National Semiconductor

LM2579 Switching Regulator

General Description

The LM2579 can easily be used in switching regulator configurations, such as the buck, boost, and inverting, to perform DC-to-DC voltage conversion. The LM2579 features a unique comparator input stage which not only has separate pins for both the inverting and non-inverting inputs, but also provides an internal 1.0V reference to each input, thereby simplifying circuit design and p.c. board layout. The output can switch up to 3A and has output pins for both its collector and emitter to promote design flexibility. An external current limit terminal may be referenced to either the ground or the V_{IN} terminal, depending upon the application. In addition, the LM2579 has an onboard oscillator, which sets the switching frequency with a single external capacitor, from <1 Hz to 100 kHz (typical).

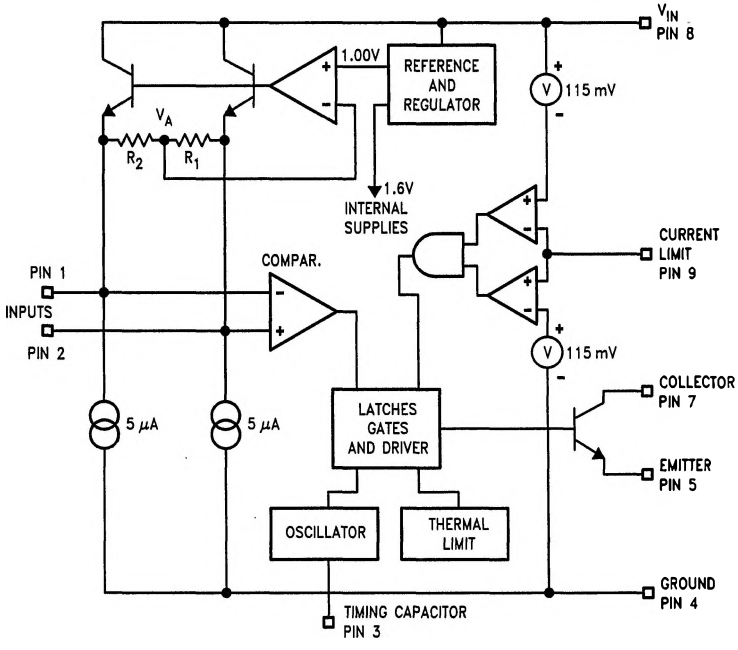
Features

- Inverting and non-inverting feedback inputs
- 1.0V reference at inputs
- Operates from supply voltages of 3.5V to 40V
- Output current up to 3A, saturation less than 0.75V
- Emitter output can swing below ground terminal, for ease of use in inverting applications
- Current limit and thermal shutdown
- Duty cycle up to 90%

Applications

- Switching regulators in buck, boost, inverting, and single-ended transformer configurations
- Motor speed control
- Lamp flasher

Functional Diagram



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Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Total Supply Voltage	50V
Collector Output to Ground	−0.3V to +50V
Emitter Output to Ground (Note 2)	−20V to +50V
Power Dissipation (Note 3)	Internally limited
Output Current	3A
Storage Temperature	−65°C to +150°C
Lead Temperature (Soldering, 10 seconds)	260°C
Maximum Junction Temperature	150°C
ESD Tolerance (Note 4)	2 kV

Operating Ratings

Ambient Temperature	$-40°C \le T_A \le +85°C$
Junction Temperature	$-40°C \le T_J \le +125°C$
Supply Voltage	$3.5V \le V_{IN} \le 40V$

Electrical Characteristics

These specifications apply for $3.5V \le V_{IN} \le 40V$, timing capacitor C_T = 3900 pF, and 25% ≤ duty cycle ≤ 75%, unless otherwise specified. Values in standard typeface are for T_J = 25°C, values in **boldface type** apply for **$-40°C \le T_J \le +125°C$.**

Symbol	Parameter	Conditions	Typical (Note 5)	Limit (Note 6)	Units
OSCILLATOR					
f_{OSC}	Frequency		20	 24 16	kHz kHz (max) kHz (min)
$\Delta f_{OSC}/\Delta T$	Frequency Drift with Temperature		**−0.13**		%/°C
	Amplitude		550		mV_{p-p}
REFERENCE/COMPARATOR (Note 7)					
V_R	Input Reference Voltage	$I_1 = I_2$ = 0 mA and $I_1 = I_2$ = 1 mA ±1% (Note 8)	1.0	 1.050/**1.070** 0.950/**0.930**	V V (max) V (min)
$\Delta V_R/\Delta V_{IN}$	Input Reference Voltage Line Regulation	$I_1 = I_2$ = 0 mA and $I_1 = I_2$ = 1 mA ±1% (Note 8)	0.003	 0.01/**0.02**	%/V %/V (max)
I_{INV}	Inverting Input Current	$I_1 = I_2$ = 0 mA, duty cycle = 25%	0.5		μA
	Level Shift Accuracy	Level Shift Current = 1mA	1.0	 10/**13**	% % (max)
$\Delta V_R/\Delta t$	Input Reference Voltage Long Term Stability		100		ppm/1000h
OUTPUT					
V_C(sat)	Collector Saturation Voltage	I_C = 3A Pulsed, Emitter Grounded	0.55	 0.75/**1.0**	V V (max)
V_E(sat)	Emitter Saturation Voltage	I_O = 3A Pulsed, $V_{IN} = V_C$ = 40V	1.7	 1.9/**2.0**	V V (max)
I_{CES}	Collector Leakage Current	$V_{IN} = V_{CE}$ = 40V, Emitter Grounded, Output OFF	0.1	 600/**750**	μA μA (max)
I_{CEX}	Emitter Leakage Current	$V_{IN} = V_C$ = 20V, V_E = −20V, Output OFF	0.1	 600/**750**	μA μA (max)
$BV_{CEO(SUS)}$	Collector-Emitter Sustaining Voltage	I_{SUST} = 0.2A (Pulsed), V_{IN} = 0	60	 50	V V (Min)

Electrical Characteristics (Continued)

These specifications apply for 3.5V ≤ V_{IN} ≤ 40V, timing capacitor C_T = 3900 pF, and 25% ≤ duty cycle ≤ 75%, unless otherwise specified. Values in standard typeface are for T_J = 25°C, values in **boldface type** apply for **−40°C ≤ T_J ≤ +125°C.**

Symbol	Parameter	Conditions	Typical (Note 5)	Limit (Note 6)	Units
CURRENT LIMIT					
V_{CL}	Sense Voltage Shutdown Level	Referred to V_{IN} or Ground	115	 80 160	mV mV (min) mV (max)
$\Delta V_{CL}/\Delta T$	Sense Voltage Temperature Drift		**0.3**		%/°C
I_{CL}	Sense Bias Current	Referred to V_{IN} Referred to Ground	40 0.4		μA μA
DEVICE POWER CONSUMPTION					
I_S	Supply Current	Output OFF, V_E = 0V	3.0	 5.0/**7.0**	mA mA (max)
		Output ON, I_C = 3A Pulsed, V_E = 0V	55	 75/**150**	mA, peak (max)

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. DC and AC electrical specifications do not apply when operating the device beyond its rated operating conditions.

Note 2: Maximum voltage between emitter and collector or supply is 50V.

Note 3: At elevated temperatures, devices must be derated based on package thermal resistance. The device in the 11-lead TO-220 package must be derated at 36°C/W, junction to ambient, or 1°C/W, junction to case.

Note 4: Human body model, R = 1.5 kΩ, C = 100 pF.

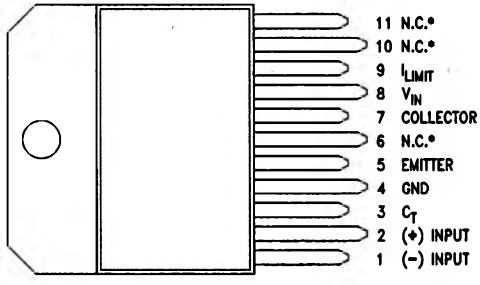
Note 5: Typical values are for T_J = 25°C and represent the most likely parametric norm.

Note 6: All limits guaranteed at room temperature (standard type face) and at **temperature extremes (bold type face).** Room temperature limits are 100% production tested. Limits at temperature extremes are guaranteed via correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).

Note 7: Input terminals are protected from accidental shorts to ground but if external voltages higher than the reference voltage is applied, excessive current will flow and should be limited to less than 5 mA.

Note 8: I_1 and I_2 are the external sink currents at the inputs (refer to Test Circuit).

Connection Diagram and Ordering Information



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Top View

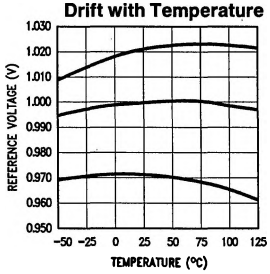
Tab connected to Pin 4 (Ground)

*N.C. = No internal connection

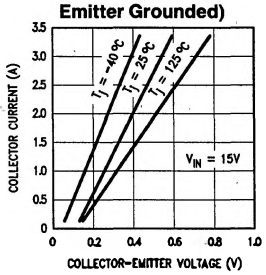
Order Number LM2579T
See NS Package Number TA11B

Typical Performance Characteristics

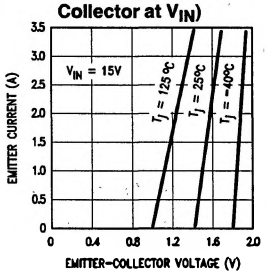
Input Reference Voltage Drift with Temperature



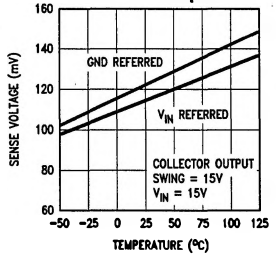
Collector Saturation Voltage (Sinking Current, Emitter Grounded)



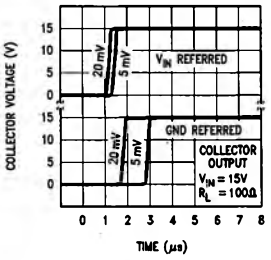
Emitter Saturation Voltage (Sourcing Current, Collector at V_{IN})



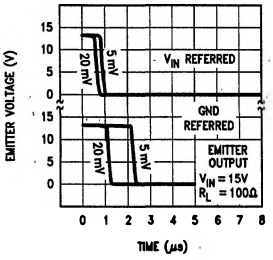
Current Limit Sense Voltage Drift with Temperature



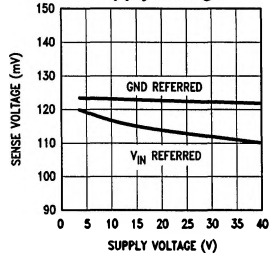
Current Limit Response Time for Various Over Drives



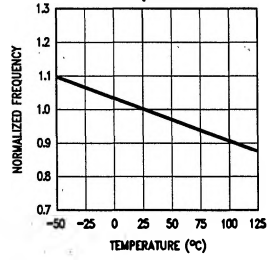
Current Limit Response Time for Various Over Drives



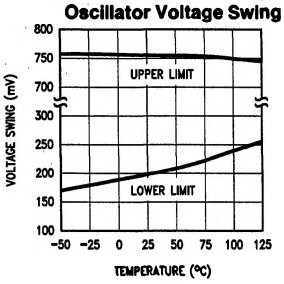
Current Limit Sense Voltage vs Supply Voltage



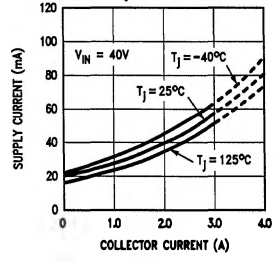
Oscillator Frequency Change with Temperature



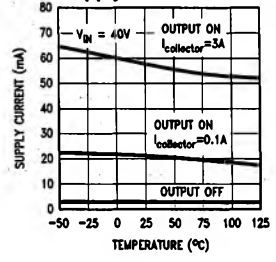
Oscillator Voltage Swing



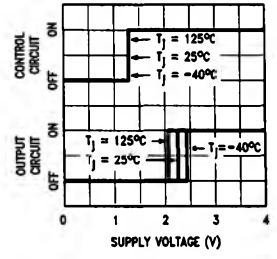
Supply Current vs Output Current



Supply Current



Start Up Voltage



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Test Circuit†

Parameter tests can be made using the test circuit shown. Select the desired V_{IN}, collector voltage and duty cycle with adjustable power supplies. A digital volt meter with an input resistance greater than 100 MΩ should be used to measure the following:

Input Reference voltage to Ground; S1 in either position.

Level Shift Accuracy (%) = $T_{P3}(V)/1V \bullet 100\%$; S1 at $I_1 = I_2 = 1$ mA.

Input current (mA) = $(1V - T_{P3}(V))/1\ M\Omega$; S1 at $I_1 = I_2 = 0$ mA.

Oscillator parameters can be measured at TP4 using a frequency counter or an oscilloscope.

The Current Limit Sense Voltage is measured by connecting an adjustable 0-to-1V floating power supply in series with the current limit terminal and referring it to either the ground or the V_{IN} terminal. Set the duty cycle to 90% and monitor test point T_{P5} while adjusting the floating power supply voltage until the LM2579's duty cycle just reaches 0%. This voltage is the Current Limit Sense Voltage.

The Supply Current should be measured with the duty cycle at 0% and S1 in the $I_1 = I_2 = 0$ mA position.

†LM2579 specifications are measured using automated test equipment. This circuit is provided for the customer's convenience when checking parameters. Due to possible variations in testing conditions, the measured values from these testing procedures may not match those of the factory.

Definition of Terms

Input Reference Voltage: The reference voltage referred to ground, applied to either the inverting or non-inverting inputs, which will cause the output to switch ON or OFF.

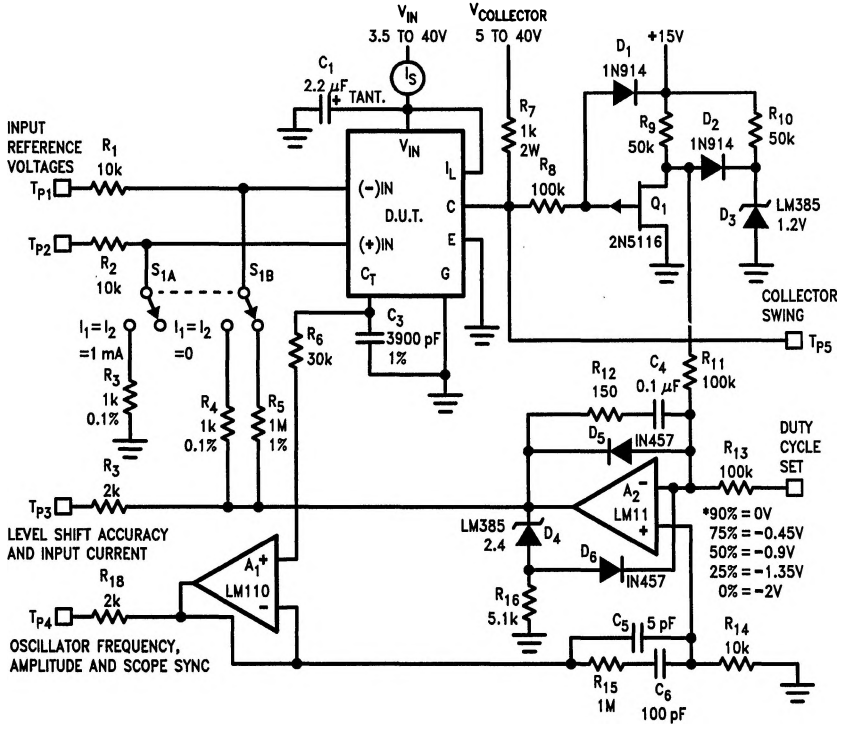
Input Reference Current: The current applied to either the inverting or the non-inverting input which will cause the output to switch ON or OFF.

Input Level Shift Accuracy: If there are two equal resistors sinking current from the inverting and non-inverting input terminals, the Input Level Shift Accuracy is the ratio of the voltage across the resistors to produce a given duty cycle at the output.

Collector Saturation Voltage: With the inverting input terminal grounded through a 10 kΩ resistor and the output transistor's emitter connected to ground, the Collector Saturation Voltage is the collector-to-emitter voltage for a given collector current.

Emitter Saturation Voltage: With the inverting input terminal grounded through a 10 kΩ resistor and the output transistor's collector connected to V_{IN}, the Emitter Saturation Voltage is the collector-to-emitter voltage for a given emitter current.

Collector-Emitter Sustaining Voltage: The collector-emitter breakdown voltage of the output transistor, measured at a specified current.



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Note 1: Op amp supplies are +15V.

Note 2: DVM input resistance > 100 MΩ.

Note 3: *LM2579 max duty cycle is 90%.

Definition of Terms (Continued)

Current Limit Sense Voltage: The voltage at the current Limit pin, referred to either the V_{IN} terminal or the ground terminal, which (via logic circuitry) will cause the output transistor to turn OFF. The logic circuitry is reset at the beginning of each oscillator cycle.

Current Limit Sense Current: The bias current for the Current Limit terminal with the applied voltage equal to the Current Limit Sense Voltage.

Supply Current: The IC power supply current, excluding current drawn through the output transistor, with the oscillator operating.

Functional Description

The LM2579 is a pulse-width modulator designed for use as a switching regulator controller. It may also be used in other applications which require controlled pulse-width voltage drive.

A control signal, usually representing output voltage, fed into the LM2579's comparator is compared with an internally-generated reference. The resulting error signal and the oscillator's output are fed to a logic network which determines when the output transistor will be turned ON or OFF. The following is a brief description of the subsections of the LM2579.

COMPARATOR INPUT STAGE

The LM2579's comparator input stage is unique in that both the inverting and non-inverting inputs are available to the user, and both contain a 1.0V reference. This is accomplished as follows: A 1.0V reference is fed into a modified voltage follower circuit (see FUNCTIONAL DIAGRAM). When both input pins are open, no current flows through R_1 and R_2. Thus, both inputs to the comparator will have the potential of the 1.0V reference, V_A. When one input, for example the non-inverting input, is pulled ΔV away from V_A, a current of $\Delta V/R_1$ will flow through R_1. This same current flows through R_2, and the comparator sees a total voltage of $2\Delta V$ between its inputs. The high gain of the system, through feedback, will correct for this imbalance and return both inputs to the 1.0V level.

This unusual comparator input stage increases circuit flexibility, while minimizing the total number of external components required for a voltage regulator system. The inverting switching regulator configuration, for example, can be set up without having to use an external op amp for feedback polarity reversal (See TYPICAL APPLICATIONS).

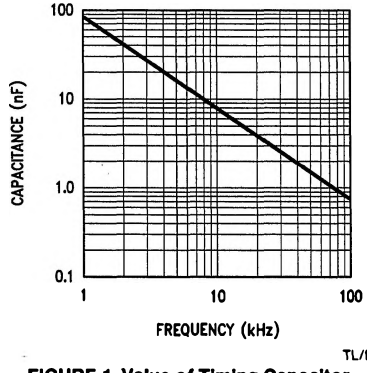

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FIGURE 1. Value of Timing Capacitor vs Oscillator Frequency

OSCILLATOR

The LM2579 provides an on-board oscillator which can be adjusted up to 100 kHz. Its frequency is set by a single external capacitor, C_1, as shown in *Figure 1*, and follows the equation

$$f_{OSC} = 8 \times 10^{-5}/C_1$$

The oscillator provides a blanking pulse to limit maximum duty cycle to 90%, and a reset pulse to the internal circuitry.

OUTPUT TRANSISTOR

The output transistor is capable of delivering up to 3A with a saturation voltage of less than 0.75V (see *Collector Saturation Voltage* and *Emitter Saturation Voltage* curves).

The emitter can be pulled below ground, as long as the total voltage between the emitter pin and collector or supply pin does not exceed 50V. This feature allows the LM2579 to be used in an inverting regulator configuration without an additional output transistor which would normally be required to protect the device from the negative output voltage.

CURRENT LIMIT

The LM2579's current limit may be referenced to either the ground or the V_{IN} pin, and operates on a cycle-by-cycle basis.

The current limit section consists of two comparators: one with its non-inverting input referenced to a voltage 115 mV below V_{IN}, the other with its inverting input referenced 115 mV above ground (see FUNCTIONAL DIAGRAM). The current limit is activated whenever the current limit terminal is pulled 115 mV away from either V_{IN} or ground.

Application Information

CIRCUIT BOARD LAYOUT

Because of fast switching of high output currents, the circuit board layout should be carefully thought out. The comparator inputs are sensitive to noise, and should be kept away from the high-energy switching signals. Feedback resistors should be located near the input terminals. A single-point ground should be used for the oscillator capacitor, device ground, and feedback (when appropriate) to avoid ground loops.

LEAD INDUCTANCE IMPACTS DIODE CHOICE

It is always important to use diodes designed for switching applications. Schottky diodes generally provide superior performance, although fast recovery diodes can also be used. Fast recovery diodes differ from Schottky diodes in their turn-on and turn-off characteristics, which can cause voltage transients that will affect circuit operation.

The turn-off, or "recovery," time of a diode refers to the time it takes for the charge that has been stored in the diode during the forward conduction period to be depleted. During this recovery period, the diode appears to be a short, causing a fast current pulse to flow through the switch. Since the LM2579's output is capable of switching current at a rate of approximately 30 A/μs, and one inch of 20-gauge wire has approximately 30 nH of inductance, a transient of nearly 1V can be generated for every inch of stray wire ($V = L\,di/dt$ = 30 nH × 30 A/μs = 0.9V). Since the LM2579's current limit sense voltage is 115 mV (typ.), transients like these can

Application Information (Continued)

greatly affect circuit operation. They can be minimized by keeping all lead lengths short, thus reducing stray inductances. Additional methods of suppressing noise spikes and switching transients are described in the Current Limit Transient Suppression section.

The turn-on time of the switching diode must also be considered. A slow turn-on can cause an increase in the voltage across the output transistor, which is rated for 50V (maximum) in the LM2579). This condition can exist in all configurations.

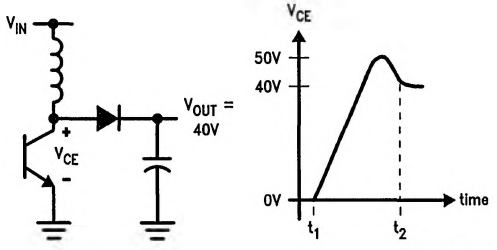

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FIGURE 2. Transient Applied to Output Transistor by Slow Turn-On of Diode

Referring to *Figure 2*, at t_1 the transistor turns OFF; at t_2, the diode turns ON. This delay allows buildup of voltage across the non-conducting diode, which is applied to the transistor until the diode begins conducting.

CURRENT LIMIT

As noted In the functional description, the current limit terminal may be referred to either V_{IN} or ground (see *Figures 3, 4*). The resistor R_{CL} converts the current to be sensed into a voltage for current limit detection.

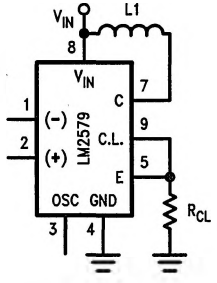

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FIGURE 3. Current Limit, Ground Referred

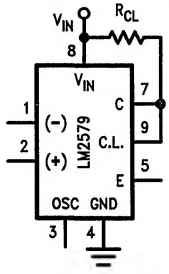

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FIGURE 4. Current Limit, V_{IN} Referred

C. L. SENSE VOLTAGE MULTIPLICATION

When a larger sense resistor value is desired, a voltage divider network may be used (see *Figures 5, 6*). This effectively multiplies the sense voltage by (1 + R1/R2). Alternatively, R1 can be replaced by a diode to increase current limit sense voltage to about 800 mV (diode V_d + 115 mV).

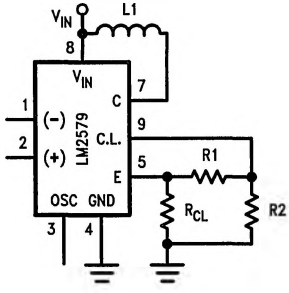

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FIGURE 5. Current Limit Sense Voltage Multiplication, Ground Referred

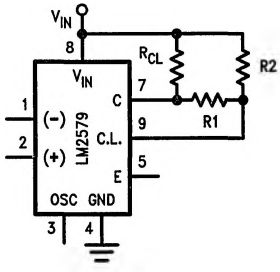

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FIGURE 6. Current Limit Sense Voltage Multiplication, V_{IN} Referred

CURRENT LIMIT TRANSIENT SUPPRESSION

When noise spikes and switching transients interfere with proper current limit operation, an RC low-pass filter can be used to control the current limit circuitry's response time (see *Figures 7, 8*).

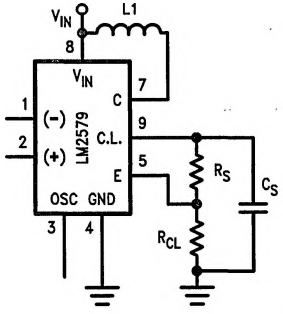

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FIGURE 7. Current Limit Transient Suppressor, Ground Referred

Application Information (Continued)

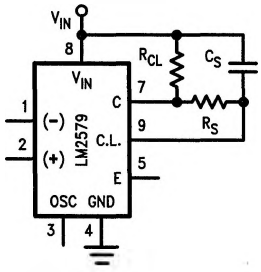

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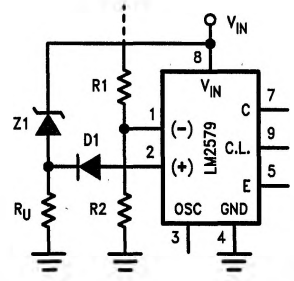
FIGURE 8: Current Limit Transient Suppressor, V_{IN} Referred

Because the input current of the current limit terminal varies according to its reference point, R_S should be less than 2 kΩ when referred to ground, and less than 100Ω when referred to V_{IN}. C_S is typically 0.01 μF.

UNDER-VOLTAGE LOCKOUT

Under-voltage lockout requires few external components, as shown in *Figure 9*. When V_{IN} becomes lower than the zener breakdown voltage, the LM2579's output transistor is turned OFF. This occurs because diode D1 will then become forward biased, allowing resistor R_U to sink a greater current from the non-inverting input than is sunk by the parallel combination of the feedback resistors, R1 and R2, at the inverting terminal. R_U should be one-fifth of the value of R1 and R2 in parallel.



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D1 = 1N457 or similar

FIGURE 9. Under-Voltage Lockout

MAXIMUM DUTY CYCLE LIMITING

The maximum duty cycle can be externally limited by adjusting the charge-to-discharge ratio of the oscillator capacitor with a single external resistor, as shown in *Figure 10*. Typical values are 50 μA for the charge current, 450 μA for the discharge current and a voltage swing from 200 mV to 750 mV. Therefore, R_d is selected for the desired charging and discharging slopes, and C1 is readjusted to set the oscillator frequency.

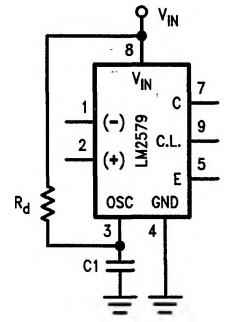

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FIGURE 10. Maximum Duty Cycle Limiting

DUTY CYCLE ADJUSTMENT

When manual or mechanical selection of the output transistor's duty cycle is needed, the circuit shown in *Figure 11* may be used. The output will turn ON with the beginning of each oscillator cycle, and turn OFF when the current sunk by R_{a1} and R_{a2} from the non-inverting terminal becomes greater than the current sunk from the inverting terminal.

With the resistor values as shown, R_{a2} can be used to adjust the duty cycle from 0% to 90%. When the sum of R_{a1} and R_{a2} is twice the value of R_p, the duty cycle will be about 50%. C1 may be a large electrolytic capacitor, to lower the oscillator frequency below 1 Hz if appropriate for the application.

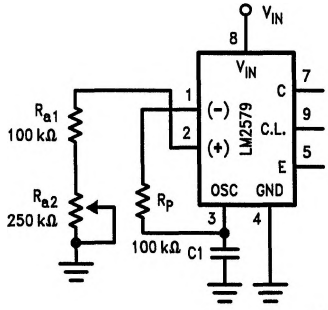

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FIGURE 11. Duty Cycle Adjustment

REMOTE SHUTDOWN

The LM2579 may be remotely shut down by sinking a greater current from the non-inverting input than from the inverting input. This may be accomplished by selecting resistor R_S to be approximately one-half the value of the parallel combination of R1 and R2 (see *Figure 12*). Shutdown will occur when V_L is high.

Application Information (Continued)

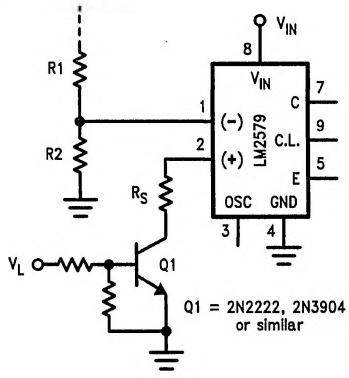

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FIGURE 12. Remote Shutdown

SYNCHRONIZING DEVICES

When several devices are to be operated at once, their oscillators may be synchronized by the application of an external signal, as shown in *Figure 13*. This drive signal should be a pulse waveform with a minimum pulse width of 2 μs, and an amplitude of from 1.5V to 2.0V. The signal source must be capable of both driving capacitive loads and delivering up to 500 μA for each LM2579.

Capacitors C1 through Cn are to be selected for a 20% slower frequency than the synchronizing frequency.

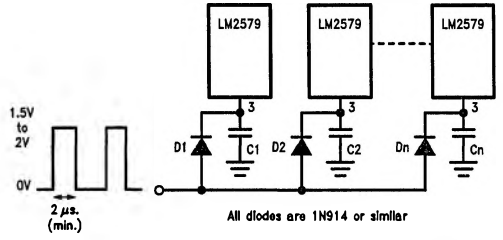

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FIGURE 13. Synchronizing Devices

IMPROVING TRANSISTOR SATURATION

The efficiency of a switching regulator is highest when the power transistor is allowed to fully saturate, minimizing the Collector-Emitter voltage when the transistor is ON. When the Collector is used as the output, with the Emitter grounded, the output transistor will fully saturate. Saturation voltage depends on the load current (see *Collector Saturation Voltage* curve), and is normally under 0.8V, over temperature.

However, when the Emitter is used as the output (Collector tied to V_{IN}, as in *Figure 14*), the output transistor cannot fully saturate because of the Darlington configuration of the output stage. This results in a 1.7V drop (typically) across the power device Q3 during the conduction period (refer to *Emitter Saturation Voltage* curve).

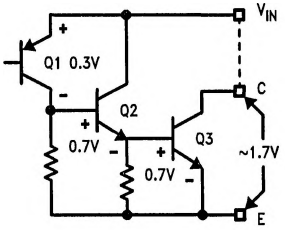

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FIGURE 14. Collector-Emitter Saturation Prevented by Darlington Construction of Output Stage (Simplified Schematic)

To achieve Collector-Emitter saturation, the base for the LM2579 output transistor Q3 must be driven higher than its Collector. This cannot happen if the Collector is tied to V_{IN}. However, by increasing V_{IN} to 1.5V or more above V_C, Collector-Emitter saturation can occur (see *Figure 15*). Techniques for accomplishing this are shown in the Typical Applications examples.

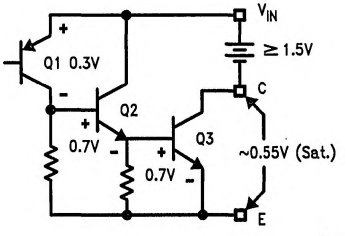

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FIGURE 15. Increasing V_{IN} Above V_C Allows Collector-Emitter Saturation

ADAPTING LM1578 DESIGNS TO THE LM2579

All LM1578 designs may be adapted for use with the LM2579 to achieve higher output power. The LM2579 is based on the design of the LM1578 switching regulator controller, with a few modifications. The output switching transistor is capable of delivering 3A (peak or DC), compared to the 0.75A maximum current rating of the LM1578, and the Emitter output can swing more negative than the ground terminal. Because of the difference in current rating, the LM2579 is in the TO-220 style package so it may be easily heat-sunk. Heat sinking is necessary for most LM2579 designs, especially those operating at high switch currents. For example, the loss of 3W in the output switch of a converter operating at 35°C ambient would raise the die temperature near its maximum rating of 150°C if no heat sink were used (see Note 3 in the Electrical Characteristics).

The other modification seen in the LM2579 is the 20 pF capacitor that is used, in LM1578 applications, to inject an end-of-cycle signal into the error comparator, improving synchronization of the switching to the oscillator. It is not necessary to add this capacitor in LM2579 applications.

Typical Applications

The LM2579 can be used in all standard configurations which require a single switching transistor. These include the buck (or step-down), boost (or step-up), invert, flyback, and forward styles.

Typical Applications (Continued)

Several design examples follow which include a variety of techniques to improve regulator performance.

Inductors having the standard values shown in the nomograph of *Figure 17* are available from Pulse Engineering (San Diego, CA); AIE Magnetics, division of Vernatron (St. Petersburg, FL); and Renco Electronics (Deer Park, NY).

BUCK REGULATOR

In the buck regulator of *Figure 16*, a 28V input is converted to 5V, with a load of up to 2.5A. Efficiency at maximum load is approximately 80%, and load regulation is approximately 0.05%/A in the range $0.3A \leq I_{LOAD} \leq 2.5A$. Switching frequency has been set to 40 kHz by the choice of 2 nF for C_1 (see *Figure 1*).

The value of the inductor, L, is determined by the use of the Inductance Calculator *(Figure 17)*, or by the equation

$$L = V_O (V_{IN} - V_O) / (\Delta I_L V_{IN} f_{OSC})$$

where ΔI_L is the current ripple through the inductor. ΔI_L is usually chosen based on the minimum load current expected of the circuit: For the Buck regulator, since $I_L = I_{LOAD}$, ΔI_L is twice the minimum load current value $\Delta I_L = 350$ mA for this circuit, so operation will become discontinuous at $(\Delta I_{L(min)}/2)(100\%/I_{L(max)}) = 7\%$ of the maximum load current. (This is the "% Discontinuity" referred to in the Inductance Calculator.)

At this minimum value, the inductor current will just reach zero at the end of every switching period. Below the "minimum," the inductor will "run dry" and the regulator will be "discontinuous," as the inductor current is zero for part of each cycle. In this mode, the inductor is no longer storing energy, so is not an effective part of the output filter. Regulation will continue but performance will be degraded.

Output ripple voltage is about 40 mVpp when the output filter capacitor, C_2, is a standard 1000 µF electrolytic. Replacing this capacitor with a 1500 µF "low ESR" (equivalent series resistance) capacitor reduces the ripple to 20 mVpp. The minimum value of this capacitor can be determined by the following equation

$$C_2 \geq V_O (V_{IN} - V_O) / (8 V_{IN} V_{RIPPLE} L f_{OSC}^2)$$

where V_{RIPPLE} is the desired maximum output voltage ripple in peak-to-peak Volts. The ripple will be greater than predicted by this equation due to effects of ESR in C_2.

Figure 16 illustrates the single-point grounding and supply bypassing necessary for this type of moderate-to-high current switching regulator. For best regulation, all high-current paths, including ground, must be kept low-resistance.

***Note:** When pin 5, the Emitter of the LM2579 output transistor, is used to drive the output filter, it may oscillate when driven into positive saturation and when loaded with capacitance of between 100 pF and 500 pF. This capacitance is usually caused by socket capacitance, input capacitance of external components (such as the Schottky diode), and stray capacitance in the layout. The oscillation, which is usually near 30 MHz, can be eliminated by adding a series RC of 4.7Ω to 10Ω and 1 nF from the Emitter (pin 5) to Ground.

In the Emitter-driven configurations, the Collector output (pin 7) is normally tied to V_{IN} (pin 8). If this connection uses long lead lengths (greater than 3" total), the Collector should be bypassed to V_{IN} with 0.01 µF (or greater), attached directly to the terminals. In addition, when current limiting is used, connections to the Current Limit pin (pin 9) should be made with short leads. Use of these techniques to minimize lead inductance will also minimize switching transients, thus reducing conducted noise.

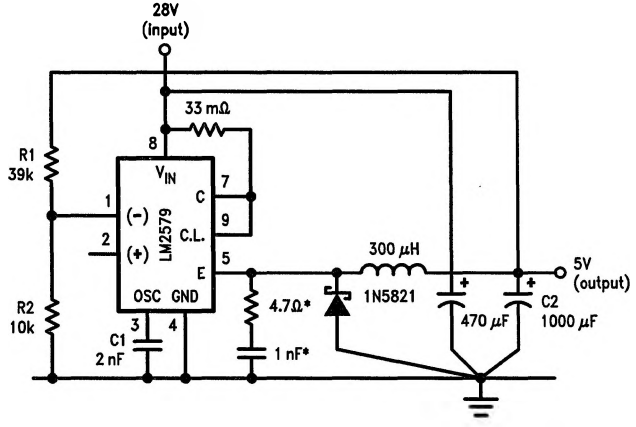

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FIGURE 16. Buck Converter: 28V to 5V at 2.5A

*Refer to Note in text.

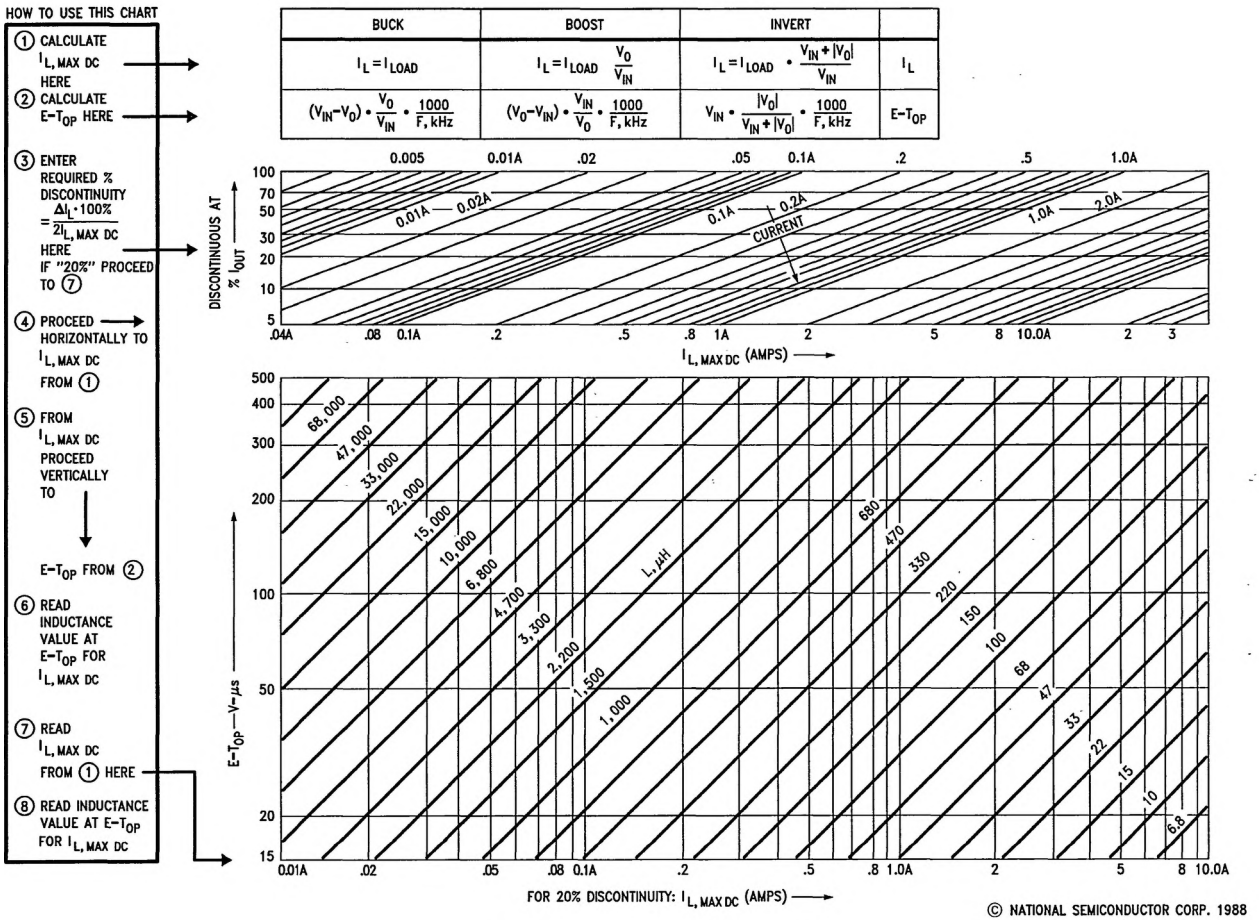

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FIGURE 17. DC/DC Inductance Calculator

Typical Applications (Continued)

BOOST REGULATOR

The boost converter of *Figure 18* produces 15V at up to 800 mA from a 5V input, with 82% efficiency. The output ripple (with an 800 mA load) is 100 mV when a standard 1000 μF electrolytic output capacitor is used, or 75 mV if a 1500 μF low-ESR electrolytic is used. The minimum value of C_2 may be calculated using the same equation as shown in the BUCK REGULATOR section.

The inductor value is selected either using the Inductance Calculator *(Figure 17)*, or by the equation

$$L = V_{IN}^2 (V_O - V_{IN}) / (\Delta I_L V_O^2 f_{OSC})$$

where, as in the previous section, ΔI_L is determined by minimum expected DC inductor current. For the boost regulator,

$$\Delta I_L = 2 I_{LOAD(min)} (V_O/V_{IN})$$

Load regulation for this circuit is approximately 0.04%/A in the range 50 mA $\leq I_{LOAD} \leq$ 800 mA. Line regulation is 4 mV/V for the input range 4.5V $\leq V_{IN} \leq$ 8.5V.

Stability of the circuit is improved with the use of a series R-C network from the Current Limit pin to the Inverting Input.

INVERTING REGULATOR

The inverting regulator of *Figure 19* converts a 15V input to −15V at 1A. The load regulation is about 30 mV/A for the range 0.1A $\leq I_{LOAD} \leq$ 1.0A.

The inductor value is determined either by the Inductance Calculator *(Figure 17)*, or by the equation

$$L = V_{IN}^2 |V_O| / [\Delta I_L (V_{IN} + |V_O|)^2 f_{OSC}]$$

where ΔI_L is based on minimum DC inductor current, and may be calculated as follows:

$$\Delta I_L = 2 I_{LOAD(min)} (V_{IN} + |V_O|) / V_{IN}$$

The output voltage ripple (at full load) is approximately 120 mVpp when C_2 is a 1000 μF standard electrolytic capacitor, or 60 mVpp when a 1500 μF low-ESR capacitor is used. The minimum value of C_2 may be calculated using the equation shown in the BUCK REGULATOR section.

The efficiency of this regulator is approximately 76%. To achieve higher efficiency, the circuit may be modified (as shown in *Figure 20*) to increase the supply voltage to the LM2579, which reduces the saturation voltage of the output transistor.

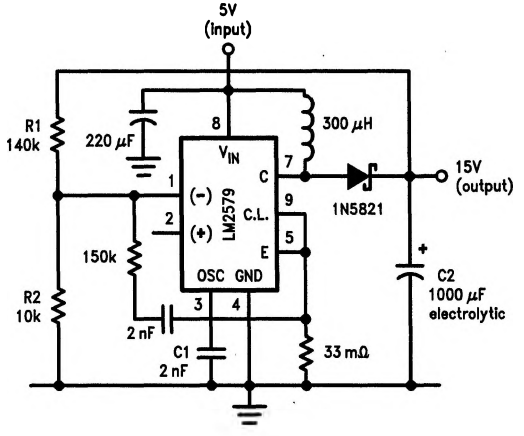

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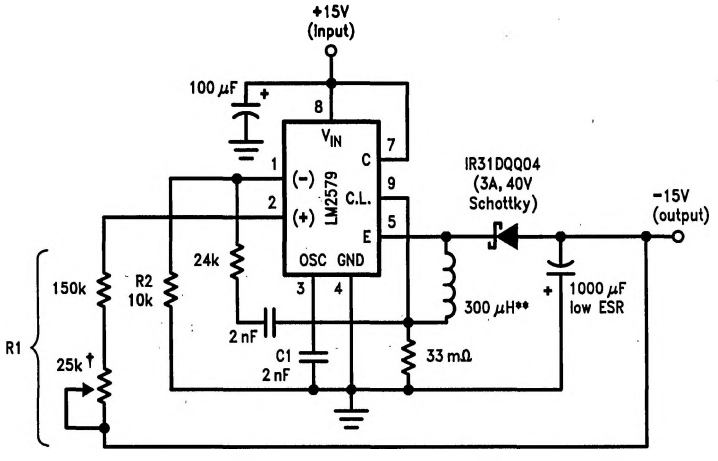
FIGURE 18. Boost Converter: 5V to 15V at 800 mA

Typical Applications (Continued)



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†Output voltage trim
*Wire-wound resistor may be used here
**See text

FIGURE 19. Inverting Regulator: + 15V to − 15V at 1A

To improve circuit stability, a series R-C network is added from the Current Limit pin to the Inverting Input. In addition, an R-C damper may be required from the Emitter to Ground, as described in the BUCK REGULATOR section Note.

****Note:** The additional winding L_B shown in *Figure 20* is used to create a flyback effect which provides an extra 3V to the LM2579 supply voltage. In this example, the inductor L was 46 turns of 20-gauge wire on an Arnold 4F-068200-2 toroid core, providing 300 µH; booster winding L_B was 20 turns of #28 wire on the same core.

Regulator efficiency will be increased to about 86% with the boosted supply voltage, as this allows the saturation voltage of the output transistor to decrease to about 0.55V (from the typical Emitter saturation voltage of 1.7V).

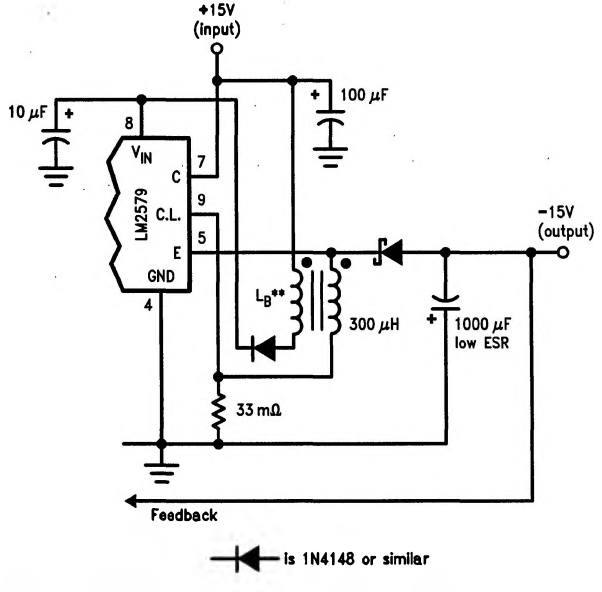

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FIGURE 20. Optional Modification to Inverting Regulator of *Figure 19* for Increased Efficiency