pin of the MIC79050 can be modulated as in Figure 5-6. It shows a simple circuit where the MIC834, an integrated comparator and reference, monitors the battery voltage and disables the MIC79050 output after the voltage on the battery exceeds a set value. When the voltage decays below this set threshold, the MIC834 drives Q1 low allowing the MIC79050 to turn on again and provide current to the battery until it is fully charged. This form of pulse charging is an acceptable way of maintaining the full charge on a cell until it is ready to be used.

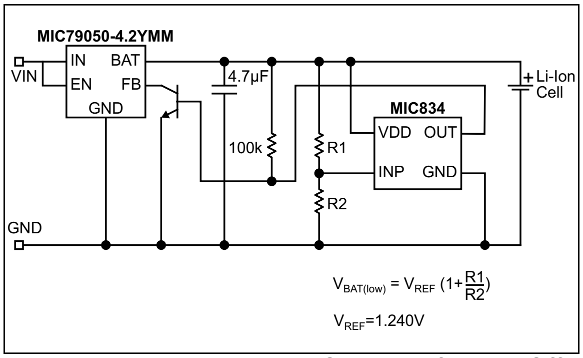


FIGURE 5-6: *Pulse Charging for Top-Off Voltage.*

5.7 Charging Rate

Lithium-ion cells are typically charged at rates that are fractional multiples of their rated capacity. The maximum varies between 1C and 1.3C (1× to 1.3× the capacity of the cell). The MIC79050 can be used for any cell size. The size of the cell and the current capability of the input source will determine the overall circuit charge rate. For example, a 1200 mAh battery charged with the MIC79050 can be charged at a maximum of 0.5C. There are no adverse effects to charging at lower charge rates; that charging will just take longer. Charging at rates greater than 1C are not recommended, nor do they decrease the charge time linearly.

The MIC79050 is capable of providing 500 mA of current at its nominal rated output voltage of 4.2V. If the input is brought below the nominal output voltage, the output will follow the input, less the saturation voltage drop of the pass element. If the cell draws more than the maximum output current of the device, the output will be pulled low, charging the cell at 600 mA to 700 mA current. If the input is a fixed source with a low output impedance, this could lead to a large drop across the MIC79050 and excess heating. By driving the feedback pin with an external PWM circuit, the MIC79050 can be used to pulse charge the battery to reduce power dissipation and bring the device and the entire unit down to a lower operating temperature. Figure 5-7 and Figure 5-8 show typical configurations for PWM-based pulse-charging topologies. Figure 5-7 uses an external PWM signal to control the charger, while Figure 5-8 uses the MIC4417 as a low duty cycle oscillator to drive the base of Q1. Consult the battery manufacturer for optimal pulse-charging techniques.

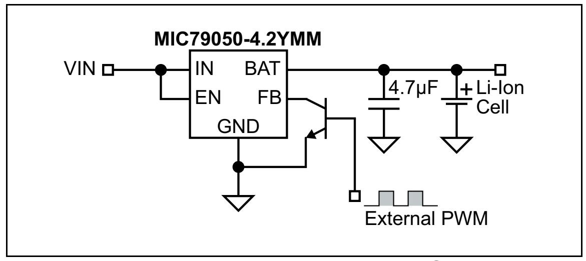


FIGURE 5-7: *External PWM Circuit Design.*

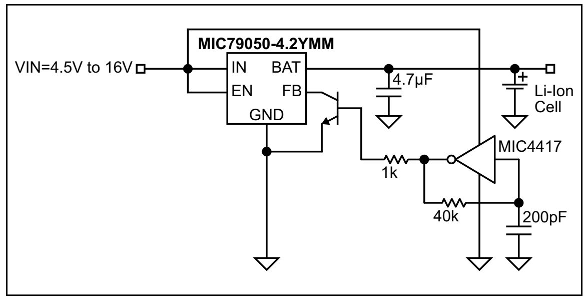


FIGURE 5-8: *PWM-Based Pulse Charging Using an MIC4417.*

Figure 5-9 shows another application to increase the output current capability of the MIC79050. By adding an external PNP power transistor, higher output current can be obtained while maintaining the same accuracy. The internal PNP now becomes the driver of a darlington array of PNP transistors, obtaining much higher output currents for applications where the charge rate of the battery is much higher.

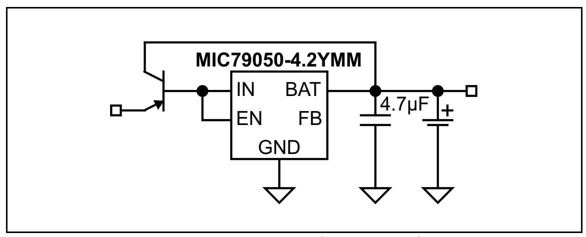


FIGURE 5-9: *High-Current Charging.*

5.8 Regulated Input Source Charging

When providing a constant-current, constant-voltage, charger solution from a well-regulated adapter circuit, the MIC79050 can be used with external components to provide a constant voltage, constant-current charger solution. Figure 5-10 shows a configuration for a high-side battery charger circuit that monitors input current to the battery and allows a constant current charge that is accurately terminated with the MIC79050. The circuit works best with smaller batteries, charging at C rates in the 300 mA to 500 mA range. The MIC7300 op-amp compares the drop across a current sense resistor and compares that to a high-side voltage reference, the LM4041, pulling the feedback pin low when the circuit is in the constant-current mode. When the current through the resistor drops and the battery gets closer to full charge, the output of the op-amp rises and allows the internal feedback network of the regulator take over, regulating the output to 4.2V.

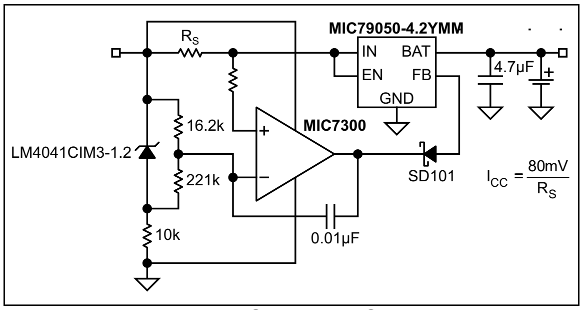


FIGURE 5-10: Constant-Current, Constant-Voltage Charger.

5.9 Simple Charging

The MIC79050 is available in a three-terminal package, allowing for extremely simple battery charging. When used with a current-limited, low-power input supply, the MIC79050-4.2YS completes a very simple, low-charge-rate, battery-charger circuit. It provides the accuracy required for termination, while a current-limited input supply offers the constant-current portion of the algorithm.

5.10 Thermal Considerations

The MIC79050 is offered in three packages for the various applications. The SOT-223 is most thermally efficient of the three packages, with the power SOIC-8 and the power MSOP-8 following suit.

5.10.1 POWER SOIC-8 THERMAL CHARACTERISTICS

One of the secrets of the MIC79050's performance is its power SOIC-8 package that features half the thermal resistance of a standard SOIC-8 package. Lower thermal resistance means more output current or higher input voltage for a given package size.

Lower thermal resistance is achieved by joining the four ground leads with the die attach paddle to create a single-piece electrical and thermal conductor. This concept has been used by MOSFET manufacturers for years, proving very reliable and cost effective for the user.

Thermal resistance consists of two main elements, θ_{JC}, or thermal resistance junction to case and θ_{CA}, thermal resistance case to ambient (Figure 5-11). θ_{JC} is the resistance from the die to the leads of the package. θ_{CA} is the resistance from the leads to the ambient air and it includes θ_{CS}, thermal resistance case to sink, and θ_{SA}, thermal resistance sink to ambient. Using the power SOIC-8 reduces the θ_{JC} dramatically and allows the user to reduce θ_{CA}. The total thermal resistance, θ_{JA}, junction to ambient thermal resistance, is the limiting factor in calculating the maximum power dissipation capability of the device. Typically, the power SOIC-8 has a θ_{JC} of 20°C/W, this is significantly lower than the standard SOIC-8, which is typically 75°C/W. θ_{CA} is reduced because pins 5-8 can now be soldered directly to a ground plane, which significantly reduces the case to sink thermal resistance and sink to ambient thermal resistance.

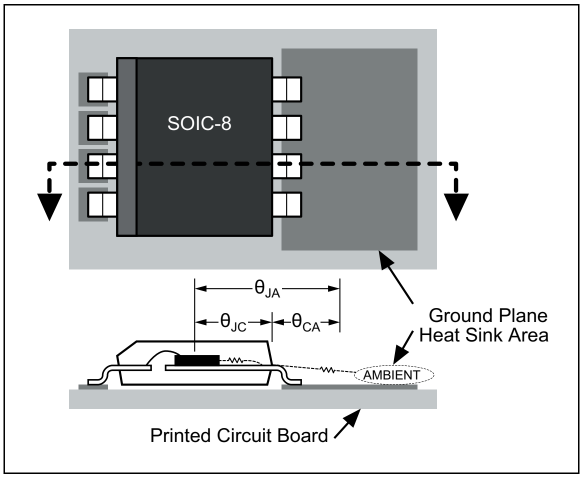


FIGURE 5-11: Thermal Resistance.

The MIC79050 is rated to a maximum junction temperature of +125°C. It is important not to exceed this maximum junction temperature during operation of the device. To prevent this maximum junction temperature from being exceeded, the appropriate ground plane heat sink must be used.

Figure 5-12 shows curves of copper area versus power dissipation, each trace corresponding to different temperature rises above ambient. From these curves, the minimum area of copper necessary for the part to operate safely can be determined. The maximum allowable temperature rise must be calculated to determine operation along which curve.

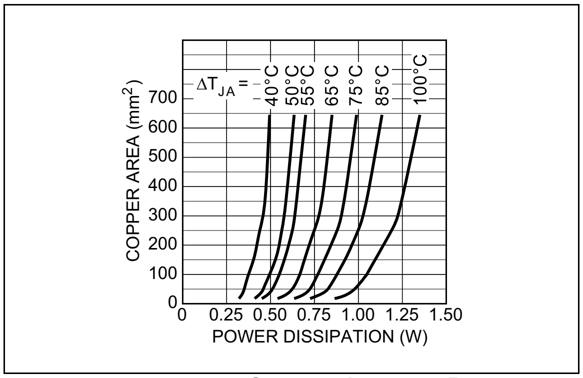


FIGURE 5-12: Copper Area vs. Power SOIC Power Dissipation (ΔT_{JA}).

ΔT is calculated by taking the maximum junction temperature and subtracting the maximum ambient operating temperature.

For example, if the maximum ambient temperature is +40°C, the ΔT is determined as follows:

EQUATION 5-1:

$$\Delta T = 125°C - 40°C = 85°C$$

Using Figure 5-12, the minimum amount of required copper can be determined based on the required power dissipation. Power dissipation in a linear regulator is calculated as follows:

EQUATION 5-2:

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

For example, using the charging circuit in Figure 5-10, assume the input is a fixed 5V and the output is pulled down to 4.2V at a charge current of 500 mA. The power dissipation in the MIC79050 is calculated as follows:

EQUATION 5-3:

$$P_D = (5V - 4.2V) \times 0.5A + 5V \times 0.012A = 0.460W$$

From Figure 5-12, the minimum amount of copper required to operate this application at a ΔT of +85°C is less than 50 mm^2.

5.10.2 QUICK METHOD

Determine the power dissipation requirements for the design along with the maximum ambient temperature at which the device will be operated. Refer to Figure 5-13, which shows safe operating curves for three different ambient temperatures: +25°C, +50°C, and +85°C. From these curves, the minimum amount of copper can be determined by knowing the maximum power dissipation required. If the maximum ambient temperature is +40°C and the power dissipation is as above, 0.46W, the curve in Figure 5-13 shows that the required area of copper is 50 mm^2.

The θ_{JA} of this package is ideally 63°C/W, but it will vary depending upon the availability of copper ground plane to which it is attached.

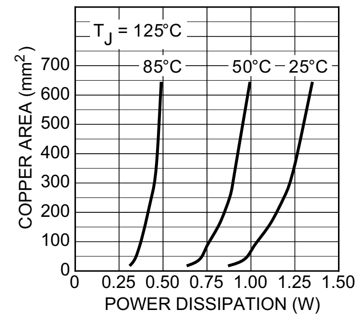


FIGURE 5-13: *Copper Area vs. Power SOIC Power Dissipation (T_A).*

5.10.3 POWER MSOP-8 THERMAL CHARACTERISTICS

The power MSOP-8 package follows the same idea as the power SOIC-8 package, using four ground leads with the die-attach paddle to create a single-piece electrical and thermal conductor, reducing thermal resistance and increasing power dissipation capability.

The same method of determining the heat sink area used for the power SOIC-8 can be applied directly to the power MSOP-8. The same two curves showing power dissipation versus copper area are reproduced for the power-MSOP-8 and they can be applied identically.

5.10.4 QUICK METHOD

Determine the power dissipation requirements for the design along with the maximum ambient temperature at which the device will be operated. Refer to Figure 5-15, which shows safe operating curves for three different ambient temperatures, +25°C, +50°C, and +85°C. From these curves, the minimum amount of copper can be determined by knowing the maximum power dissipation required. If the maximum ambient temperature is +25°C and the power dissipation is 1W, the curve in Figure 5-15 shows that the required area of copper is 500 mm^2, when using the power MSOP-8.

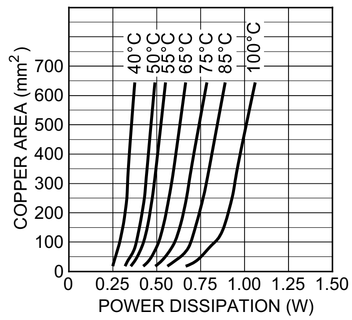


FIGURE 5-14: *Copper Area vs. Power MSOP Power Dissipation (ΔT_{JA}).*

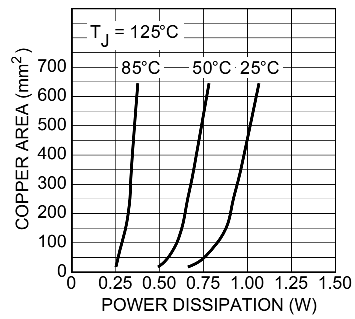
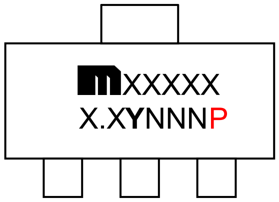


FIGURE 5-15: *Copper Area vs. Power MSOP Power Dissipation (T_A).*

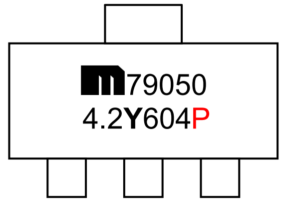
6.0 PACKAGING INFORMATION

6.1 Package Marking Information

3-Lead SOT-223*

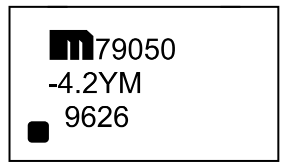


Example

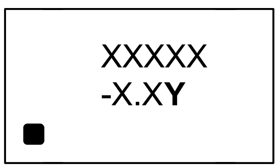


8-Lead SOIC*

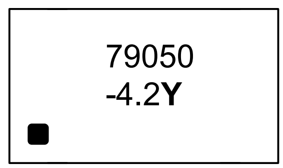
Example



8-Lead MSOP*



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).

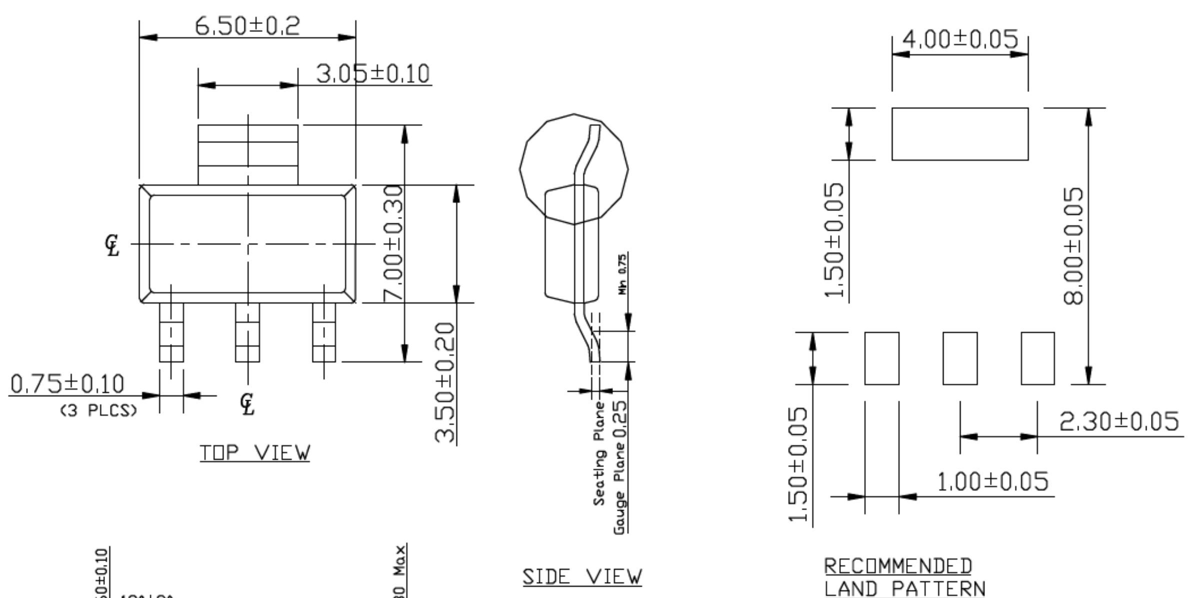
Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.

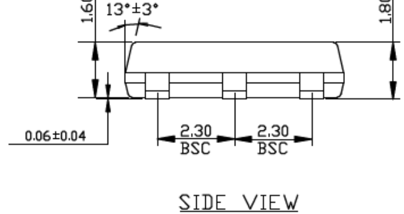
Underbar (_) and/or Overbar (‾) symbol may not be to scale.

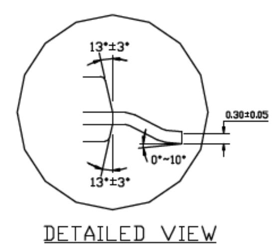
3-Lead SOT-223 Package Outline and Recommended Land Pattern

TITLE
3 LEAD SOT223 PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

DRAWING #	SOT223-3LD-PL-1	**UNIT**	MM







NOTE:

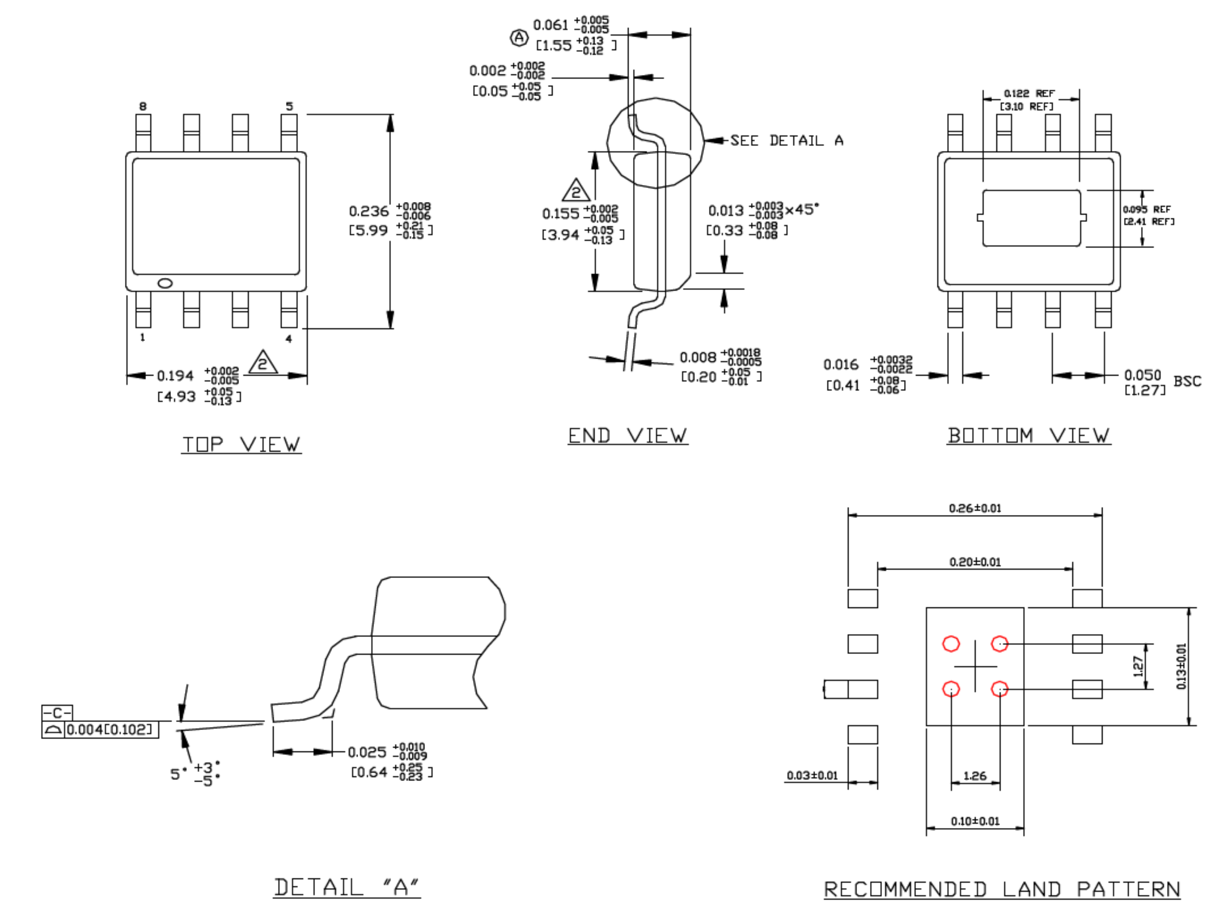
1. Dimensions and tolerances are as per ANSI Y14.5M, 1982.
2. Controlling dimension: Millimeters.
3. Dimensions are exclusive of mold flash and gate burr.
4. All specification comply to Jedec spec TO261 Issue C.

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

8-Lead SOIC Package Outline and Recommended Land Pattern

TITLE
8 LEAD SOICN EPAD PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

DRAWING #	SOICNEP-8LD-PL-1	**UNIT**	INCH [MM]



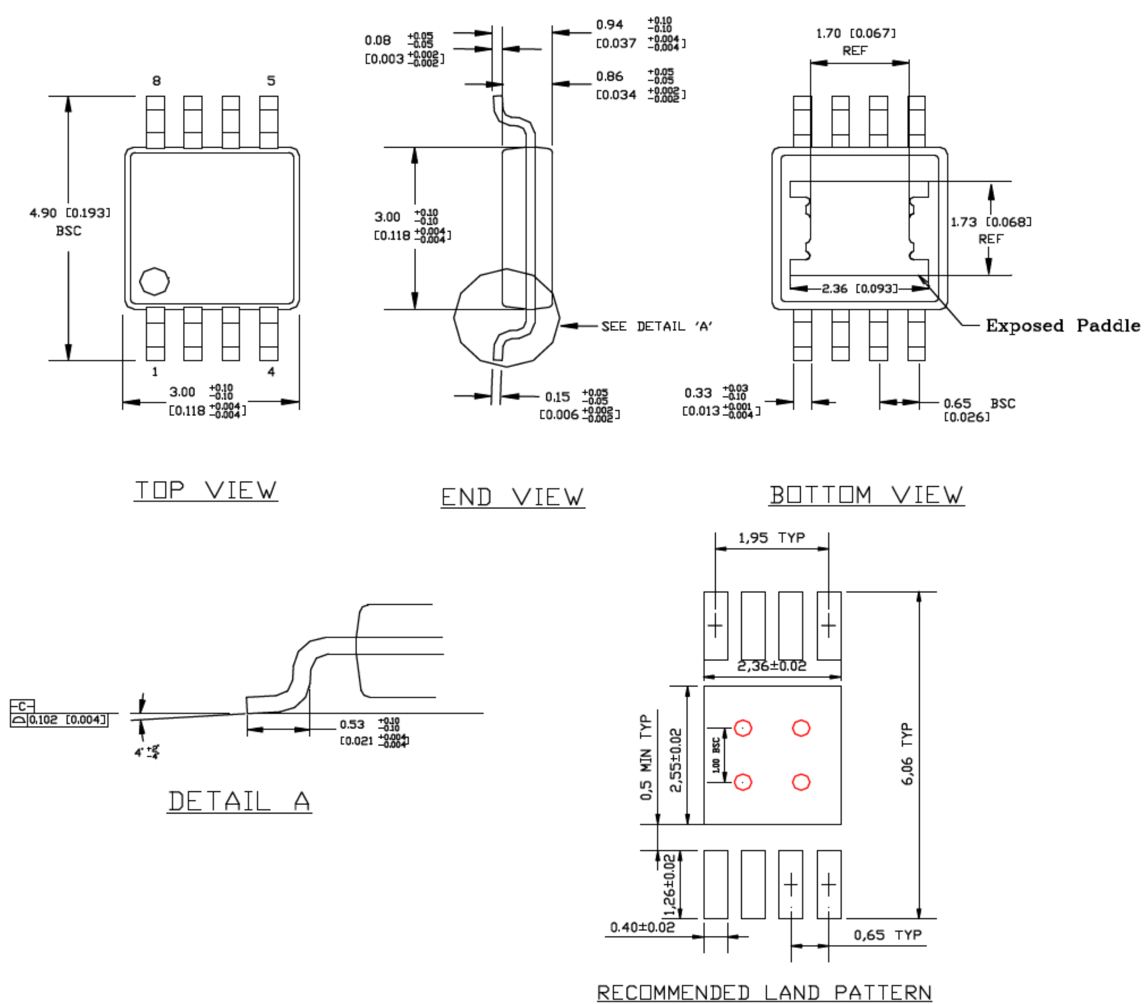
NOTE:
1. DIMENSION DOES NOT INCLUDE MOLD FLASH OR PROTRUSIONS, EITHER OF WHICH SHALL EXCEED 0.006 INCHES PER SIDE
2. RED CIRCLES IN LAND PATTERN REPRESENT THERMAL VIAS. RECOMMENDED SIZE IS 0.30-0.30MM IN DIAMETER AND SHOULD BE CONNECTED TO GND FOR MAXIMUM THERMAL PERFORMANCE

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

8-Lead MSOP Package Outline and Recommended Land Pattern

TITLE
8 LEAD MSOP EPAD PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

DRAWING #	MSOPEP-8LD-PL-1	UNIT	MM [INCH]



NOTE:
1. DIMENSION DOES NOT INCLUDE MOLD FLASH OR PROTRUSIONS, EITHER OF WHICH SHALL NOT EXCEED 0.20 [0.008] PER SIDE
2. RED CIRCLES IN LAND PATTERN REPRESENT THERMAL VIAS. RECOMMENDED SIZE IS 0.30-0.35MM IN DIAMETER, 1.00 PITCH AND SHOULD BE CONNECTED TO GND FOR MAXIMUM PERFORMANCE

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

NOTES:

APPENDIX A: REVISION HISTORY

Revision A (July 2017)

- Converted Micrel document MIC79050 to Microchip data sheet DS20005771A.
- 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 NO.	–X.X	X	XX	–XX
Device	Voltage	Temperature	Package	Media Type

Device:	MIC79050:		Simple Lithium-Ion Battery Charger
Voltage:	4.2	=	4.2V
Temperature:	Y	=	–40°C to +125°C
Package:	S	=	3-Lead SOT-223
	M	=	8-Lead SOIC
	MM	=	8-Lead MSOP
Media Type:	<blank>	=	78/Tube (SOT-223)
	<blank>	=	95/Tube (SOIC)
	<blank>	=	100/Tube (MSOP)
	TR	=	2,500/Reel (All Packages)

Examples:

a) MIC79050-4.2YS: Simple Lithium-Ion Battery Charger, 4.2V, –40°C to +125°C, 3-Lead SOT-223, 78/Tube

b) MIC79050-4.2YS-TR: Simple Lithium-Ion Battery Charger, 4.2V, –40°C to +125°C, 3-Lead SOT-223, 2,500/Reel

c) MIC79050-4.2YM: Simple Lithium-Ion Battery Charger, 4.2V, –40°C to +125°C, 8-Lead SOIC, 95/Tube

d) MIC79050-4.2YM-TR: Simple Lithium-Ion Battery Charger, 4.2V, –40°C to +125°C, 8-Lead SOIC, 2,500/Reel

e) MIC79050-4.2YMM: Simple Lithium-Ion Battery Charger, 4.2V, –40°C to +125°C, 8-Lead MSOP, 100/Tube

f) MIC79050-4.2YMM-TR: Simple Lithium-Ion Battery Charger, 4.2V, –40°C to +125°C, 8-Lead MSOP, 2,500/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.

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