# 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
- Pb-Free Packages are Available*

*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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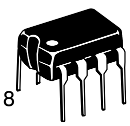
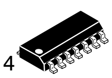
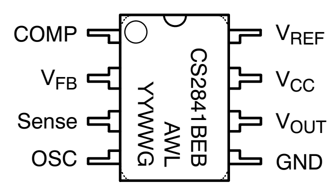



**PDIP-8**
**N SUFFIX**
**CASE 626**

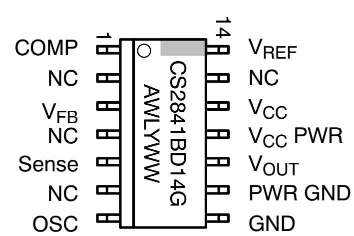



**SOIC-14**
**D SUFFIX**
**CASE 751A**

**PIN CONNECTIONS AND MARKING DIAGRAM**




**PDIP-8**




**SOIC-14**

| | |
|---|---|
| CS2841B | = Device Code |
| A | = Assembly Location |
| WL | = Wafer Lot |
| YY, Y | = Year |
| WW | = Work Week |
| G | = Pb-Free Package |

**ORDERING INFORMATION**

See detailed ordering and shipping information in the package dimensions section on page 2 of this data sheet.

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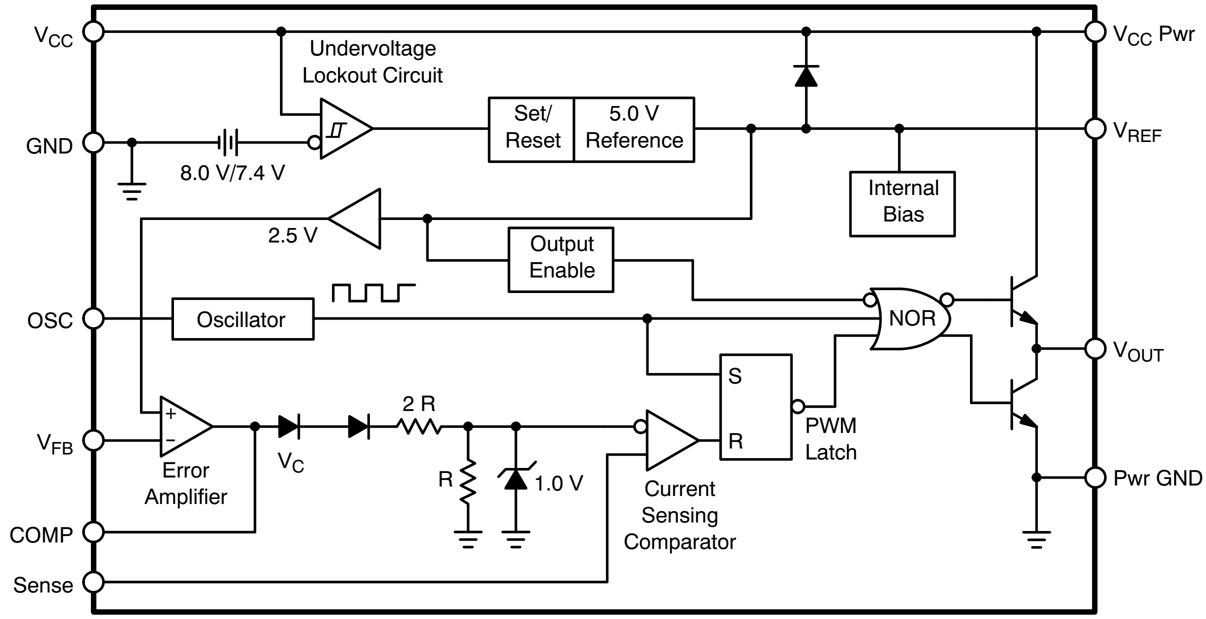



**Figure 1. Block Diagram**

## 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<br>Reflow (SMD styles only) Note 2 | 260 peak<br>230 peak | °C<br>°C |

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

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

## ORDERING INFORMATION

| Device | Package | Shipping† |
|---|---|---|
| CS2841BEBN8 | PDIP−8 | 50 Units / Rail |
| CS2841BEBN8G | PDIP−8<br>(Pb−Free) | 50 Units / Rail |
| CS2841BED14 | SOIC−14 | 55 Units / Rail |
| CS2841BED14G | SOIC−14<br>(Pb−Free) | 55 Units / Rail |
| CS2841BEDR14 | SOIC−14 | 2500 / Tape & Reel |
| CS2841BEDR14G | SOIC−14<br>(Pb−Free) | 2500 / Tape & Reel |

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

**ELECTRICAL CHARACTERISTICS** ($-40°C \le T_A \le 85°C$, $R_T$ = 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 |
|---|---|---|---|---|---|
| **Reference Section** | | | | | |
| Output Voltage | $T_J$ = 25°C, $I_{OUT}$ = 1.0 mA | 4.9 | 5.0 | 5.1 | V |
| Line Regulation | $8.4 \le V_{CC} \le 16$ V | – | 6.0 | 20 | mV |
| Load Regulation | $1.0 \le I_{OUT} \le 20$ 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.<br>Sawtooth Mode: $-40°C \le T_A \le +85°C$<br>Triangular Mode: $T_J$ =25°C. See Figure 7. | 47<br>44<br>44 | 52<br>52<br>52 | 57<br>60<br>60 | kHz<br>kHz<br>kHz |
| Voltage Stability | $8.4 \le V_{CC} \le 16$ V | – | 0.2 | 1.0 | % |
| Temperature Stability | Sawtooth Mode: $T_{MIN} \le T_A \le T_{MAX}$. Note 4<br>Triangular Mode: $T_{MIN} \le T_A \le T_{MAX}$. Note 4 | –<br>– | 5.0<br>8.0 | –<br>– | %<br>% |
| Amplitude | $V_{OSC}$ (Peak to Peak) | – | 1.7 | – | V |
| Discharge Current | $T_J$ = 25°C<br>$T_{MIN} \le T_A \le T_{MAX}$ | 7.4<br>7.2 | 8.3<br>– | 9.2<br>9.4 | mA<br>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 |
| $A_{VOL}$ | $2.0 \le V_{OUT} \le 4.0$ V | 65 | 90 | – | dB |
| Unity Gain Bandwidth | Note 4 | 0.7 | 1.0 | – | MHz |
| PSRR | $8.4\text{ V} \le V_{CC} \le 16$ 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 | $12\text{ V} \le V_{CC} \le 25$ 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:

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

**ELECTRICAL CHARACTERISTICS** ($-40°C \le T_A \le 85°C$, $R_T$ = 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<br>$I_{SINK}$ = 200 mA | –<br>– | 0.1<br>1.5 | 0.4<br>2.2 | V<br>V |
| Output High Level | $I_{SOURCE}$ = 20 mA<br>$I_{SOURCE}$ = 200 mA | 13<br>12 | 13.5<br>13.5 | –<br>– | V<br>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** | | | | | |
| Startup 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 # | | | |
|---|---|---|---|
| **PDIP−8** | **SOIC−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

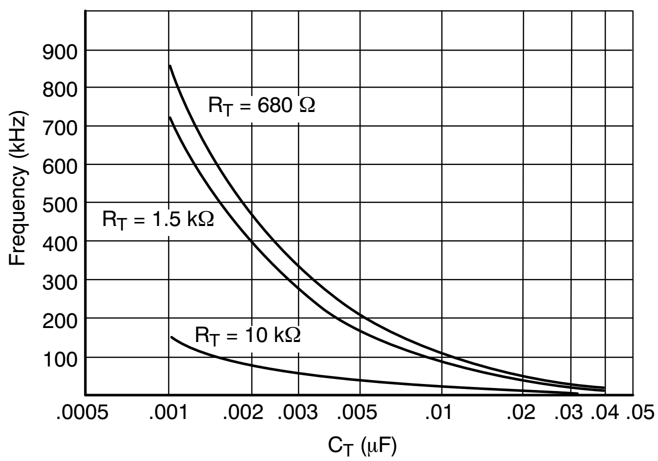



**Figure 2. Oscillator Frequency vs. $C_T$**

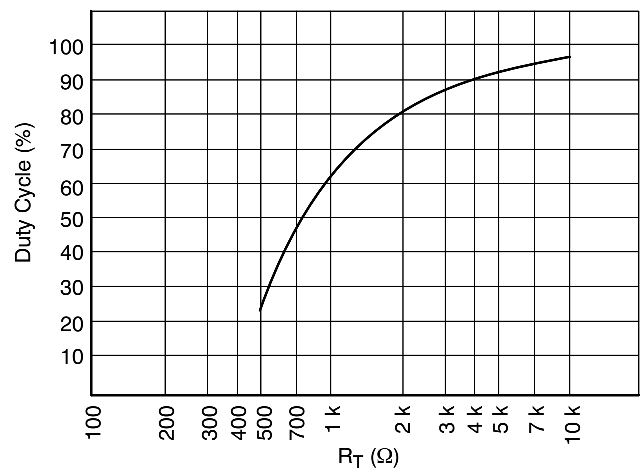



**Figure 3. Oscillator Duty Cycle vs. $R_T$**

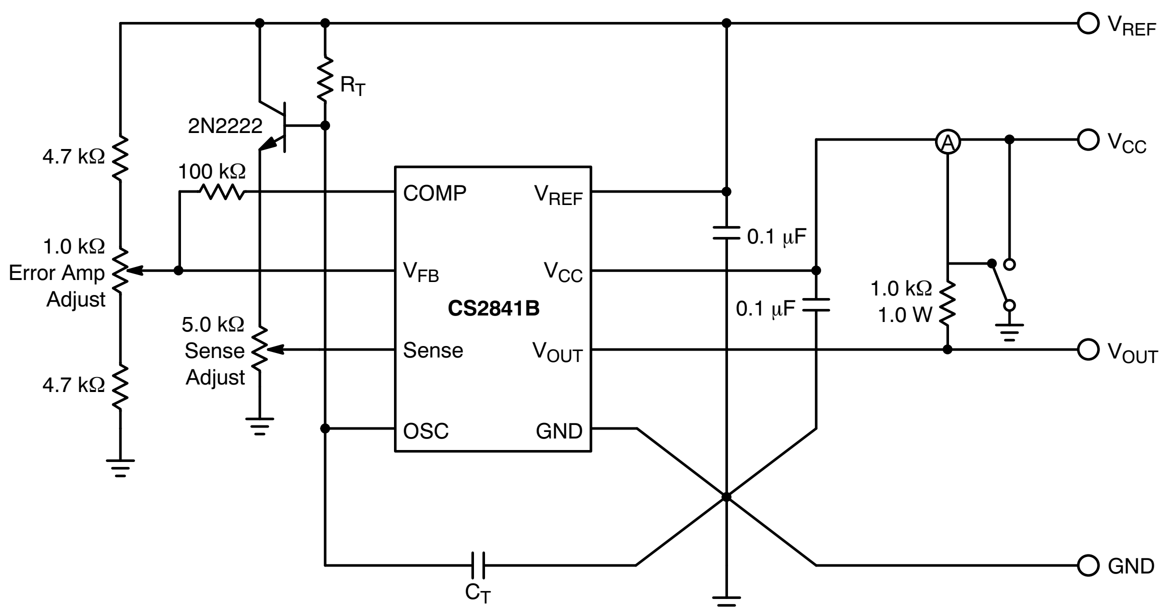



**Figure 4. Test Circuit**

## 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.

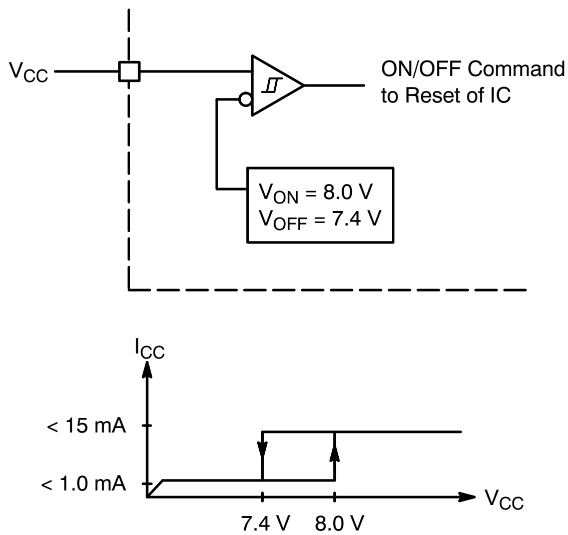



**Figure 5. Typical Undervoltage Characteristics**

### PWM Waveform

To generate the PWM waveform, the control voltage from the error amplifier is compared to a current sense signal representing 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.

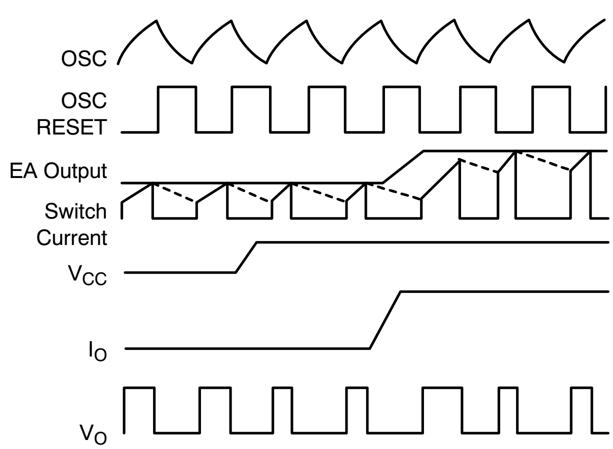



**Figure 6. Timing Diagram for Key CS2841B Parameters**

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.

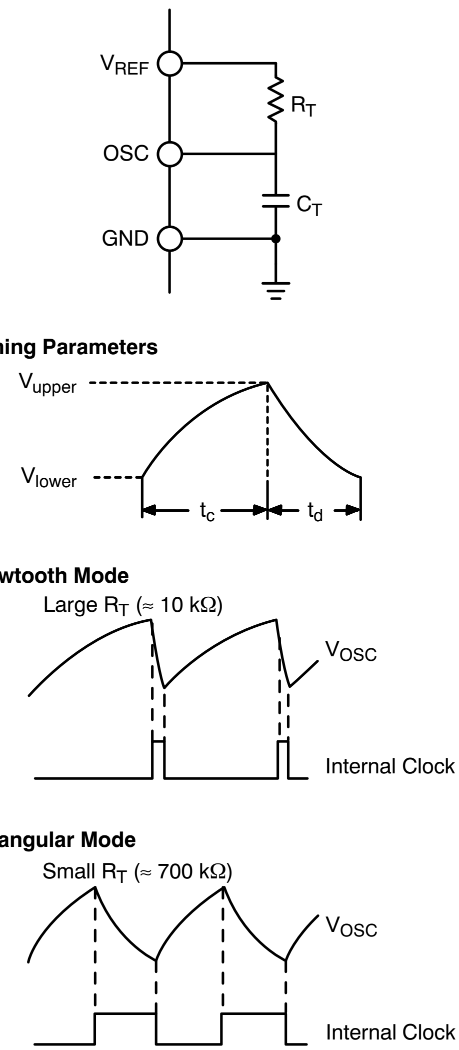



**Figure 7. Oscillator Timing Network and Parameters**

### 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:

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

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

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.

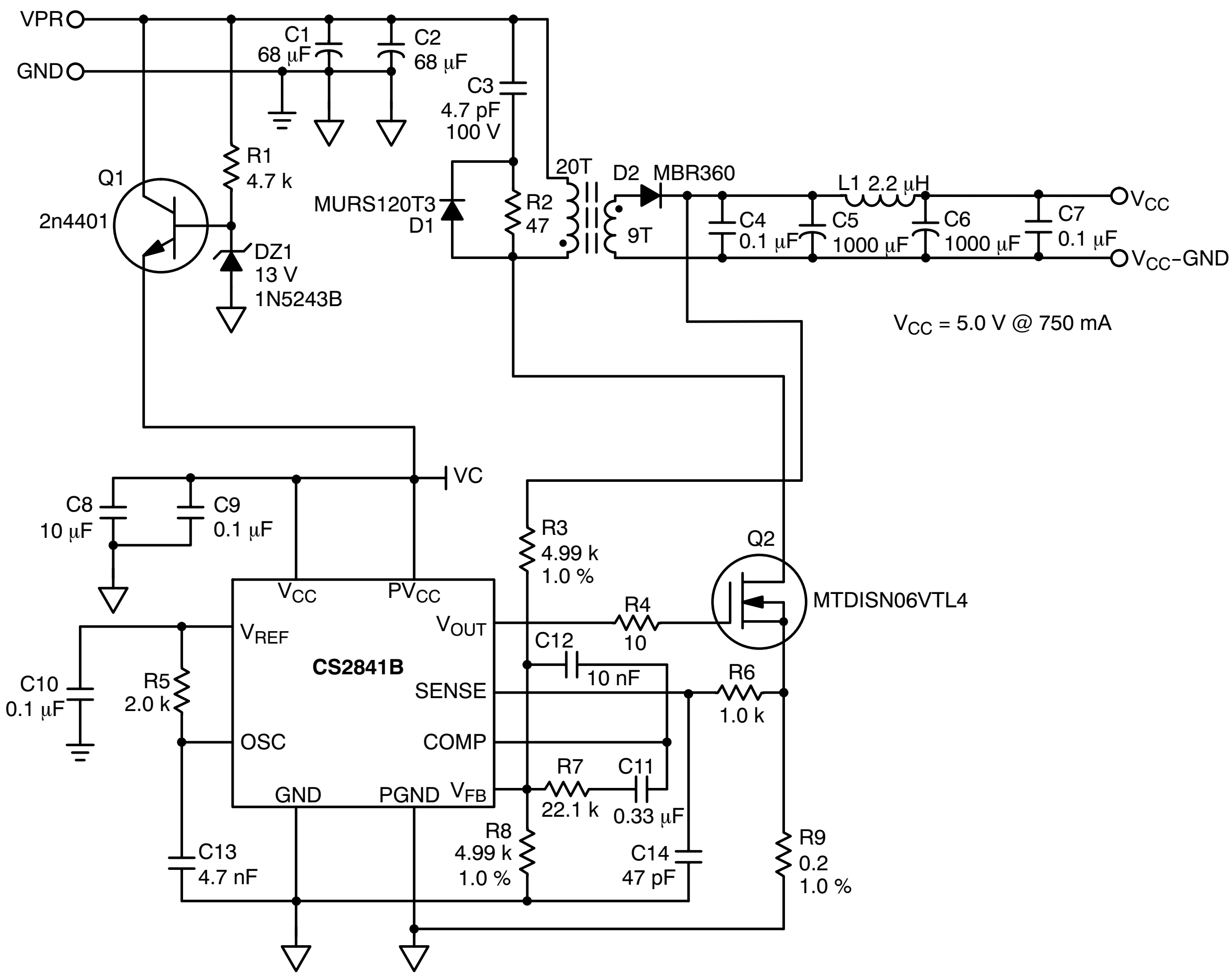



**Figure 8. Flyback Application**

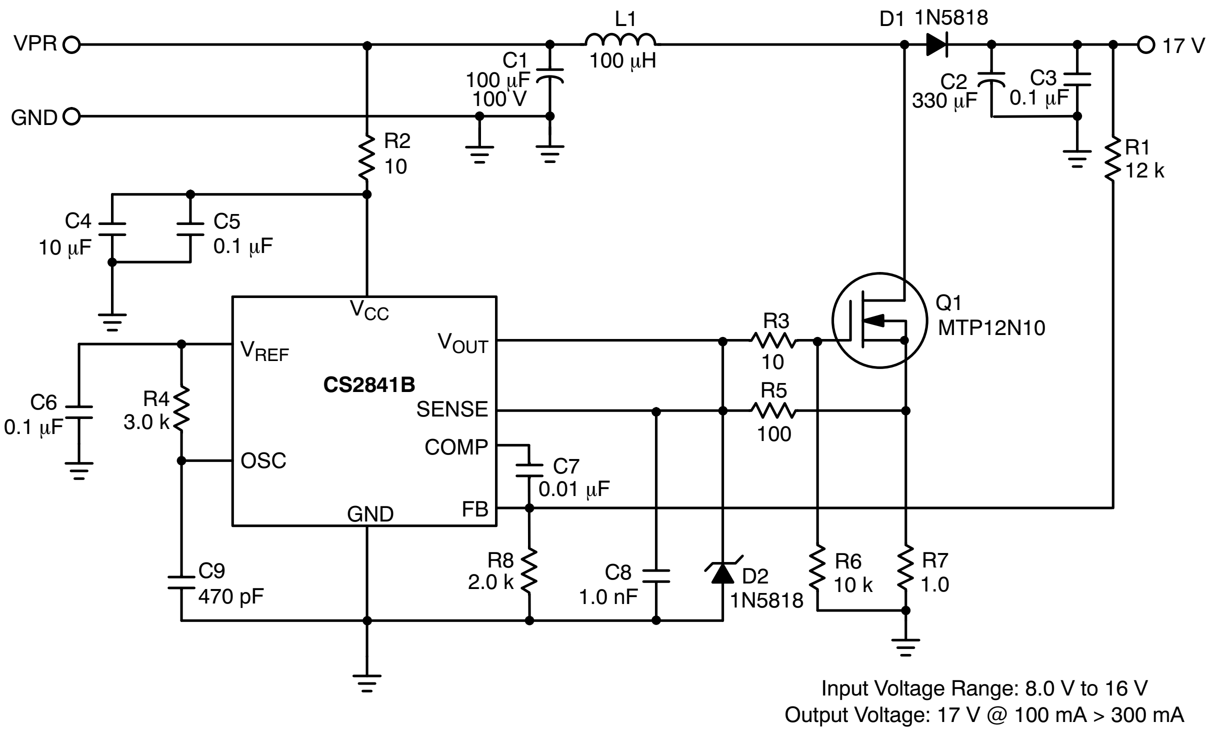


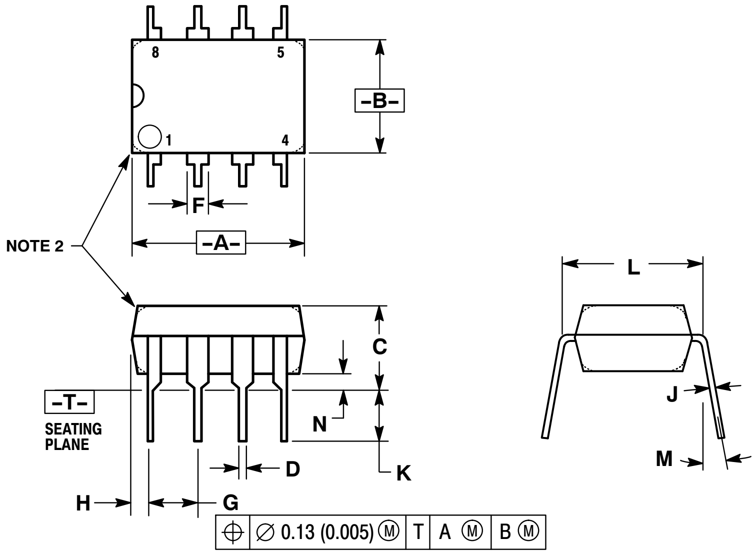

**Figure 9. Boost Application**

**PACKAGE THERMAL DATA**

| Parameter | | PDIP-8 | SOIC-14 | Unit |
|---|---|---|---|---|
| $R_{\theta JC}$ | Typical | 52 | 30 | °C/W |
| $R_{\theta JA}$ | Typical | 100 | 125 | °C/W |

## PACKAGE DIMENSIONS

**PDIP−8**
CASE 626−05
ISSUE L

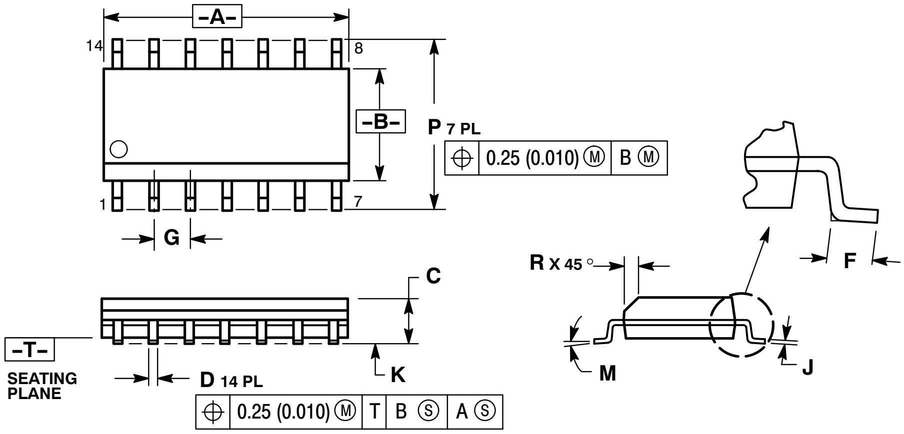



NOTES:
1. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.
2. PACKAGE CONTOUR OPTIONAL (ROUND OR SQUARE CORNERS).
3. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.

| | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | 9.40 | 10.16 | 0.370 | 0.400 |
| B | 6.10 | 6.60 | 0.240 | 0.260 |
| C | 3.94 | 4.45 | 0.155 | 0.175 |
| D | 0.38 | 0.51 | 0.015 | 0.020 |
| F | 1.02 | 1.78 | 0.040 | 0.070 |
| G | 2.54 BSC | | 0.100 BSC | |
| H | 0.76 | 1.27 | 0.030 | 0.050 |
| J | 0.20 | 0.30 | 0.008 | 0.012 |
| K | 2.92 | 3.43 | 0.115 | 0.135 |
| L | 7.62 BSC | | 0.300 BSC | |
| M | --- | 10° | --- | 10° |
| N | 0.76 | 1.01 | 0.030 | 0.040 |

## PACKAGE DIMENSIONS

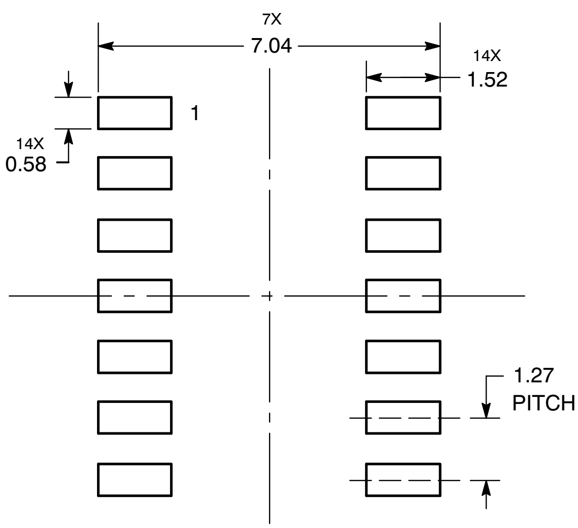
**SOIC−14**
CASE 751A−03
ISSUE J




NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.

| | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | 8.55 | 8.75 | 0.337 | 0.344 |
| B | 3.80 | 4.00 | 0.150 | 0.157 |
| C | 1.35 | 1.75 | 0.054 | 0.068 |
| D | 0.35 | 0.49 | 0.014 | 0.019 |
| F | 0.40 | 1.25 | 0.016 | 0.049 |
| G | 1.27 BSC | | 0.050 BSC | |
| J | 0.19 | 0.25 | 0.008 | 0.009 |
| K | 0.10 | 0.25 | 0.004 | 0.009 |
| M | 0 ° | 7 ° | 0 ° | 7 ° |
| P | 5.80 | 6.20 | 0.228 | 0.244 |
| R | 0.25 | 0.50 | 0.010 | 0.019 |

## SOLDERING FOOTPRINT

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