CS2841B

Automotive Current Mode PWM Control Circuit

The CS2841B provides all the necessary features to implement off–line fixed frequency current–mode control with a minimum number of external components.

The CS2841B (a variation of the CS2843A) is designed specifically for use in automotive operation. The low start threshold voltage of 8.0 V (typ), and the ability to survive 40 V automotive load dump transients are important for automotive subsystem designs. The CS2841 series has a history of quality and reliability in automotive applications.

The CS2841B incorporates a precision temperature–controlled oscillator with an internally trimmed discharge current to minimize variations in frequency. Duty–cycles greater than 50% are also possible. On board logic ensures that V_{REF} is stabilized before the output stage is enabled. Ion implant resistors provide tighter control of undervoltage lockout.

Features

- Optimized for Off–Line Control
- Internally Trimmed Temperature Compensated Oscillator
- Maximum Duty–Cycle Clamp
- V_{REF} Stabilized Before Output Stage Enabled
- Low Start–Up Current
- Pulse–By–Pulse Current Limiting
- Improved Undervoltage Lockout
- Double Pulse Suppression
- 1.0 % Trimmed Bandgap Reference
- High Current Totem Pole Output

ON Semiconductor™

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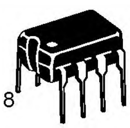
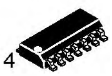


8
1

DIP–8
N SUFFIX
CASE 626



14
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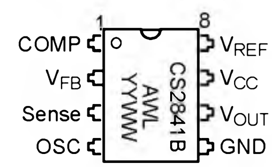
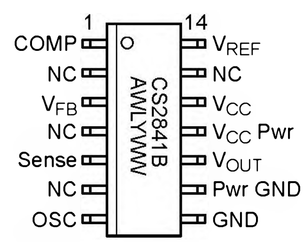
SO–14
D SUFFIX
CASE 751A

PIN CONNECTIONS AND MARKING DIAGRAM



DIP–8



SO–14

A	=	Assembly Location
WL, L	=	Wafer Lot
YY, Y	=	Year
WW, W	=	Work Week

ORDERING INFORMATION

Device	Package	Shipping
CS2841BEN8	DIP–8	50 Units/Rail
CS2841BED14	SO–14	55 Units/Rail
CS2841BEDR14	SO–14	2500 Tape & Reel

May, 2001 – Rev. 4
Publication Order Number:
CS2841B/D

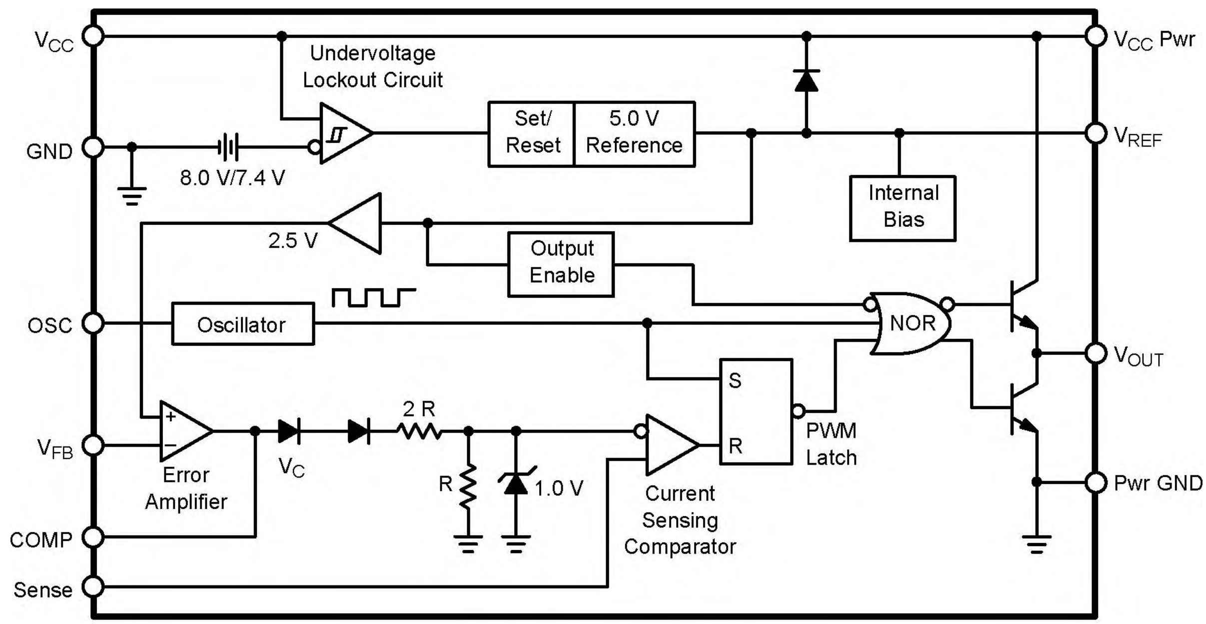


Figure 1. Block Diagram

MAXIMUM RATINGS*

Rating		Value	Unit
Supply Voltage (Low Impedance Source)		40	V
Output Current		±1.0	A
Output Energy (Capacitive Load)		5.0	μJ
Analog Inputs (V_{FB}, Sense)		–0.3 to 5.5	V
Error Amp Output Sink Current		10	mA
Lead Temperature Soldering	Wave Solder (through hole styles only) Note 1 Reflow (SMD styles only) Note 2	260 peak 230 peak	°C °C

1. 10 seconds max.
2. 60 seconds max above 183°C

*The maximum package power dissipation must be observed.

ELECTRICAL CHARACTERISTICS (–40°C ≤ T_A ≤ 85°C, R_T = 680 kΩ, C_T = 0.022 μF for Triangular Mode, V_{CC} = 15 V (Note 3), R_T = 10 kΩ, C_T = 3.3 nF for Sawtooth Mode (see Figure 7); unless otherwise specified.)

Characteristic	Test Conditions	Min	Typ	Max	Unit
Reference Section					
Output Voltage	T_J = 25°C, I_{OUT} = 1.0 mA	4.9	5.0	5.1	V
Line Regulation	8.4 ≤ V_{CC} ≤ 16 V	–	6.0	20	mV
Load Regulation	1.0 ≤ I_{OUT} ≤ 20 mA	–	6.0	25	mV
Temperature Stability	Note 4	–	0.2	0.4	mV/°C
Total Output Variation	Line, Load, Temp. Note 4	4.82	–	5.18	V
Output Noise Voltage	10 Hz ≤ f ≤ 10 kHz, T_J = 25°C. Note 4	–	50	–	μV
Long Term Stability	T_A = 125°C, 1000 Hrs. Note 4	–	5.0	25	mV
Output Short Circuit	T_A = 25°C	–30	–100	–180	mA
Oscillator Section					
Initial Accuracy	Sawtooth Mode: T_J = 25°C. See Figure 7. Sawtooth Mode: –40°C ≤ T_A ≤ +85°C Triangular Mode: T_J =25°C. See Figure 7.	47 44 44	52 52 52	57 60 60	kHz kHz kHz
Voltage Stability	8.4 ≤ V_{CC} ≤ 16 V	–	0.2	1.0	%
Temperature Stability	Sawtooth Mode: T_{MIN} ≤ T_A ≤ T_{MAX}. Note 4 Triangular Mode: T_{MIN} ≤ T_A ≤ T_{MAX}. Note 4	– –	5.0 8.0	– –	% %
Amplitude	V_{OSC} (Peak to Peak)	–	1.7	–	V
Discharge Current	T_J = 25°C T_{MIN} ≤ T_A ≤ T_{MAX}	7.4 7.2	8.3 –	9.2 9.4	mA mA
Error Amp Section					
Input Voltage	V_{COMP} = 2.5 V	2.42	2.5	2.58	V
Input Bias Current	V_{FB} = 0 V	–	–0.3	–2.0	μA
A_{VOL}	2.0 ≤ V_{OUT} ≤ 4.0 V	65	90	–	dB
Unity Gain Bandwidth	Note 4	0.7	1.0	–	MHz
PSRR	8.4 V ≤ V_{CC} ≤ 16 V	60	70	–	dB
Output Sink Current	V_{FB} = 2.7 V, V_{COMP} = 1.1 V	2.0	6.0	–	mA
Output Source Current	V_{FB} = 2.3 V, V_{COMP} = 5.0 V	–0.5	–0.8	–	mA
V_{OUT} High	V_{FB} = 2.3 V, R_L = 15 kΩ to Ground	5.0	6.0	–	V
V_{OUT} Low	V_{FB} = 2.7 V, R_L = 15 kΩ to V_{REF}	–	0.7	1.1	V
Current Sense Section					
Gain	Notes 5 and 6	2.85	3.0	3.15	V/V
Maximum Input Signal	V_{COMP} = 5.0 V. Note 5	0.9	1.0	1.1	V
PSRR	12 V ≤ V_{CC} ≤ 25 V. Note 5	–	70	–	dB
Input Bias Current	V_{Sense} = 0 V	–	–2.0	–10	μA
Delay to Output	T_J = 25°C. Note 4	–	150	300	ns

3. Adjust V_{CC} above the start threshold before setting at 15 V.
4. These parameters, although guaranteed, are not 100% tested in production.
5. Parameter measured at trip point of latch with V_{FB} = 0.
6. Gain defined as:

$$A = \frac{\Delta V_{COMP}}{\Delta V_{Sense}};\ 0 \leq V_{Sense} \leq 0.8\ V.$$

ELECTRICAL CHARACTERISTICS (continued) ($-40°C \le T_A \le 85°C$, R_T = 680 kΩ, C_T = 0.022 μF for Triangular Mode, V_{CC} = 15 V (Note 3), R_T = 10 kΩ, C_T = 3.3 nF for Sawtooth Mode (see Figure 7); unless otherwise specified.)

Characteristic	Test Conditions	Min	Typ	Max	Unit
Output Section					
Output Low Level	I_{SINK} = 20 mA I_{SINK} = 200 mA	– –	0.1 1.5	0.4 2.2	V V
Output High Level	I_{SOURCE} = 20 mA I_{SOURCE} = 200 mA	13 12	13.5 13.5	– –	V V
Rise Time	T_J = 25°C, C_L = 1.0 nF. Note 7	–	50	150	ns
Fall Time	T_J = 25°C, C_L = 1.0 nF. Note 7	–	50	150	ns
Output Leakage	Undervoltage Active, V_{OUT} = 0	–	–0.01	–10	μA
Total Standby Current					
Start–Up Current	–	–	0.5	1.0	mA
Operating Supply Current I_{CC}	$V_{FB} = V_{Sense}$ = 0 V, R_T = 10 kΩ, C_T = 3.3 nF	–	11	17	mA
Undervoltage Lockout Section					
Start Threshold	–	7.6	8.0	8.4	V
Min. Operating Voltage	After Turn On	7.0	7.4	7.8	V

7. These parameters, although guaranteed, are not 100% tested in production.

PACKAGE PIN DESCRIPTION

PACKAGE PIN #			
DIP–8	SO–14	PIN SYMBOL	FUNCTION
1	1	COMP	Error amp output, used to compensate error amplifier.
2	3	V_{FB}	Error amp inverting input.
3	5	Sense	Noninverting input to Current Sense Comparator.
4	7	OSC	Oscillator timing network with Capacitor to Ground, resistor to V_{REF}.
5	8	GND	Ground.
	9	Pwr GND	Output driver Ground.
6	10	V_{OUT}	Output drive pin.
	11	V_{CC} Pwr	Output driver positive supply.
7	12	V_{CC}	Positive power supply.
8	14	V_{REF}	Output of 5.0 V internal reference.
	2, 4, 6, 13	NC	No connection.

TYPICAL PERFORMANCE CHARACTERISTICS

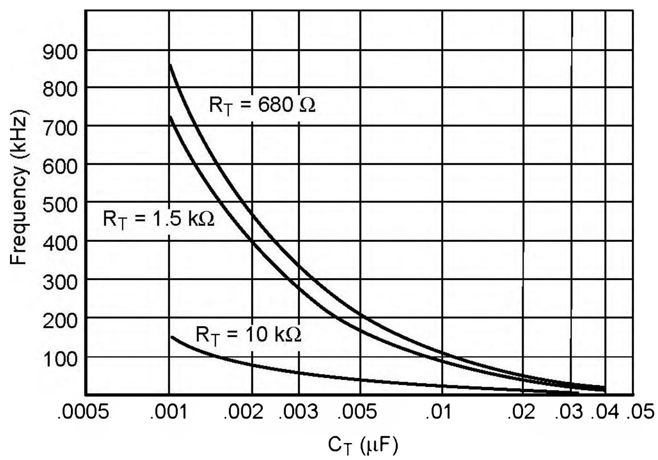


Figure 2. Oscillator Frequency vs. C_T

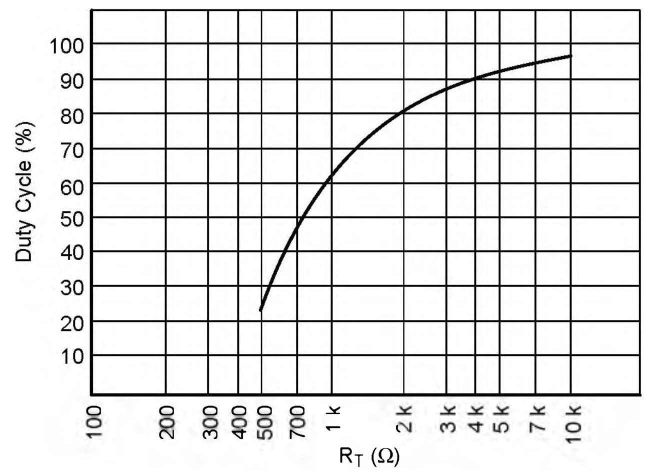


Figure 3. Oscillator Duty Cycle vs. R_T

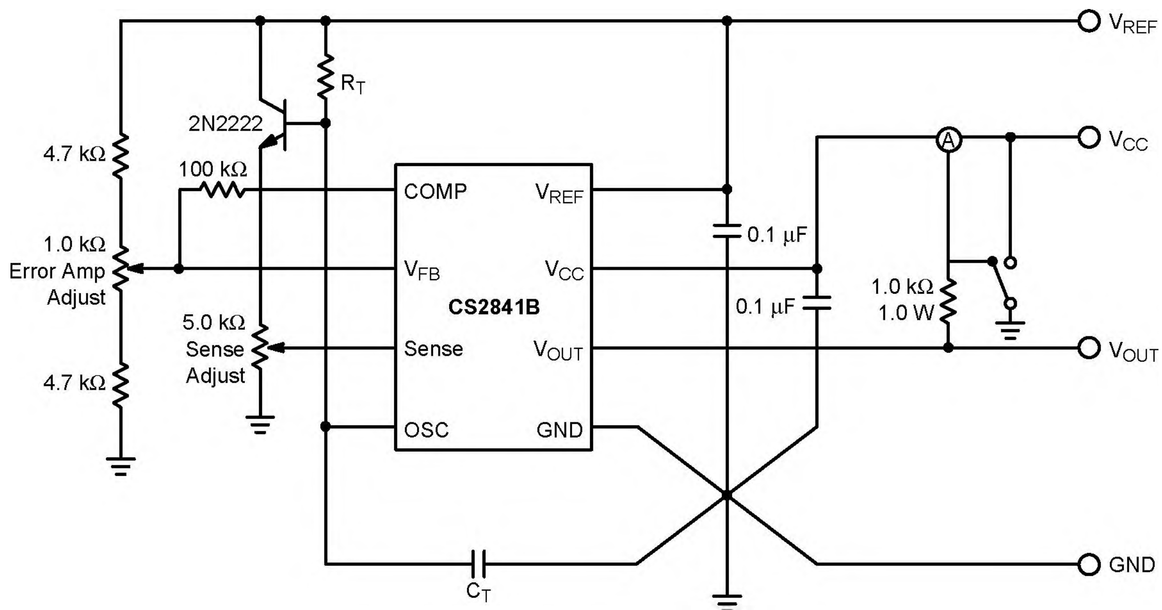


Figure 4. Test Circuit

CIRCUIT DESCRIPTION

Undervoltage Lockout

During Undervoltage Lockout (Figure 5), the output driver is biased to a high impedance state. The output should be shunted to ground with a resistor to prevent output leakage current from activating the power switch.

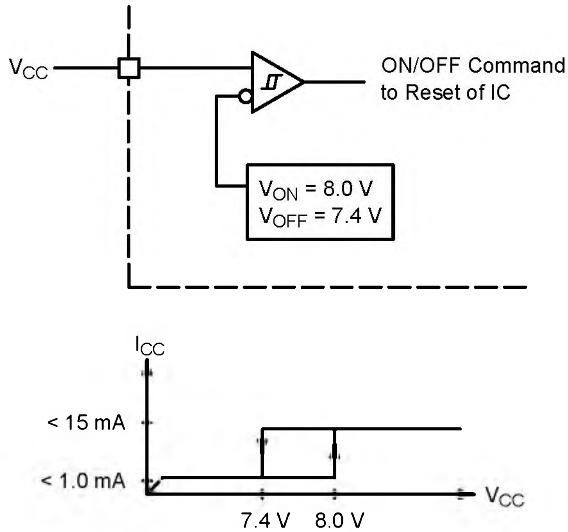


Figure 5. Typical Undervoltage Characteristics

PWM Waveform

To generate the PWM waveform, the control voltage from the error amplifier is compared to a current sense signal which represents the peak output inductor current (Figure 6). An increase in V_{CC} causes the inductor current slope to increase, thus reducing the duty cycle. This is an inherent feed–forward characteristic of current mode control, since the control voltage does not have to change during changes of input supply voltage.

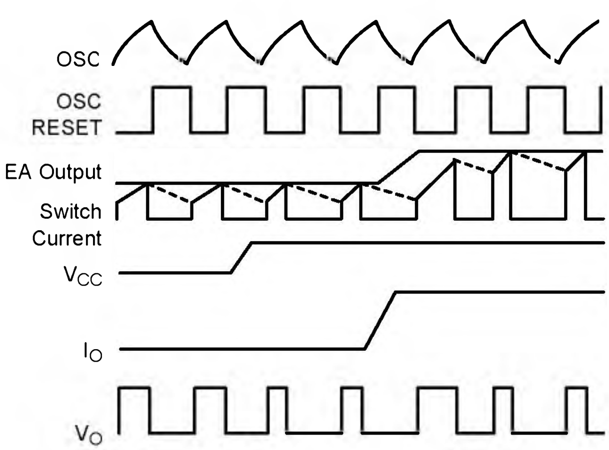


Figure 6. Timing Diagram for Key CS2841B Parameters

When the power supply sees a sudden large output current increase, the control voltage will increase allowing the duty cycle to momentarily increase. Since the duty cycle tends to exceed the maximum allowed to prevent transformer saturation in some power supplies, the internal oscillator waveform provides the maximum duty cycle clamp as programmed by the selection of OSC components.

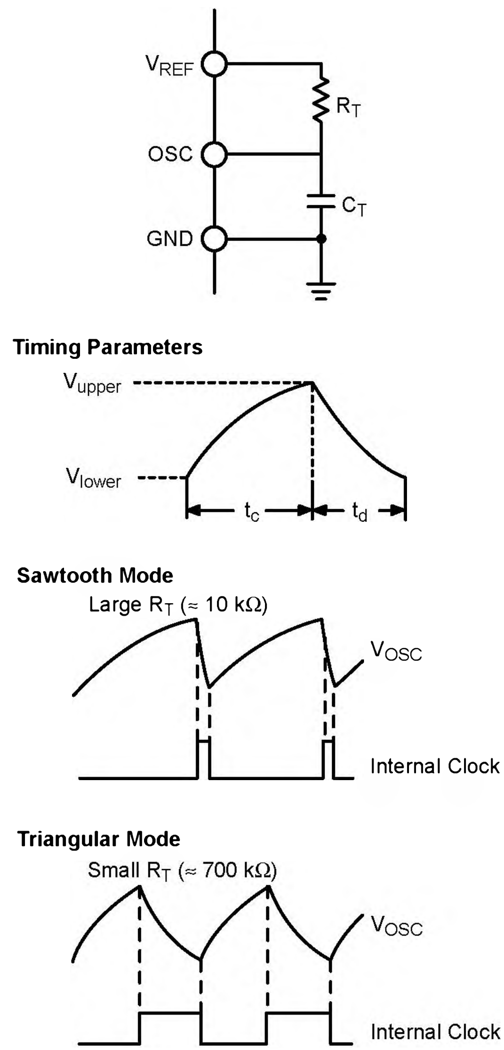


Figure 7. Oscillator Timing Network and Parameters

Setting the Oscillator

Oscillator timing capacitor, C_T, is charged by V_{REF} through R_T and discharged by an internal current source. During the discharge time, the internal clock signal blanks out the output to the Low state, thus providing a user selected maximum duty cycle clamp. Charge and discharge times are determined by the general formulas:

$$t_c = R_T C_T \ln\left(\frac{V_{REF} - V_{lower}}{V_{REF} - V_{upper}}\right)$$

$$t_d = R_T C_T \ln\left(\frac{V_{REF} - I_d R_T - V_{lower}}{V_{REF} - I_d R_T - V_{upper}}\right)$$

Substituting in typical values for the parameters in the above formulas:

$V_{REF} = 5.0\ V$
$V_{upper} = 2.7\ V$
$V_{lower} = 1.0\ V$
$I_d = 8.3\ mA$
$t_c \approx 0.5534 R_T C_T$

$$t_d = R_T C_T \ln\left(\frac{2.3 - 0.0083 R_T}{4.0 - 0.0083 R_T}\right)$$

The frequency and maximum duty cycle can be determined from the Typical Performance Characteristic graphs.

Grounding

High peak currents associated with capacitive loads necessitate careful grounding techniques. Timing and bypass capacitors should be connected close to GND pin in a single point ground.

The transistor and 5.0 kΩ potentiometer are used to sample the oscillator waveform and apply an adjustable ramp to Sense.

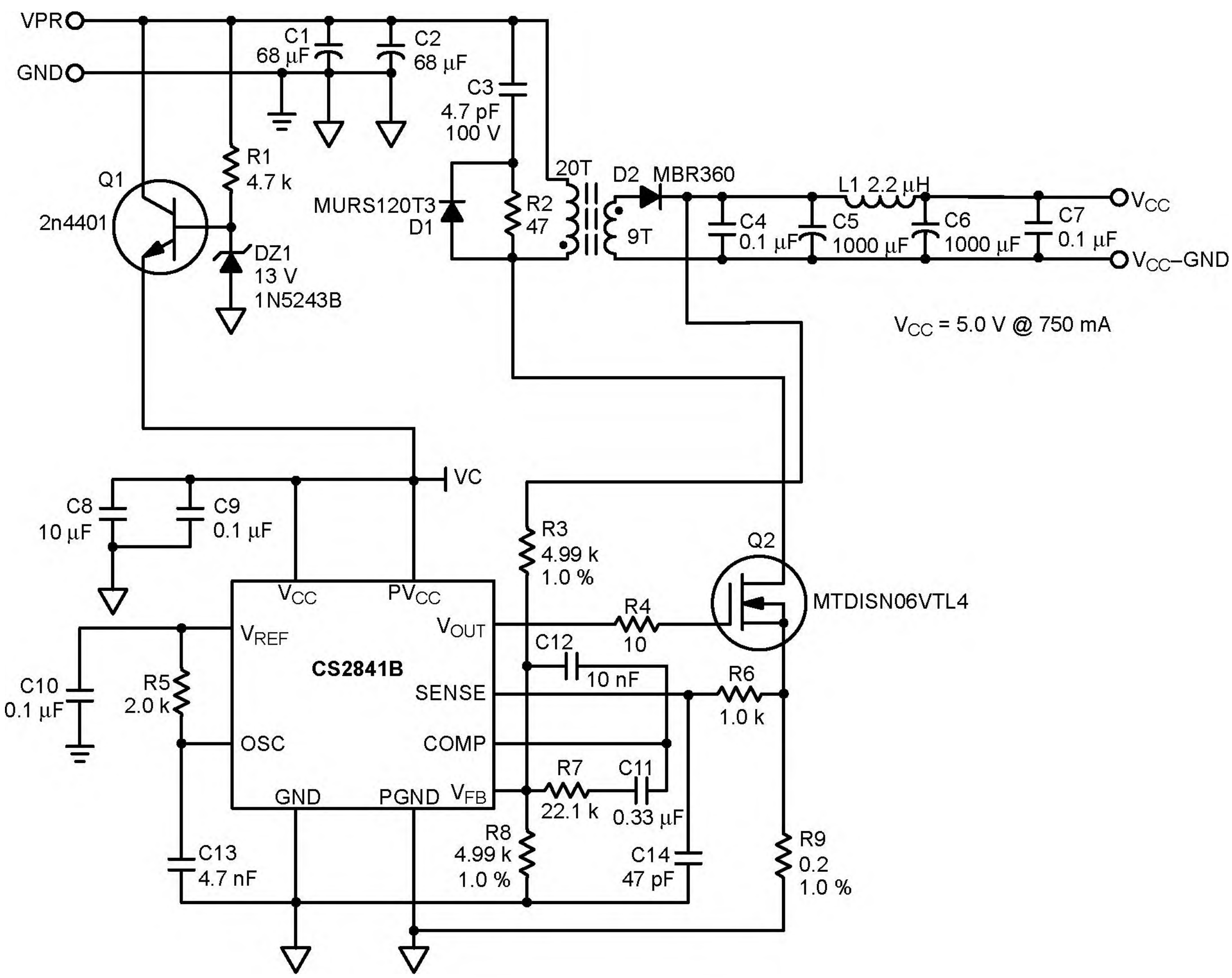


Figure 8. Flyback Application

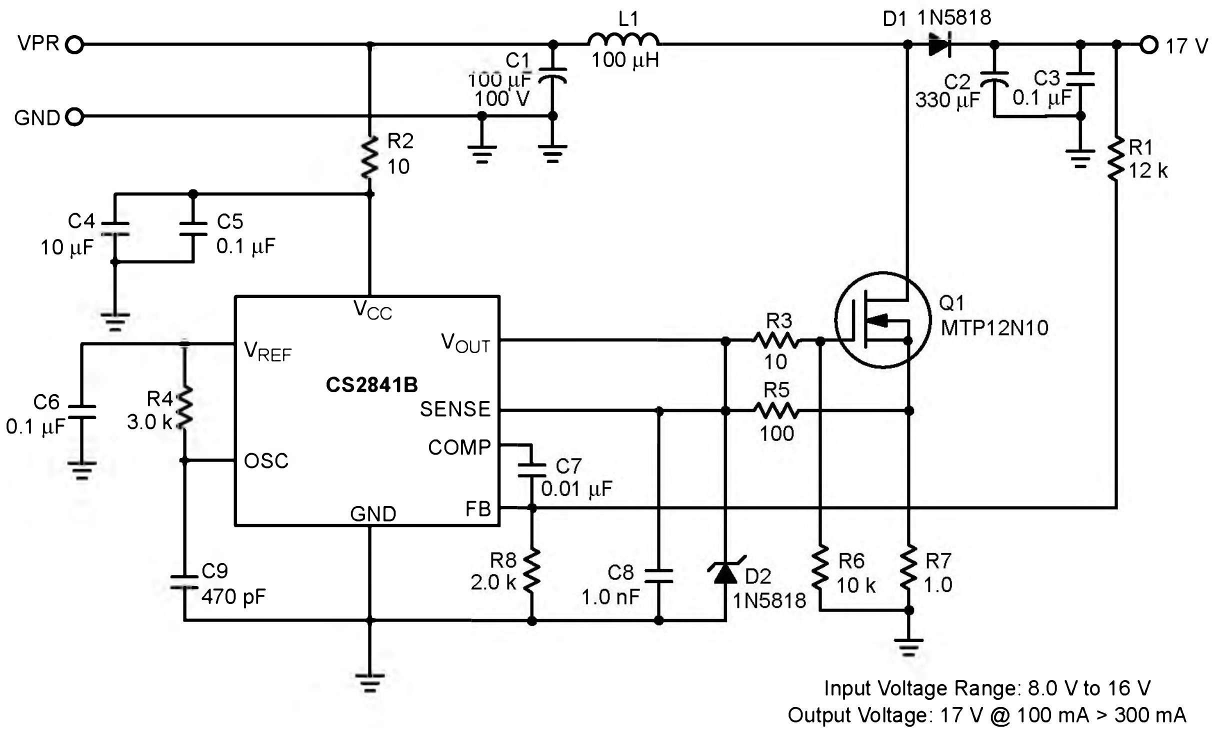


Figure 9. Boost Application

PACKAGE THERMAL DATA

Parameter		DIP–8	SO–14	Unit
$R_{\Theta JC}$	Typical	52	30	°C/W
$R_{\Theta JA}$	Typical	100	125	°C/W