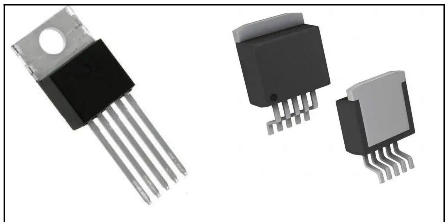
D2587A

4V to 40V, 5A Boost DC/DC Converter



TO220-5 TO263-5

General Description

The D2587A series regulator is a monolithic integrated circuit designed for trans, boost and forward converter applications. The device is available in four different output voltage versions: 3.3V, 5V, 12V, and adjustable voltage. These regulators require few external components, and thus are cost-effective and easy to use. Typical boost and trans regulator circuits are included in the data sheet. Also listed are selection guidelines for diodes and capacitors and standard inductors and anti-type transformers designed for operating in conjunction with the above switch regulator. The power switch is a 5A NPN device that cuts off a 65V voltage. The power switches are protected by current and thermal restriction circuits and undervoltage locking circuits. This IC contains a 100kHz fixed-frequency internal oscillator that allows the use of small magnets. Other features include soft start modes that reduce the surge current during startup, improved current mode control functions that suppress the input voltage and output load transients, and periodic current limits. The power system ensures output voltage tolerance for different lines and load conditions is ± 4%.

The D2587A is available in TO220-5 and TO263-5 package.

Features

- 3.3V, 5V, 12V and adjustable output versions
- There is no need for external components
- Standard inductor and transformer series
- The NPN output switch current is 5A, which can cut off the 65V voltage
- Wide input voltage range: 4V to 40V
- Current mode operation that improves transient response, line regulation, and current limitation
- 100kHz Switch frequency
- The internal soft start function reduces the surge current during start
- Protection for the output transistor through current restriction, undervoltage locking and thermal shutdown
- The highest system output voltage tolerance for different lines and load conditions is ± 4%

Package Information

Part NO.	Package Description	Package Marking	Package Option
D2587A-3.3(T)	TO220-5	CHMC D2587A 33 SXXXX	50/Tube
D2587A-3.3(S)	TO263-5	CHMC D2587A 33 SXXXX	50/Tube 800/Reel
D2587A-5.0(T)	TO220-5	CHMC D2587A 50 SXXXX	50/Tube
D2587A-5.0(S)	TO263-5	CHMC D2587A 50 SXXXX	50/Tube 800/Reel
D2587A-12(T)	TO220-5	CHMC D2587A 12 SXXXX	50/Tube
D2587A-12(S)	TO263-5	CHMC D2587A 12 SXXXX	50/Tube 800/Reel
D2587A-ADJ(T)	TO220-5	CHMC D2587A ADJ SXXXX	50/Tube
D2587A-ADJ(S)	TO263-5	CHMC D2587A ADJ SXXXX	50/Tube 800/Reel

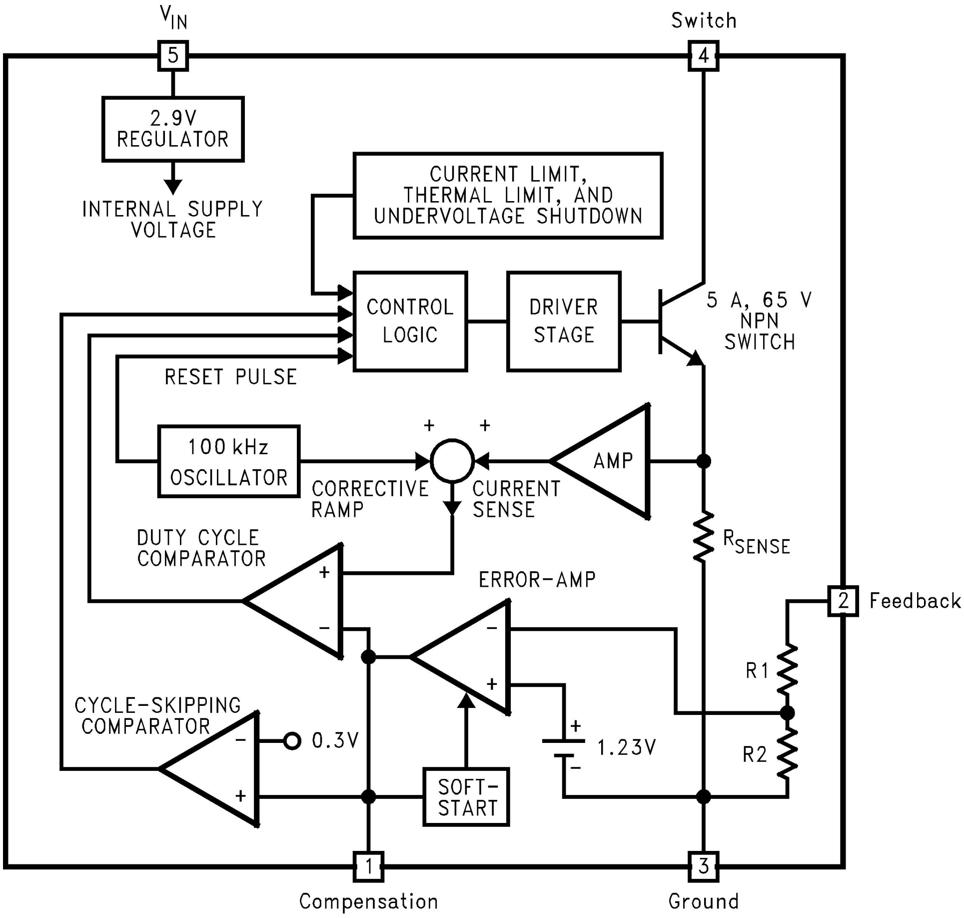
CHMC:Trademark D2587A:Part NO. 33(3.3V)/50(5.0V)/12(12V)/ADJ(ADJ):Output Voltage SXXXX:Lot NO.

Applications

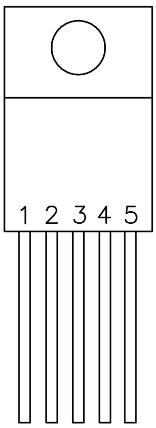
- Reverse shock voltage regulator
- Multi-output regulator
- Simple booster regulator
- Forward converter

Functional Block Diagram

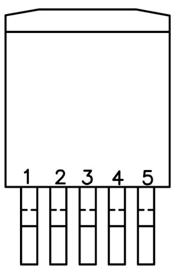
For Fixed Versions 3.3 V, R1 = 3.4 k, R2 = 2 k, 5 V, R1 = 6.15 k, R2 = 2k 12V, R1 = 8.73 k, R2 = 1 k. For Adj. Version R1 = Short (0Ω), R2 = Open



Pin Configuration



D2587A(TO220-5)



D2587A(TO263-5)

Pin Description

Pin Number	Pin Name
1	Comp
2	FEEDBACK
3	GND
4	Switch
5	VIN

Absolute Maximum Ratings

Parameter Name	Symbol	Value	Unit
Maximum Supply Voltage	V_{IN}	$-0.4 \leq V_{IN} \leq 45$	V
Switch Voltage	Vsw	$-0.4 \leq Vsw \leq 65$	V
Compensation Pin Voltage	V_{COMP}	$-0.4 \leqslant V_{COMP} \leqslant 2.4$	V
Power Dissipation	P_{DMAX}	Internally Limited	
Storage Temperature Range	Tstg	-65~+150	℃
Maximum Junction Temperature	T_{JA}	150	℃
Feedback Pin Voltage	V_{FB}	$-0.4 \leq V_{FB} \leq 2\ V_{OUT}$	V
Lead Temperature (Soldering, 10 Seconds)	T_L	260	℃
Switch Current	I_{SW}	Internally Limited	
Electrostatic discharge (minimum)(Human-body model)	$V_{(ESD)}$	2000	V

Recommended Operating Conditions

Parameter Name	Symbol	Value	Unit
Supply Voltage	V_{IN}	4~40	V
Junction temperature range	Tj	-40~+125	℃
Output Switch Current	I_{SW}	$I_{SW} \leq 5.0$	A
Output Switch Voltage	V_{SW}	0~60	V

Thermal Information

THERMAL METRIC(1)(2)		D2587A TO263 5 PINS	D2587A TO220 5 PINS	UNIT
RθJA	Junction-to-ambient thermal resistance	56(3)	65(4)	°C/W
		35(5)	45(6)	
		26(7)	—	
RθJC	Junction-to-case thermal resistance	2	2	°C/W

(1) For more information about traditional and new thermal metrics, see the Semiconductor and IC package thermal metrics application report.
(2) External components such as the diode, inductor, input and output capacitors can affect switching regulator performance. When the D2587A is used as shown in Figure 61 and Figure 62, system performance will be as specified by the system parameters.
(3) Junction-to-ambient thermal resistance for the 5 lead TO263 mounted horizontally against a PC board area of 0.136 square inches (the same size as the TO263 package) of 1 oz. (0.0014 in. thick) copper.
(4) Junction-to-ambient thermal resistance (no external heat sink) for the 5 lead TO220 package mounted vertically, with ½ inch leads in a socket, or on a PC board with minimum copper area.
(5) Junction-to-ambient thermal resistance for the 5 lead TO-263 mounted horizontally against a PC board area of 0.4896 square inches (3.6 times the area of the TO263 package) of 1 oz. (0.0014 in. thick) copper.
(6) Junction-to-ambient thermal resistance (no external heat sink) for the 5 lead TO220 package mounted vertically, with ½ inch leads soldered to a PC board containing approximately 4 square inches of (1oz.) copper area surrounding the leads.
(7) Junction-to-ambient thermal resistance for the 5 lead TO263 mounted horizontally against a PC board copper area of 1.0064 square inches (7.4 times the area of the TO263 package) of 1 oz. (0.0014 in. thick) copper. Additional copper area reduces thermal resistance further. See the thermal model in Switchers Made Simple® software.

Electrical Characteristics （3.3V）

（Specifications with standard type face are for T_J = 25°C, and those in **bold** apply over full Operating Temperature Range.Unless otherwise specified, V_{IN} = 5V.）

PARAMETER		TEST CONDITIONS	TYP	MIN	MAX	UNIT
SYSTEM PARAMETERS Test Circuit of Figure 61(1)						
V_{OUT}	Output Voltage	V_{IN} = 4V to 12V I_{LOAD} = 400 mA to 1.75A	3.3	3.17/**3.14**	3.43/**3.46**	V
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	V_{IN} = 4V to 12V I_{LOAD} = 400 mA	20		50/**100**	mV
$\Delta V_{OUT}/\Delta I_{LOAD}$	Load Regulation	V_{IN} = 12V I_{LOAD} = 400 mA to 1.75A	20		50/**100**	mV
η	Efficiency	V_{IN} = 12V, I_{LOAD} = 1A	75			%
UNIQUE DEVICE PARAMETERS (2)						
V_{REF}	Output Reference Voltage	Measured at Feedback Pin V_{COMP} = 1.0V	3.3	3.242/**3.234**	3.358/**3.366**	V
ΔV_{REF}	Reference Voltage Line Regulation	V_{IN} = 4V to 40V	2.0			mV
G_M	Error Amp Transconductance	I_{COMP} = −30 µA to +30 µA V_{COMP} = 1.0V	1.193	**0.678**	**2.259**	mmho
A_{VOL}	Error Amp Voltage Gain	V_{COMP} = 0.5V to 1.6V R_{COMP} = 1.0 MΩ (3)	260	151/**75**		V/V

(1) External components such as the diode, inductor, input and output capacitors can affect switching regulator performance. When the D2587A is used as shown in Figure 61 and Figure 62, system performance will be as specified by the system parameters.
(2) All room temperature limits are 100% production tested, and all limits at temperature extremes are specified via correlation using standard Statistical Quality Control (SQC) methods.
(3) A 1-MΩ resistor is connected to the compensation pin (which is the error amplifier output) to ensure accuracy in measuring A_{VOL}.

Electrical Characteristics （5V）

（Specifications with standard type face are for T_J = 25°C, and those in **bold** apply over full Operating Temperature Range.Unless otherwise specified, V_{IN} = 5V.）

PARAMETER		TEST CONDITIONS	TYP	MIN	MAX	UNIT
SYSTEM PARAMETERS Test Circuit of Figure 61[1]						
V_{OUT}	Output Voltage	V_{IN} = 4V to 12V I_{LOAD} = 500 mA to 1.45A	5.0	4.80/**4.75**	5.20/**5.25**	V
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	V_{IN} = 4V to 12V I_{LOAD} = 500 mA	20		50/**100**	mV
$\Delta V_{OUT}/\Delta I_{LOAD}$	Load Regulation	V_{IN} = 12V I_{LOAD} = 500 mA to 1.45A	20		50/**100**	mV
η	Efficiency	V_{IN} = 12V, I_{LOAD} = 750 mA	80			%
UNIQUE DEVICE PARAMETERS [2]						
V_{REF}	Output Reference Voltage	Measured at Feedback Pin V_{COMP} = 1.0V	5.0	4.913/**4.900**	5.088/**5.100**	V
ΔV_{REF}	Reference Voltage Line Regulation	V_{IN} = 4V to 40V	3.3			mV
G_M	Error Amp Transconductance	I_{COMP} = −30 µA to +30 µA V_{COMP} = 1.0V	0.750	**0.447**	**1.491**	mmho
A_{VOL}	Error Amp Voltage Gain	V_{COMP} = 0.5V to 1.6V R_{COMP} = 1.0 MΩ [3]	165	99/**49**		V/V

(1) External components such as the diode, inductor, input and output capacitors can affect switching regulator performance. When the D2587A is used as shown in Figure 61 and Figure 62, system performance will be as specified by the system parameters.

(2) All room temperature limits are 100% production tested, and all limits at temperature extremes are specified via correlation using standard Statistical Quality Control (SQC) methods.

(3) A 1-MΩ resistor is connected to the compensation pin (which is the error amplifier output) to ensure accuracy in measuring AVOL.

Electrical Characteristics （12V）

（Specifications with standard type face are for T_J = 25°C, and those in **bold** apply over full Operating Temperature Range.Unless otherwise specified, V_{IN} = 5V.）

PARAMETER		TEST CONDITIONS	TYP	MIN	MAX	UNIT
SYSTEM PARAMETERS Test Circuit of Figure 62[1]						
V_{OUT}	Output Voltage	V_{IN} = 4V to 10V I_{LOAD} = 300 mA to 1.2A	12.0	11.52/**11.40**	12.48/**12.60**	V
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	V_{IN} = 4V to 10V I_{LOAD} = 300 mA	20		100/**200**	mV
$\Delta V_{OUT}/\Delta I_{LOAD}$	Load Regulation	V_{IN} = 10V I_{LOAD} = 300 mA to 1.2A	20		100/**200**	mV
η	Efficiency	V_{IN} = 10V, I_{LOAD} = 1A	90			%
UNIQUE DEVICE PARAMETERS [2]						
V_{REF}	Output Reference Voltage	Measured at Feedback Pin V_{COMP} = 1.0V	12.0	11.79/**11.76**	12.21/**12.24**	V
ΔV_{REF}	Reference Voltage Line Regulation	V_{IN} = 4V to 40	7.8			mV
G_M	Error Amp Transconductance	I_{COMP} = −30 µA to +30 µA V_{COMP} = 1.0V	0.328	**0.186**	**0.621**	mmho
A_{VOL}	Error Amp Voltage Gain	V_{COMP} = 0.5V to 1.6V R_{COMP} = 1.0 MΩ [3]	70	41/**21**		V/V

(1) External components such as the diode, inductor, input and output capacitors can affect switching regulator performance. When the D2587A is used as shown in Figure 61 and Figure 62, system performance will be as specified by the system parameters.

(2) All room temperature limits are 100% production tested, and all limits at temperature extremes are specified via correlation using standard Statistical Quality Control (SQC) methods.

(3) A 1-MΩ resistor is connected to the compensation pin (which is the error amplifier output) to ensure accuracy in measuring A_{VOL}.

Electrical Characteristics: Adjustable

(Specifications with standard type face are for T_J = 25°C, and those in **bold** apply over full Operating Temperature Range.Unless otherwise specified, V_{IN} = 5V.)

PARAMETER		TEST CONDITIONS	TYP	MIN	MAX	UNIT
SYSTEM PARAMETERS Test Circuit of Figure 62(1)						
V_{OUT}	Output Voltage	V_{IN} = 4V to 10V I_{LOAD} = 300 mA to 1.2A	12.0	11.52/**11.40**	12.48/**12.60**	V
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	V_{IN} = 4V to 10V I_{LOAD} = 300 mA	20		100/**200**	mV
$\Delta V_{OUT}/\Delta I_{LOAD}$	Load Regulation	V_{IN} = 10V I_{LOAD} = 300 mA to 1.2A	20		100/**200**	mV
η	Efficiency	V_{IN} = 10V, I_{LOAD} = 1A	90			%
UNIQUE DEVICE PARAMETERS (2)						
V_{REF}	Output Reference Voltage	Measured at Feedback Pin V_{COMP} = 1.0V	1.230	1.208/**1.205**	1.252/**1.255**	V
ΔV_{REF}	Reference Voltage Line Regulation	V_{IN} = 4V to 40V	1.5			mV
G_M	Error Amp Transconductance	I_{COMP} = −30 µA to +30 µA V_{COMP} = 1.0V	3.200	**1.800**	**6.000**	mmho
A_{VOL}	Error Amp Voltage Gain	V_{COMP} = 0.5V to 1.6V R_{COMP} = 1.0 MΩ (3)	670	400/**200**		V/V
I_B	Error Amp Input Bias Current	V_{COMP} = 1.0V	125		425/**600**	nA

(1) External components such as the diode, inductor, input and output capacitors can affect switching regulator performance. When the D2587A is used as shown in Figure 61 and Figure 62, system performance will be as specified by the system parameters.

(2) All room temperature limits are 100% production tested, and all limits at temperature extremes are specified via correlation using standard Statistical Quality Control (SQC) methods.

(3) A 1-MΩ resistor is connected to the compensation pin (which is the error amplifier output) to ensure accuracy in measuring AVOL.

Electrical Characteristics: All Output Voltage Versions (1)

(Specifications with standard type face are for T_J = 25°C, and those in **bold** apply over full Operating Temperature Range.Unless otherwise specified, V_{IN} = 5V.)

PARAMETER		TEST CONDITIONS	TYP	MIN	MAX	UNIT
I_S	Input Supply Current	(Switch Off) See(2)	11		15.5/**16.5**	mA
		I_{SWITCH} = 3.0A	85		140/**165**	mA
V_{UV}	Input Supply Undervoltage Lockout	R_{LOAD} = 100Ω	3.30	**3.05**	**3.75**	V
f_O	Oscillator Frequency	Measured at Switch Pin R_{LOAD} = 100Ω V_{COMP} = 1.0V	100	85/**75**	115/**125**	kHz
f_{SC}	Short-Circuit Frequency	Measured at Switch Pin R_{LOAD} = 100Ω $V_{FEEDBACK}$ = 1.15V	25			kHz
V_{EAO}	Error Amplifier Output Swing	Upper Limit See(3)	2.8	2.6/**2.4**		V
		Lower Limit See(2)	0.25		0.40/**0.55**	V
I_{EAO}	Error Amp Output Current (Source or Sink)	See(4)	165	110/**70**	260/**320**	µA

(1) All room temperature limits are 100% production tested, and all limits at temperature extremes are specified via correlation using standard Statistical Quality Control (SQC) methods.

(2) To measure this parameter, the feedback voltage is set to a high value, depending on the output version of the device, to force the error amplifier output low. Adj: VFB = 1.41 V; 3.3 V: VFB = 3.8 V; 5 V: VFB = 5.75 V; 12 V: VFB = 13.8 V.

(3) To measure this parameter, the feedback voltage is set to a low value, depending on the output version of the device, to force the error amplifier output high. Adj: VFB = 1.05 V; 3.3 V: VFB = 2.81 V; 5 V: VFB = 4.25 V; 12 V: VFB = 10.2 V.

(4) To measure the worst-case error amplifier output current, the D2587A is tested with the feedback voltage set to its low value (specified in Note 7) and at its high value (specified in Note 8).

Electrical Characteristics: All Output Voltage Versions (1) (continued)

（Specifications with standard type face are for T_J = 25°C, and those in **bold** apply over full Operating Temperature Range.Unless otherwise specified, V_{IN} = 5V.）

PARAMETER		TEST CONDITIONS	TYP	MIN	MAX	UNIT
I_{SS}	Soft Start Current	$V_{FEEDBACK}$ = 0.92V V_{COMP} = 1.0V	11.0	8.0/**7.0**	17.0/**19.0**	µA
D	Maximum Duty Cycle	R_{LOAD} = 100Ω See(3)	98	93/**90**		%
I_L	Switch Leakage Current	Switch Off V_{SWITCH} = 60V	15		300/**600**	µA
V_{SUS}	Switch Sustaining Voltage	dV/dT = 1.5V/ns		65		V
V_{SAT}	Switch Saturation Voltage	I_{SWITCH} = 5.0A	0.7		1.1/**1.4**	V
I_{CL}	NPN Switch Current Limit		6.5	**5.0**	**9.5**	A

Typical Characteristics

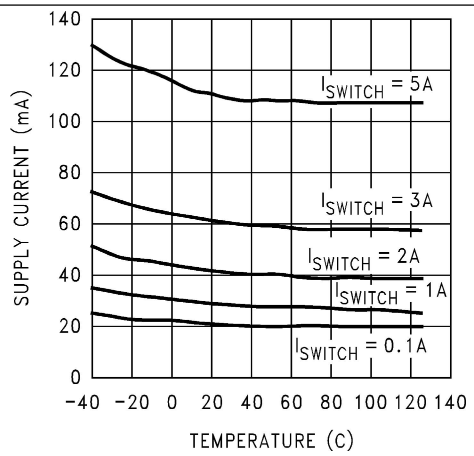


Figure 1. Supply Current vs Temperature

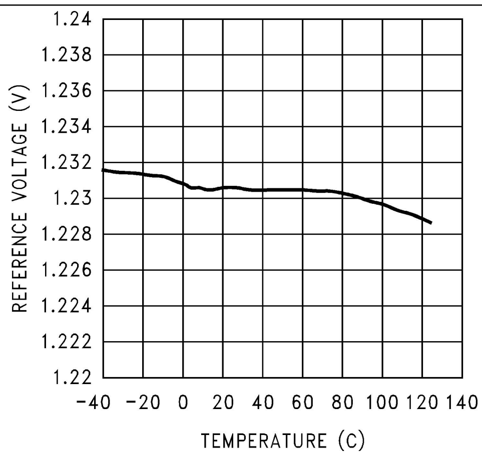


Figure 2. Reference Voltage vs Temperature

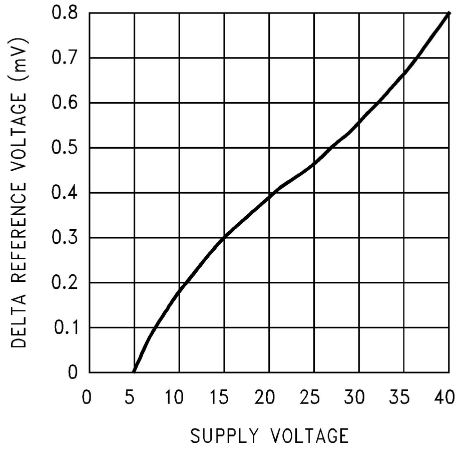


Figure 3. ΔReference Voltage vs Supply Voltage

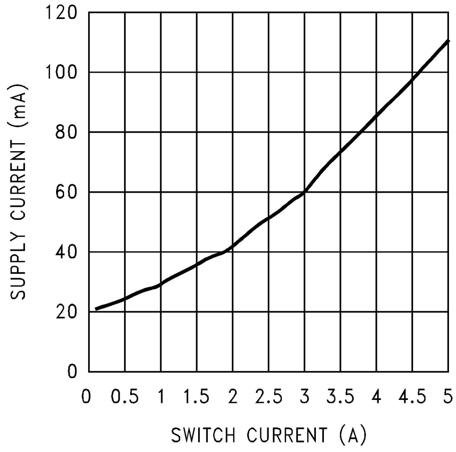


Figure 4. Supply Current vs Switch Current

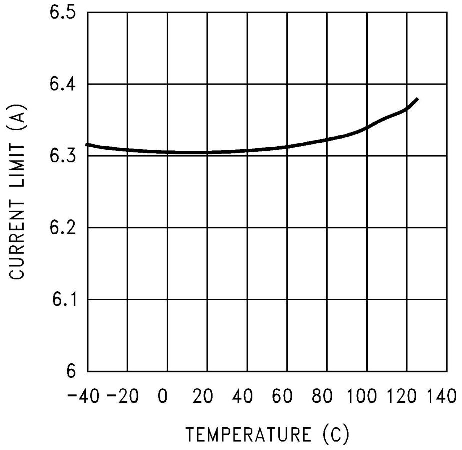


Figure 5. Current Limit vs Temperature

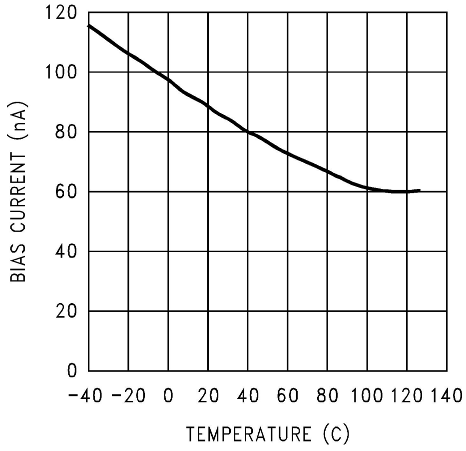


Figure 6. Feedback Pin Bias Current vs Temperature

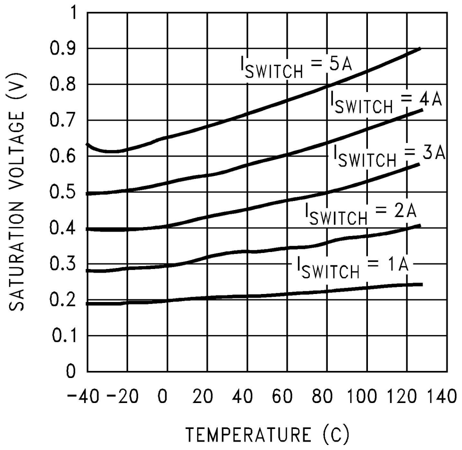


Figure 7. Switch Saturation Voltage vs Temperature

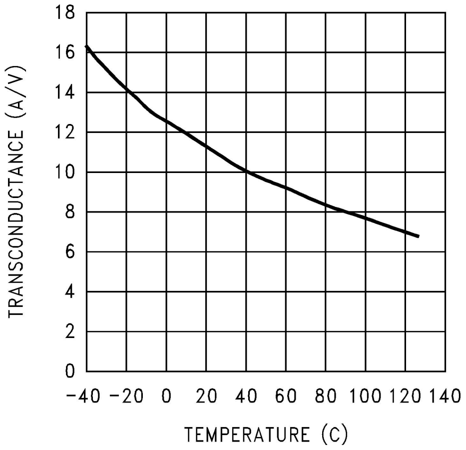


Figure 8. Switch Transconductance vs Temperature

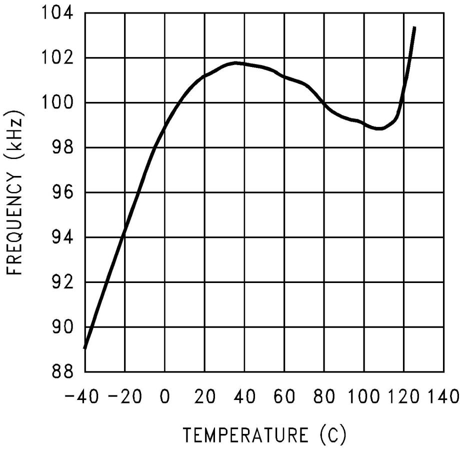


Figure 9. Oscillator Frequency vs Temperature

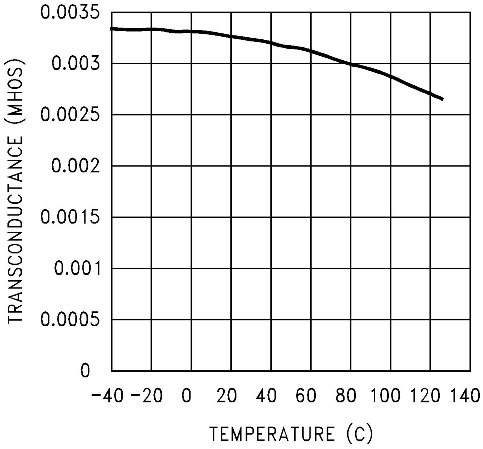


Figure 10. Error Amp Transconductance vs Temperature

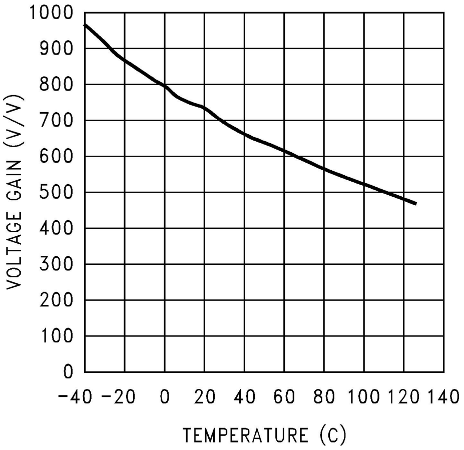


Figure 11. Error Amp Voltage Gain vs Temperature

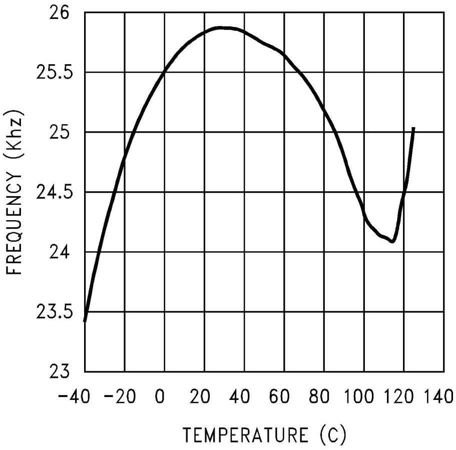
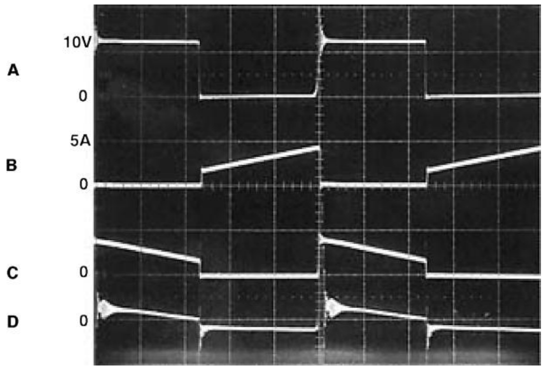


Figure 12. Short Circuit Frequency vs Temperature



A: Switch Voltage, 10 V/div B: Switch Current, 5 A/div C: Output Rectifier Current, 5 A/div D: Output Ripple Voltage, 100 mV/div AC-Coupled

Horizontal: 2 μs/div

Figure 13. Switching Waveforms

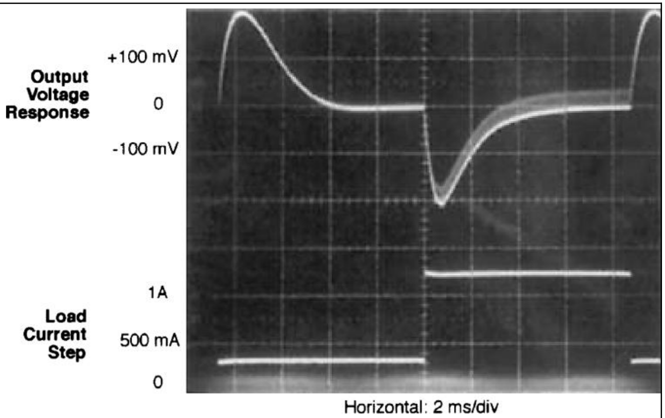


Figure 14. V_{OUT} Load Current Step Response

Detailed Description

Overview

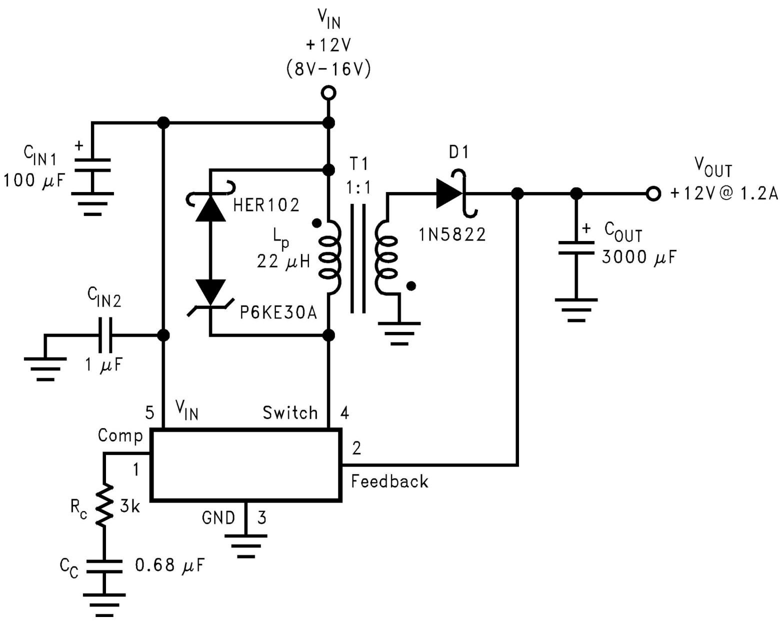
The D2587A is ideally suited for use in the flyback regulator topology. The flyback regulator can produce a single output voltage, such as the one shown in Figure 15, or multiple output voltages. In Figure 15, the flyback regulator generates an output voltage that is inside the range of the input voltage. This feature is unique to flyback regulators and cannot be duplicated with buck or boost regulators.

The operation of a flyback regulator is as follows (refer to Figure 15): when the switch is on, current flows through the primary winding of the transformer, T1, storing energy in the magnetic field of the transformer. Note that the primary and secondary windings are out of phase, so no current flows through the secondary when current flows through the primary. When the switch turns off, the magnetic field collapses, reversing the voltage polarity of the primary and secondary windings. Now rectifier D1 is forward biased and current flows through it, releasing the energy stored in the transformer. This produces voltage at the output.

The output voltage is controlled by modulating the peak switch current. This is done by feeding back a portion of the output voltage to the error amp, which amplifies the difference between the feedback voltage and a 1.23-V reference. The error amp output voltage is compared to a ramp voltage proportional to the switch current (in other words, inductor current during the switch on time). The comparator terminates the switch on time when the two voltages are equal, thereby controlling the peak switch naintain a constant output voltage.

As shown in Figure 15, the D2587A can be used as a flyback regulator by using a minimum number of external components. The switching waveforms of this regulator are shown in Figure 13. Typical Performance Characteristics observed during the operation of this circuit are shown in Figure 14.

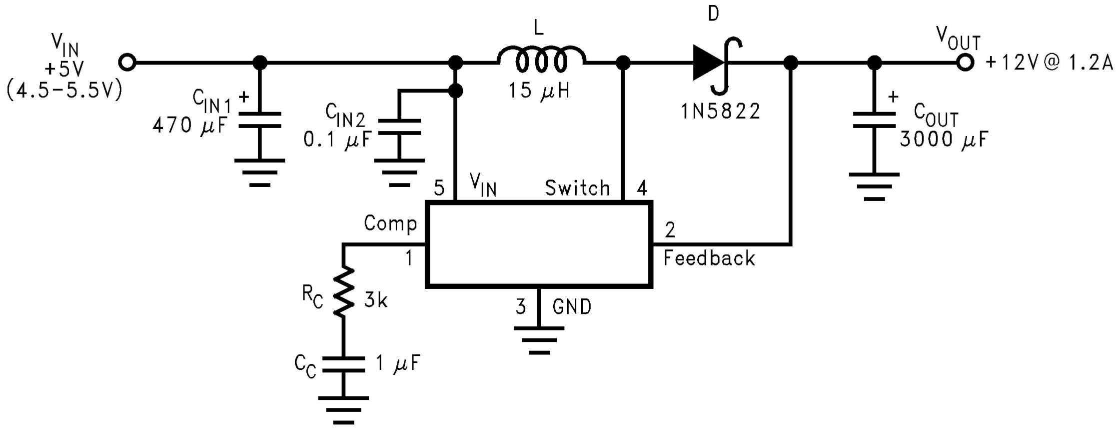
Figure 15. 12-V Flyback Regulator Design Example



Step-Up (Boost) Regulator Operation

Figure 16 shows the D2587A used as a step-up (boost) regulator. This is a switching regulator that produces an output voltage greater than the input supply voltage.

A brief explanation of how the D2587A Boost Regulator works is as follows (refer to Figure 16). When the NPN switch turns on, the inductor current ramps up at the rate of VIN/L, storing energy in the inductor. When the switch turns off, the lower end of the inductor flies above VIN, discharging its current through diode (D) into the output capacitor (COUT) at a rate of (VOUT − VIN)/L. Thus, energy stored in the inductor during the switch on time is transferred to the output during the switch off time. The output voltage is controlled by adjusting the peak switch current, as described in the section.



By adding a small number of external components (as shown in Figure 16), the D2587A can be used to produce a regulated output voltage that is greater than the applied input voltage. The switching waveforms observed during the operation of this circuit are shown in . Typical performance of this regulator is shown in .

Figure 16. 12-V Boost Regulator

Application And Implementation

Application Information

The D2587A series of regulators are monolithic integrated circuits specifically designed for flyback, step-up (boost), and forward converter applications. Requiring a minimum number of external components, these regulators are cost effective and simple to use.

Typical Applications

Typical Boost Regulator Applications

Figure 18 through Figure 21 show four typical boost applications)—one fixed and three using the adjustable version of the D2587A. Each drawing contains the part number(s) and manufacturer(s) for every component. For the fixed 12-V output application, the part numbers and manufacturers' names for the inductor are listed in . For applications with different output voltages, refer to the Switchers Made Simple software.

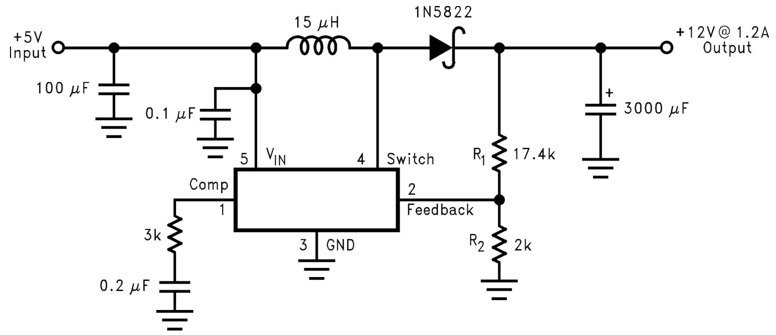


Figure 17. Boost Regulator

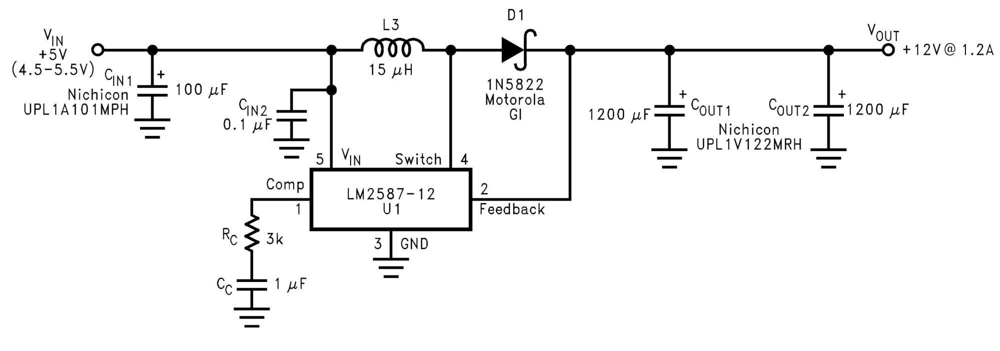


Figure 18. 5-V To 12-V Boost Regulator

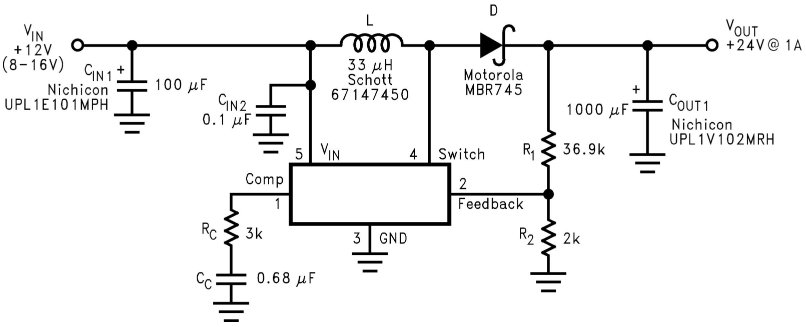


Figure 19. 12-V To 24-V Boost Regulator

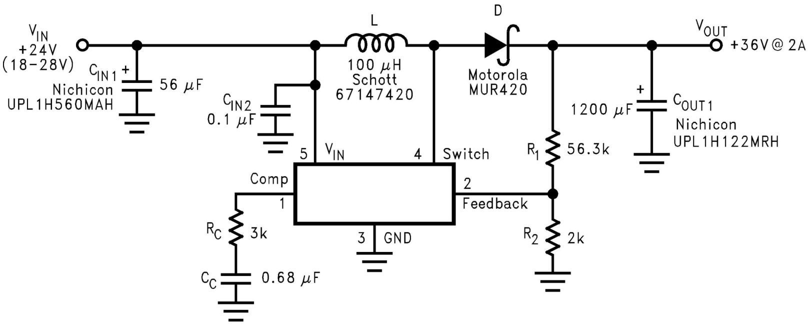
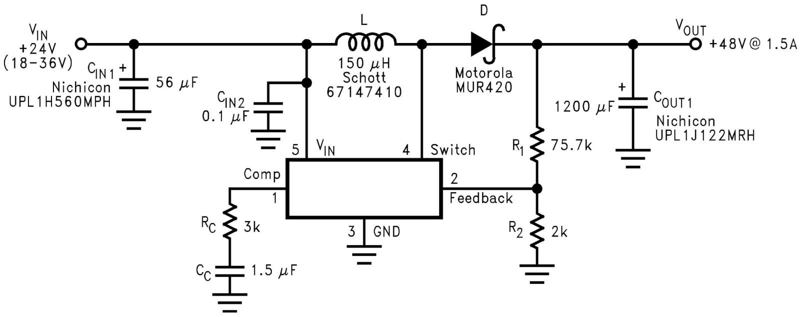


Figure 20. 24-V To 36-V Boost Regulator



*The LM2585 will require a heat sink in these applications. The size of the heat sink will depend on the maximum ambient temperature. To calculate the thermal resistance of the IC and the size of the heat sink needed, see

Figure 21. 24-V To 48-V Boost Regulator

Typical Flyback Regulator Applications

Figure 24 Figure 25 Figure 26 show six typical flyback applications, varying from single output to triple output. Each drawing contains the part number(s) and manufacturer(s) for every component except the transformer. For the transformer part numbers and manufacturers names, see the table in . For applications with different output voltages—requiring the D2587A-ADJ—or different output configurations that do not match the standard configurations, refer to the Switchers Made Simple software.

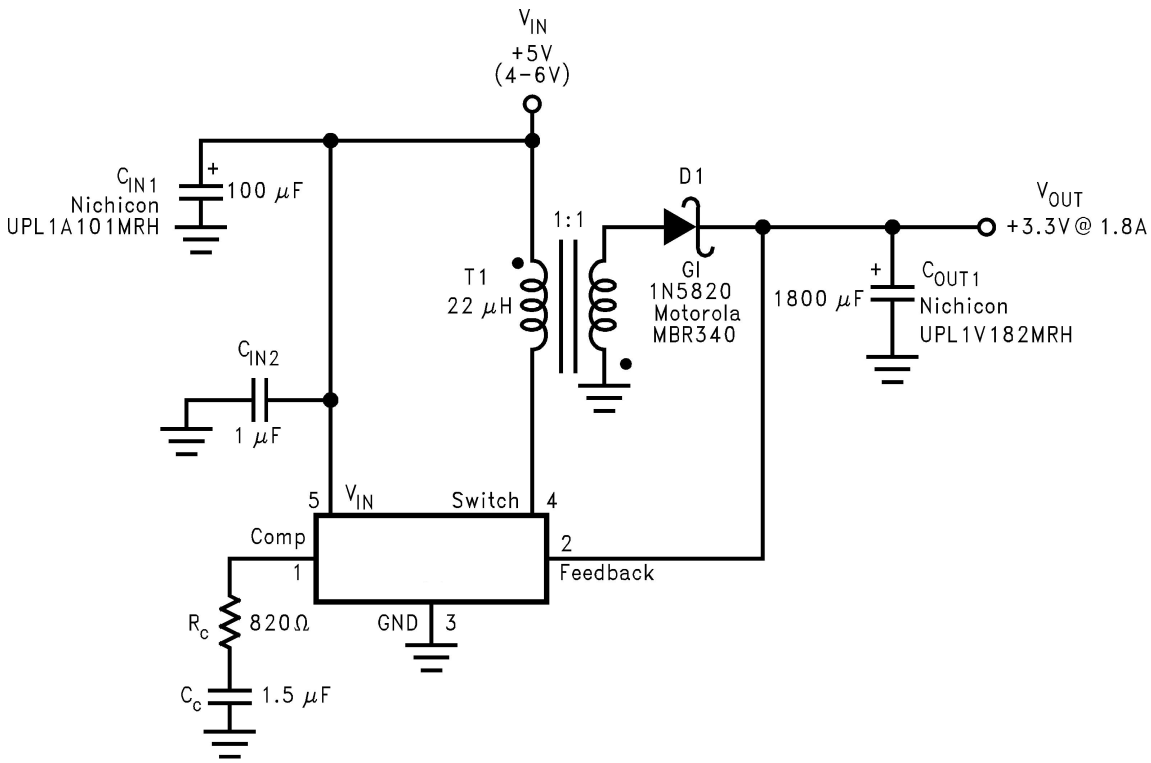


Figure 22. Single-Output Flyback Regulator

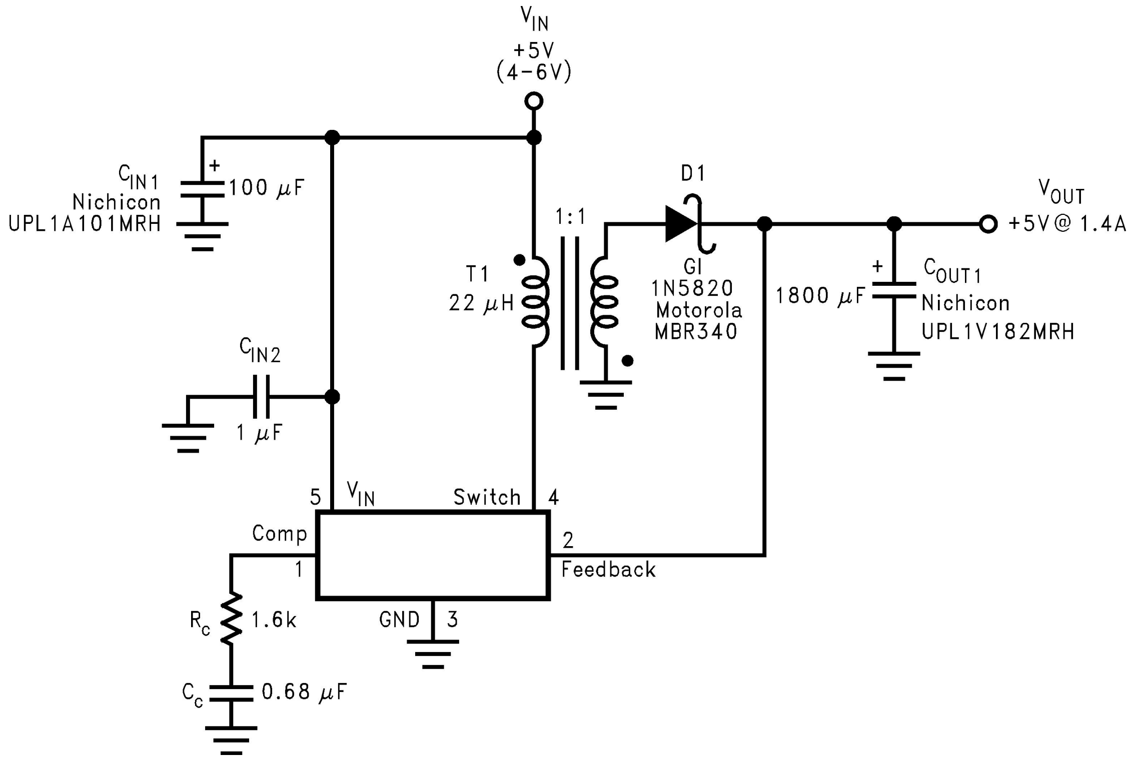


Figure 23. Single-Output Flyback Regulator

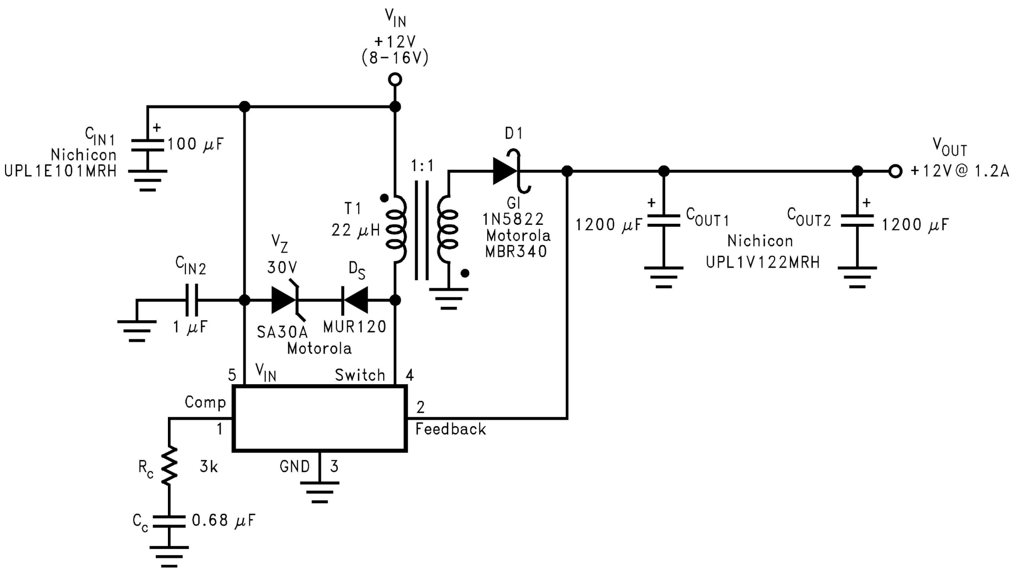


Figure 24. Single-Output Flyback Regulator

Figure 24. Single-Output Flyback Regulator

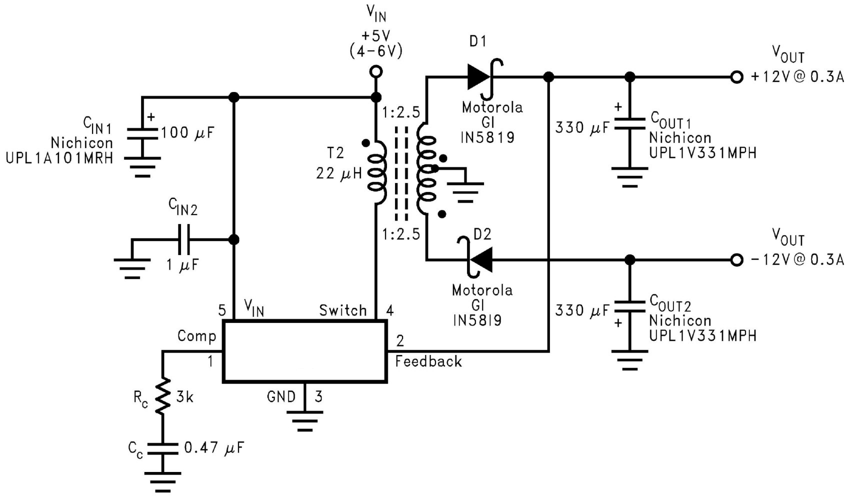


Figure 25. Dual-Output Flyback Regulator

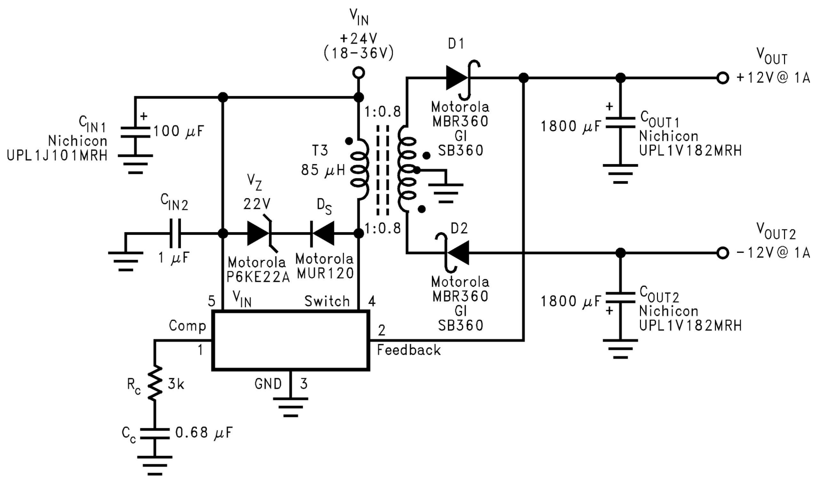


Figure 26. Dual-Output Flyback Regulator

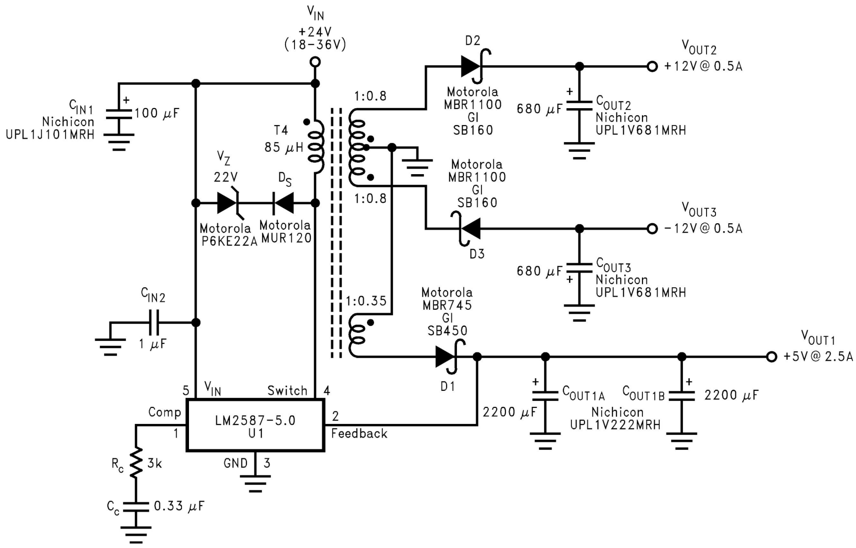


Figure 27. Triple-Output Flyback Regulator

Transformer Selection

lists the standard transformers available for flyback regulator applications. Included in the table are the turns ratio(s) for each transformer, as well as the output voltages, input voltage ranges, and the maximum load currents for each circuit.

Applications			Figure 24	Figure 25	Figure 26	Figure 27
Transformers	T1	T1	T1	T2	T3	T4
V_{IN}	4V–6V	4V–6V	8V–16V	4V–6V	18V–36V	18V–36V
V_{OUT1}	3.3V	5V	12V	12V	12V	5V
I_{OUT1} (Max)	1.8A	1.4A	1.2A	0.3A	1A	2.5A
N_1	1	1	1	2.5	0.8	0.35
V_{OUT2}				−12V	−12V	12V
I_{OUT2} (Max)				0.3A	1A	0.5A
N_2				2.5	0.8	0.8
V_{OUT3}						−12V
I_{OUT3} (Max)						0.5A
N_3						0.8

Table 1. Transformer Selection Table

Transformer Footprints

through Figure 58 show the footprints of each transformer, listed in .

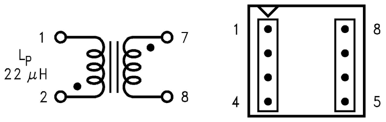


Figure 28. Coilcraft Q4434-B (Top View)

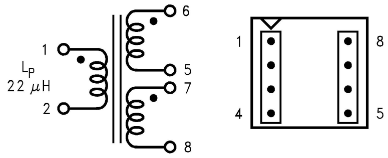


Figure 29. Coilcraft Q4337-B (Top View)

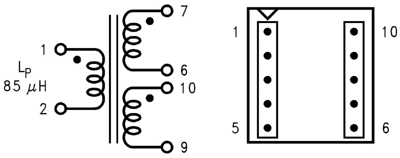


Figure 30. Coilcraft Q4343-B (Top View)

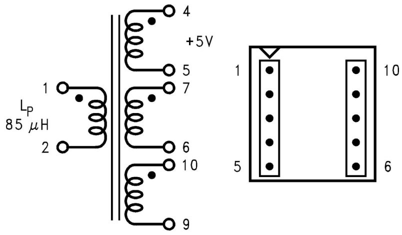


Figure 31. Coilcraft Q4344-B (Top View)

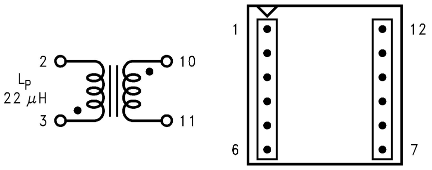


Figure 32. Coilcraft Q4435-B (Surface Mount) (Top View)

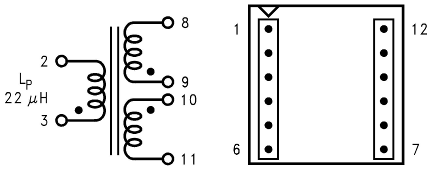


Figure 33. Coilcraft Q4436-B (Surface Mount) (Top View)

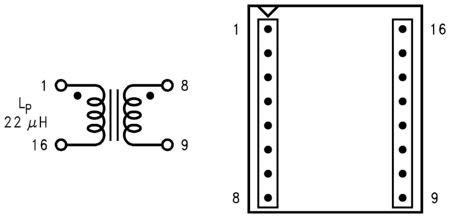


Figure 34. Pulse PE-68411 (Surface Mount) (Top View)

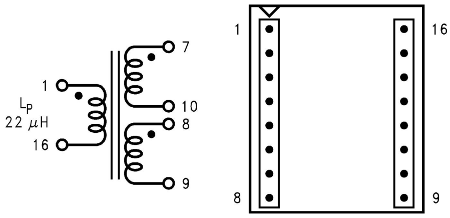


Figure 35. Pulse PE-68412 (Surface Mount) (Top View)

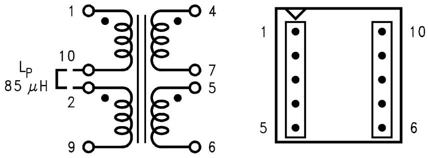


Figure 36. Pulse PE-68421 (Surface Mount) (Top View)

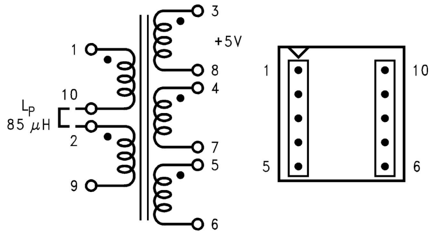


Figure 37. Pulse PE-68422 (Surface Mount) (Top View)

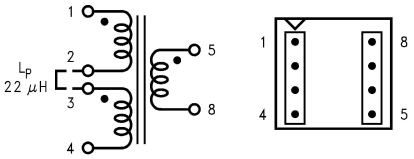


Figure 38. Renco RL-5530 (Top View)

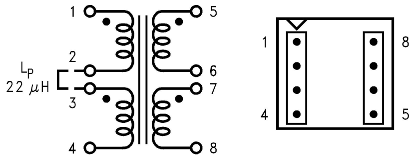


Figure 39. Renco RL-5531 (Top View)

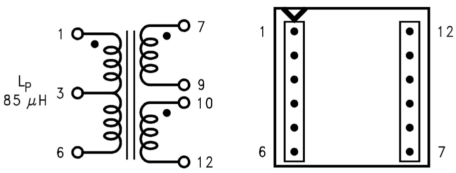


Figure 40. Renco RL-5534 (Top View)

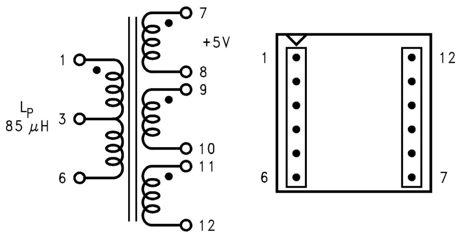


Figure 41. Renco RL-5535 (Top View)

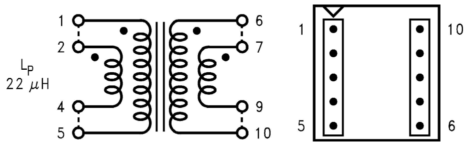


Figure 42. Schott 67141450 (Top View)

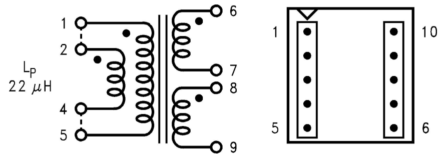


Figure 43. Schott 67140860 (Top View)

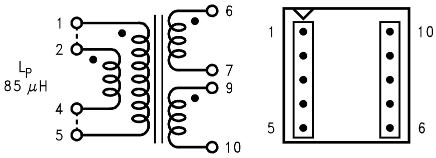


Figure 44. Schott 67140920 (Top View)

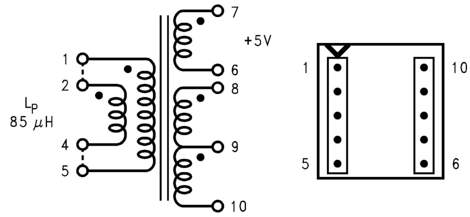


Figure 45. Schott 67140930 (Top View)

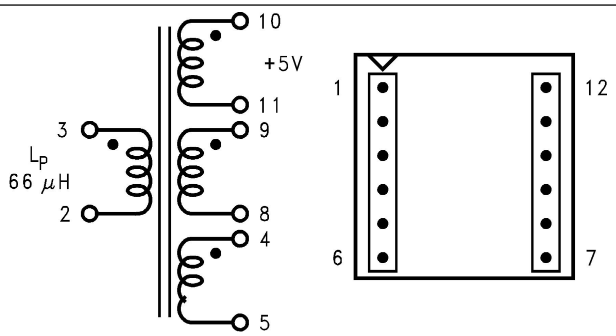


Figure 46. Coilcraft Q4437-B (Top View)
(Surface Mount)

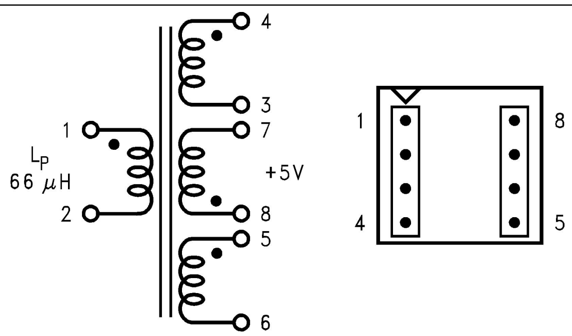


Figure 47. Coilcraft Q4338-B
(Top View)

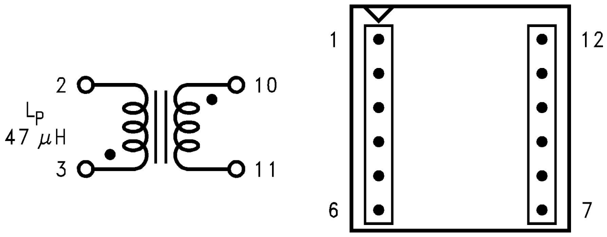


Figure 48. Coilcraft S6057-A (Top View)
(Surface Mount)

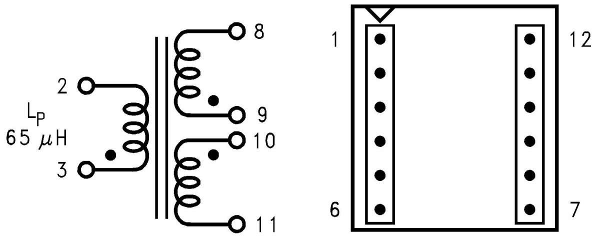


Figure 49. Coilcraft Q4438-B (Top View)
(Surface Mount)

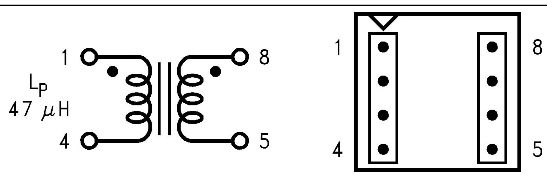


Figure 50. Pulse Pe-68482 (Top View)

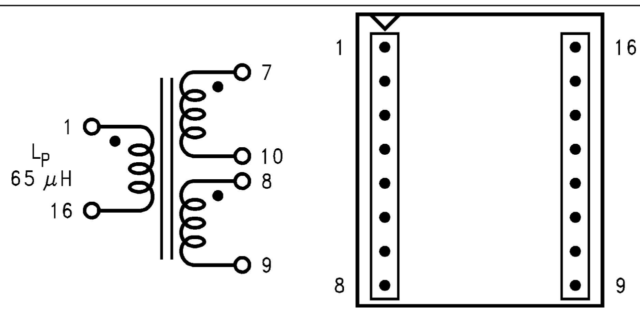


Figure 51. Pulse Pe-68414 (Top View)
(Surface Mount)

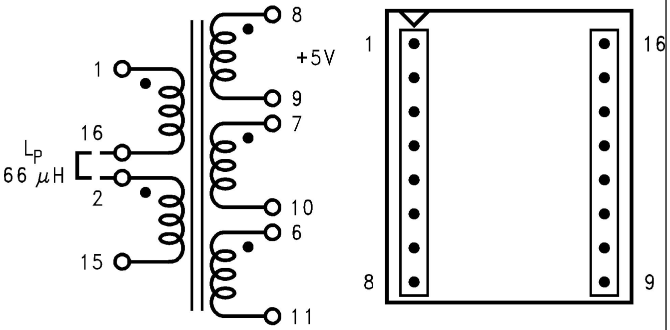


Figure 52. Pulse Pe-68413 (Top View)
(Surface Mount)

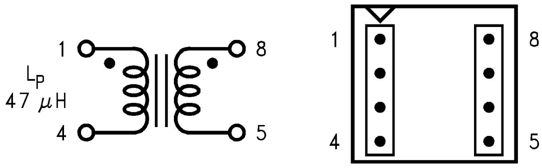


Figure 53. Renco RI-5751 (Top View)

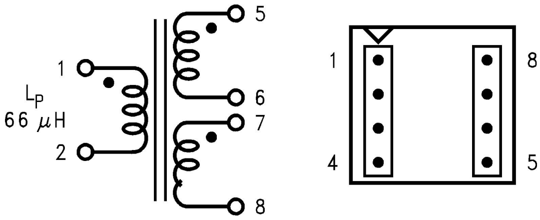


Figure 54. Renco RI-5533
(Top View)

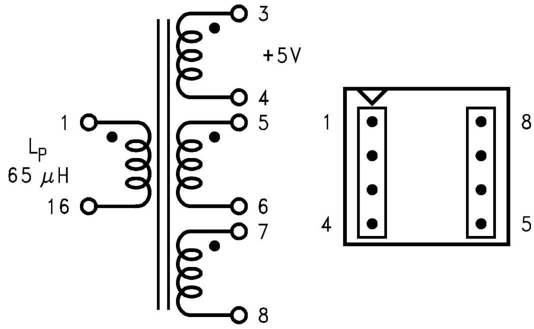


Figure 55. Renco RI-5532 (Top View)

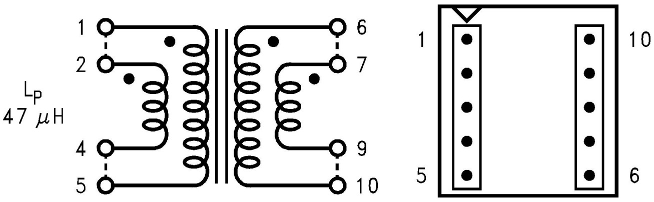


Figure 56. Schott 26606 (Top View)

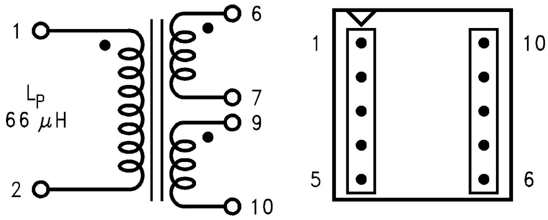


Figure 57. Schott 67140900 (Top View)

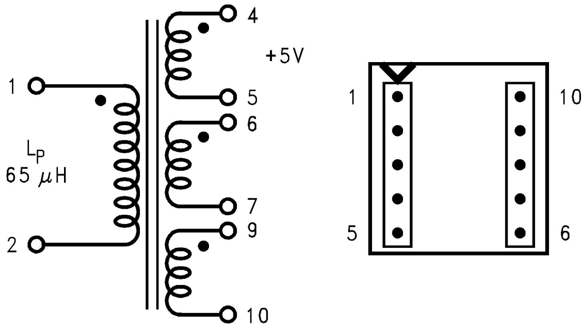


Figure 58. Schott 67140890
(Top View)

Programming Output Voltage (Selecting R_1 And R_2)

Referring to the adjustable regulator in Figure 17, the output voltage is programmed by the resistors R_1 and R_2 by the following formula:

$V_{OUT} = V_{REF}\,(1 + R_1/R_2)$ where $V_{REF} = 1.23V$ (1)

Resistors R_1 and R_2 divide the output voltage down so that it can be compared with the 1.23V internal reference. With R_2 between 1k and 5k, R_1 is:

$R_1 = R_2\,(V_{OUT}/V_{REF} - 1)$ where $V_{REF} = 1.23V$ (2)

For best temperature coefficient and stability with time, use 1% metal film resistors.

Short Circuit Condition

Due to the inherent nature of boost regulators, when the output is shorted (see Figure 17), current flows directly from the input, through the inductor and the diode, to the output, bypassing the switch. The current limit of the switch does not limit the output current for the entire circuit. To protect the load and prevent damage to the switch, the current must be externally limited, either by the input supply or at the output with an external current limit circuit. The external limit should be set to the maximum switch current of the device, which is 5A.

In a flyback regulator application (Figure 59), using the standard transformers, the D2587A will survive a short circuit to the main output. When the output voltage drops to 80% of its nominal value, the frequency will drop to 25 kHz. With a lower frequency, off times are larger. With the longer off times, the transformer can release all of its stored energy before the switch turns back on. Hence, the switch turns on initially with zero current at its collector. In this condition, the switch current limit will limit the peak current, saving the device.

Flyback Regulator Input Capacitors

A flyback regulator draws discontinuous pulses of current from the input supply. Therefore, there are two input capacitors needed in a flyback regulator; one for energy storage and one for filtering (see Figure 59). Both are required due to the inherent operation of a flyback regulator. To keep a stable or constant voltage supply to the D2587A, a storage capacitor (≥100 µF) is required. If the input source is a recitified DC supply and/or the application has a wide temperature range, the required rms current rating of the capacitor might be very large. This means a larger value of capacitance or a higher voltage rating will be needed of the input capacitor. The storage capacitor will also attenuate noise which may interfere with other circuits connected to the same input supply voltage.

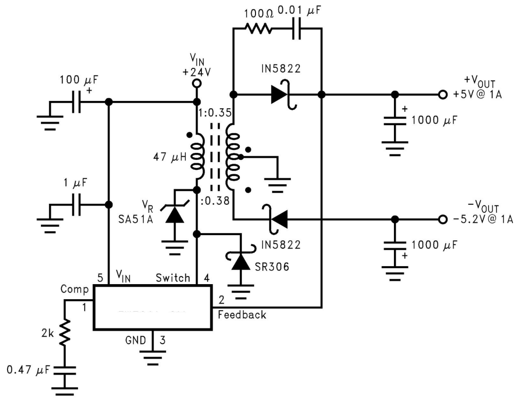


Figure 59. Flyback Regulator

In addition, a small bypass capacitor is required due to the noise generated by the input current pulses. To eliminate the noise, insert a 1.0 µF ceramic capacitor between V_{IN} and ground as close as possible to the device.

Switch Voltage Limits

In a flyback regulator, the maximum steady-state voltage appearing at the switch, when it is off, is set by the transformer turns ratio, N, the output voltage, V_{OUT}, and the maximum input voltage, V_{IN} (Max):

$$V_{SW(OFF)} = V_{IN}\,(Max) + (V_{OUT} + V_F)/N \qquad (3)$$

where V_F is the forward biased voltage of the output diode, and is 0.5V for Schottky diodes and 0.8V for ultra-fast recovery diodes (typically). In certain circuits, there exists a voltage spike, V_{LL}, superimposed on top of the steady-state voltage (see Figure 13, waveform A). Usually, this voltage spike is caused by the transformer leakage inductance and/or the output rectifier recovery time. To “clamp” the voltage at the switch from exceeding its maximum value, a transient suppressor in series with a diode is inserted across the transformer primary (as shown in the circuit on the front page and other flyback regulator circuits throughout the datasheet). The schematic in Figure 59 shows another method of clamping the switch voltage. A single voltage transient suppressor (the SA51A) is inserted at the switch pin. This method clamps the total voltage across the switch, not just the voltage across the primary.

If poor circuit layout techniques are used (see the Layout Guidelines section), negative voltage transients may appear on the Switch pin (pin 4). Applying a negative voltage (with respect to the IC's ground) to any monolithic IC pin causes erratic and unpredictable operation of that IC. This holds true for the D2587A IC as well. When used in a flyback regulator, the voltage at the Switch pin (pin 4) can go negative when the switch turns on. The “ringing” voltage at the switch pin is caused by the output diode capacitance and the transformer leakage inductance forming a resonant circuit at the secondary(ies). The resonant circuit generates the “ringing” voltage, which gets reflected back through the transformer to the switch pin. There are two common methods to avoid this problem. One is to add an RC snubber around the output rectifier(s), as in Figure 59. The values of the resistor and the capacitor must be chosen so that the voltage at the Switch pin does not drop below −0.4V. The resistor may range in value between 10Ω and 1 kΩ, and the capacitor will vary from 0.001 μF to 0.1 μF.

The other method to reduce or eliminate the “ringing” is to insert a Schottky diode clamp between pins 4 and 3 (ground), also shown in Figure 59. This prevents the voltage at pin 4 from dropping below −0.4V. The reverse voltage rating of the diode must be greater than the switch off voltage.

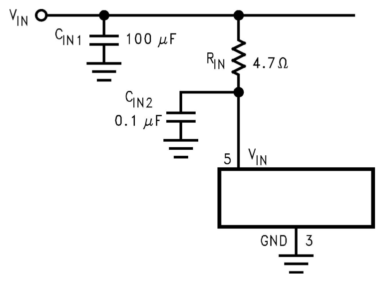


Figure 60. Input Line Filter

Output Voltage Limitations

The maximum output voltage of a boost regulator is the maximum switch voltage minus a diode drop. In a flyback regulator, the maximum output voltage is determined by the turns ratio, N, and the duty cycle, D, by the equation:

$$V_{OUT} \approx N \times V_{IN} \times D/(1 - D) \quad (4)$$

The duty cycle of a flyback regulator is determined by the following equation:

$$D = \frac{V_{OUT} + V_F}{N(V_{IN} - V_{SAT}) + V_{OUT} + V_F} \approx \frac{V_{OUT}}{N(V_{IN}) + V_{OUT}} \quad (5)$$

Theoretically, the maximum output voltage can be as large as desired—just keep increasing the turns ratio of the transformer. However, there exists some physical limitations that prevent the turns ratio, and thus the output voltage, from increasing to infinity. The physical limitations are capacitances and inductances in the D2587A switch, the output diode(s), and the transformer—such as reverse recovery time of the output diode (mentioned above).

Noisy Input Line Condition)

A small, low-pass RC filter should be used at the input pin of the D2587A if the input voltage has an unusual large amount of transient noise, such as with an input switch that bounces. The circuit in Figure 60 demonstrates the layout of the filter, with the capacitor placed from the input pin to ground and the resistor placed between the input supply and the input pin. Note that the values of RIN and C_{IN} shown in the schematic are good enough for most applications, but some readjusting might be required for a particular application. If efficiency is a major concern, replace the resistor with a small inductor (say 10 µH and rated at 100 mA).

Stability

All current-mode controlled regulators can suffer from an instability, known as subharmonic oscillation, if they operate with a duty cycle above 50%. To eliminate subharmonic oscillations, a minimum value of inductance is required to ensure stability for all boost and flyback regulators. The minimum inductance is given by:

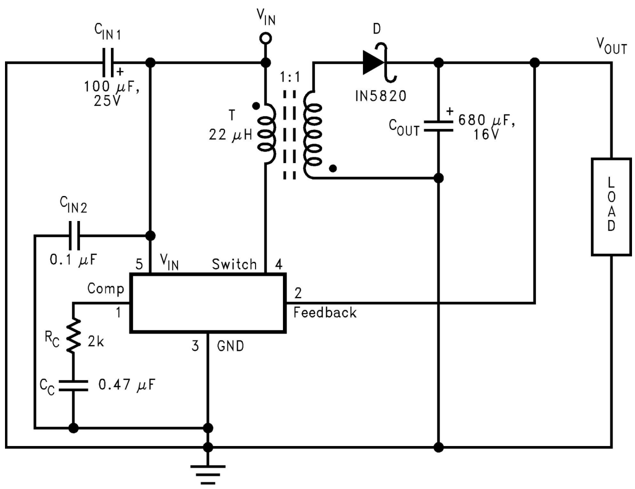
$$L(\mathrm{Min}) = \frac{2.92\,[(V_{IN}(\mathrm{Min}) - V_{SAT}) \times (2D(\mathrm{Max}) - 1)]}{1 - D(\mathrm{Max})}\ (\mu H)$$

where

- V_{SAT} is the switch saturation voltage and can be found in the Characteristic Curves. (6)

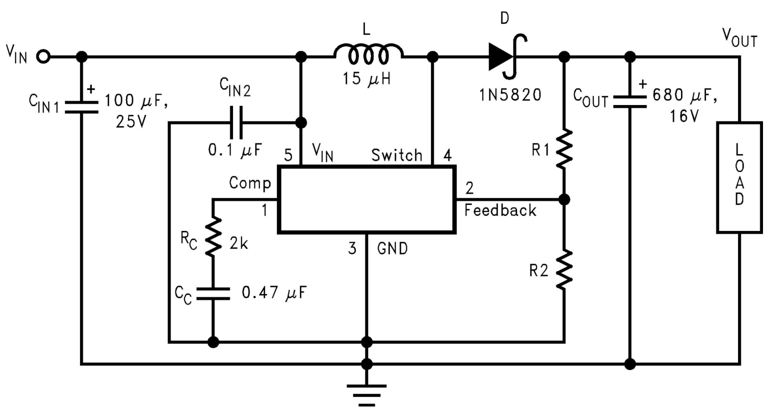
Additional Application Examples

Test Circuits



C_{IN1}—100 μF, 25V Aluminum Electrolytic C_{IN2}—0.1 μF CeramicT—22 μH, 1:1 Schott #67141450D—1N5820C_{OUT}—680 μF, 16V Aluminum Electrolytic C_C—0.47 μF Ceramic R_C—2k

Figure 61. D2587A-3.3 and D2587A-5.0 Test Circuit



C_{IN1}—100 μF, 25V Aluminum Electrolytic C_{IN2}—0.1 μF CeramicL—15 μH, Renco #RL-5472-5D—1N5820C_{OUT}—680 μF, 16V Aluminum Electrolytic C_C—0.47 μF Ceramic R_C—2kFor 12V Devices: R_1 = Short (0Ω) and R_2 = Open For ADJ Devices: R_1 = 48.75k, ±0.1% and R2 = 5.62k, ±1%

Figure 62. D2587A-12 and D2587A-ADJ Test Circuit

Layout

Layout Guidelines

As in any switching regulator, layout is very important. Rapidly switching currents associated with wiring inductance generate voltage transients which can cause problems. For minimal inductance and ground loops, keep the length of the leads and traces as short as possible. Use single point grounding or ground plane construction for best results. Separate the signal grounds from the power grounds (as indicated in Figure 63). When using the adjustable version, physically locate the programming resistors as near the regulator IC as possible, to keep the sensitive feedback wiring short.

Layout Example

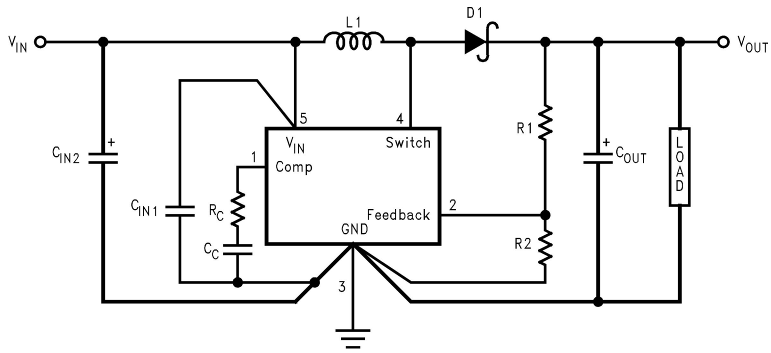


Figure 63. Circuit Board Layout

Heat Sink/Thermal Considerations

In many cases, no heat sink is required to keep the D2587A junction temperature within the allowed operating range. For each application, to determine whether or not a heat sink will be required, the following must be identified:

1) Maximum ambient temperature (in the application).

2) Maximum regulator power dissipation (in the application).

3) Maximum allowed junction temperature (125°C for the D2587A). For a safe, conservative design, a temperature approximately 15°C cooler than the maximum junction temperature should be selected (110°C).

4) D2587A package thermal resistances θ_{JA} and θ_{JC} (given in the Electrical Characteristics).

Total power dissipated (P_D) by the D2587A can be estimated as follows:

Boost:

$$P_D = 0.15\Omega \times \left(\frac{I_{LOAD}}{1-D}\right)^2 \times D + \frac{I_{LOAD}}{50\times(1-D)} \times D \times V_{IN}$$

Flyback:

$$P_D = 0.15\Omega \times \left(\frac{N \times \Sigma I_{LOAD}}{1-D}\right)^2 \times D + \frac{N\times\Sigma I_{LOAD}}{50\times(1-D)} \times D \times V_{IN}$$

V_{IN} is the minimum input voltage, V_{OUT} is the output voltage, N is the transformer turns ratio, D is the duty cycle, and I_{LOAD} is the maximum load current (and $\sum I_{LOAD}$ is the sum of the maximum load currents for multiple-output flyback regulators). The duty cycle is given by:

Boost:

$$D = \frac{V_{OUT} + V_F - V_{IN}}{V_{OUT} + V_F - V_{SAT}} \approx \frac{V_{OUT} - V_{IN}}{V_{OUT}}$$

Flyback:

$$D = \frac{V_{OUT} + V_F}{N(V_{IN} - V_{SAT}) + V_{OUT} + V_F} \approx \frac{V_{OUT}}{N(V_{IN}) + V_{OUT}}$$

where

- V_F is the forward biased voltage of the diode and is typically 0.5V for Schottky diodes and 0.8V for fast recovery diodes.
- V_{SAT} is the switch saturation voltage and can be found in the Characteristic Curves. (8)

When no heat sink is used, the junction temperature rise is:

$\Delta T_J = P_D \times \theta_{JA}$. (9)

Adding the junction temperature rise to the maximum ambient temperature gives the actual operating junction temperature:

$T_J = \Delta T_J + T_A$. (10)

If the operating junction temperature exceeds the maximum junction temperatue in item 3 above, then a heat sink is required. When using a heat sink, the junction temperature rise can be determined by the following:

$\Delta T_J = P_D \times (\theta_{JC} + \theta_{Interface} + \theta_{Heat\ Sink})$ (11)

Again, the operating junction temperature will be:

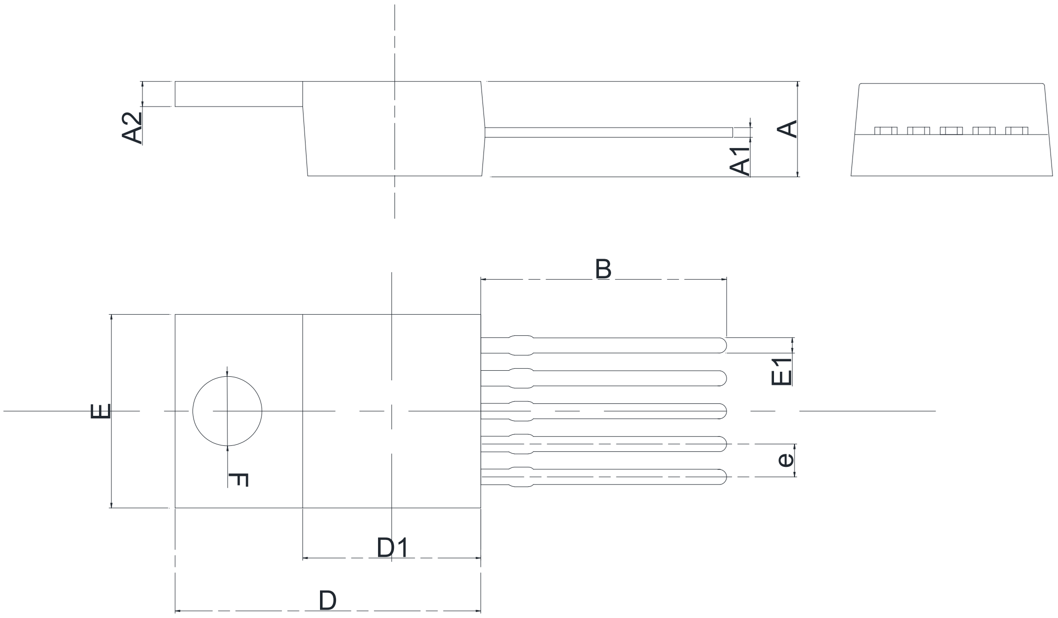
$T_J = \Delta T_J + T_A$ (12)

As before, if the maximum junction temperature is exceeded, a larger heat sink is required (one that has a lower thermal resistance).

Included in the Switchers Made Simple design software is a more precise (non-linear) thermal model that can be used to determine junction temperature with different input-output parameters or different component values. It can also calculate the heat sink thermal resistance required to maintain the regulator junction temperature below the maximum operating temperature.

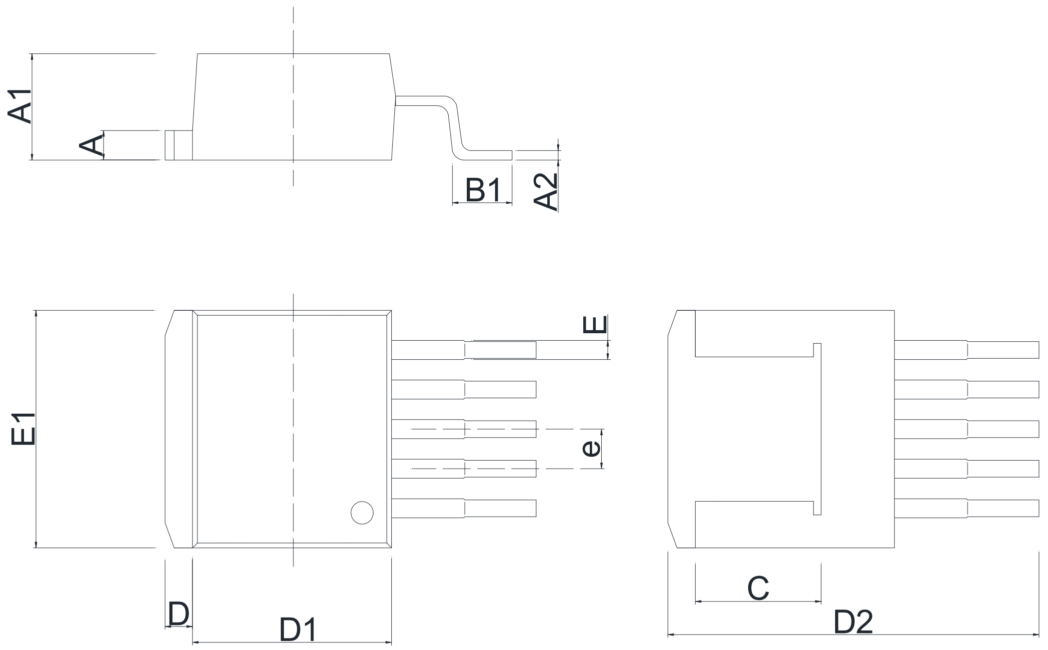
Outline Dimensions

TO220-5: Unit：mm



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	4.300	4.700	0.169	0.185
A1	0.450	0.600	0.017	0.023
A2	1.250	1.400	0.049	0.055
B	12.880	13.380	0.507	0.527
D	15.500	15.900	0.610	0.626
D1	9.000	9.400	0.354	0.370
E	9.700	10.100	0.381	0.398
E1	0.660	0.914	0.025	0.036
e	1.702（BSC）		0.670（BSC）	
F	Φ3.500	Φ3.700	Φ0.137	Φ0.146

TO263-5:	Unit:mm



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.170	1.370	0.046	0.054
A1	4.350	4.750	0.171	0.187
A2	0.310	0.530	0.012	0.021
B1	2.340	2.740	0.092	0.108
C	5.080 REF		0.200 REF	
D	1.170	1.370	0.046	0.054
D1	8.100	8.900	0.318	0.350
D2	14.550	15.550	0.572	0.612
E	0.660	0.860	0.025	0.034
E1	9.800	10.310	0.385	0.406
e	1.700（BSC）		0.067（BSC）	

Statements

- Silicore Technology reserves the right to make changes without further notice to any products or specifications herein. Before customers place an order, customers need to confirm whether datasheet obtained is the latest version, and to verify the integrity of the relevant information.

- Failure or malfunction of any semiconductor products may occur under particular conditions, customers shall have obligation to comply with safety standards when customers use Silicore Technology products to do their system design and machine manufacturing, and take corresponding safety measures in order to avoid potential risk of failure that may cause personal injury or property damage.

- The product upgrades without end, Silicore Technology will wholeheartedly provide customers integrated circuits that have better performance and better quality.