# Current Mode PWM Control Circuit

The CS52843 provides all the necessary features to implement off-line fixed frequency current-mode control with a minimum number of external components.

The CS52843 incorporates a new precision temperature—controlled oscillator to minimize variations in frequency. An undervoltage lockout ensures that  $V_{REF}$  is stabilized before the output stage is enabled. In the CS52843 turn on is at 8.4 V and turn off at 7.6 V.

Other features include low start—up current, pulse—by—pulse current limiting, and a high—current totem pole output for driving capacitive loads, such as gate of a power MOSFET. The output is low in the off state, consistent with N—channel devices.

#### **Features**

- Optimized for Off-Line Control
- Internally Temperature Compensated Oscillator
- V<sub>REF</sub> Stabilized before Output Stage is Enabled
- Very Low Start–Up Current 300 µA (typ)
- Pulse-by-Pulse Current Limiting
- Improved Undervoltage Lockout
- Double Pulse Suppression
- 2.0% 5.0 Volt Reference
- High Current Totem Pole Output



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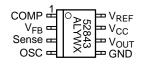


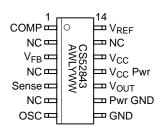
SO-8 D SUFFIX CASE 751



SO-14 D SUFFIX CASE 751A

# PIN CONNECTIONS AND MARKING DIAGRAMS





A = Assembly Location

WL, L = Wafer Lot YY, Y = YearWW, W = Work Week

#### **ORDERING INFORMATION**

| Device       | Package | Shipping         |
|--------------|---------|------------------|
| CS52843ED8   | SO-8    | 95 Units/Rail    |
| CS52843EDR8  | SO-8    | 2500 Tape & Reel |
| CS52843ED14  | SO-14   | 55 Units/Rail    |
| CS52843EDR14 | SO-14   | 2500 Tape & Reel |

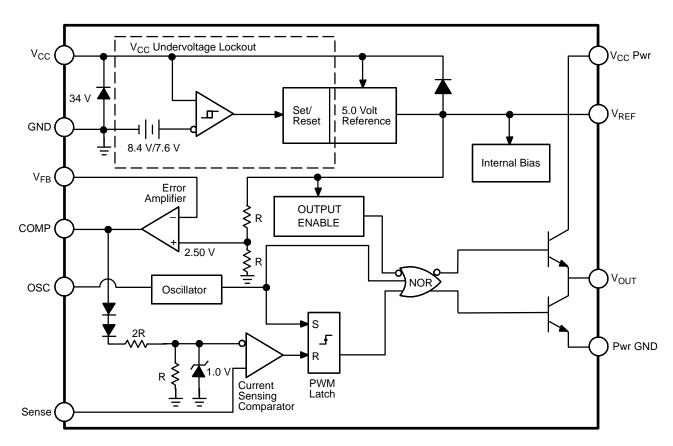


Figure 1. Block Diagram

#### **MAXIMUM RATINGS\***

| Rating  | Value                          | Unit |
|---|--------------------------------|------|
| Supply Voltage (I <sub>CC</sub> < 30 mA)              | Self Limiting                  | -    |
| Supply Voltage (Low Impedance Source)                 | 30                             | ٧    |
| Output Current  | ±1.0                           | Α    |
| Output Energy (Capacitive Load)                       | 5.0                            | μJ   |
| Analog Inputs (V <sub>FB</sub> , V <sub>SENSE</sub> ) | -0.3 to 5.5                    | V    |
| Error Amp Output Sink Current                         | 10                             | mA   |
| Lead Temperature Soldering: Reflow: (SMD              | styles only) (Note 1) 230 peak | °C   |

<sup>1. 60</sup> second maximum above 183°C.

<sup>\*</sup>The maximum package power dissipation must be observed.

**ELECTRICAL CHARACTERISTICS**  $(-40^{\circ}C \le T_A \le 85^{\circ}C; V_{CC} = 15 \text{ V (Note 2.)}; R_T = 680 \Omega; C_T = 0.022 \mu\text{F for triangle mode, } R_T = 10 \text{ k}\Omega; C_T = 3.3 \text{ nF sawtooth mode; unless otherwise specified.)}$ 

| Parameter              | meter Test Conditions  |          | Тур        | Max        | Unit       |  |
|------------------------|--|----------|------------|------------|------------|--|
| Reference Section      | ·  | 1        |            |            |            |  |
| Output Voltage         | Output Voltage T <sub>J</sub> = 25°C, I <sub>REF</sub> = 1.0 mA                                      |          |            | 5.1        | V          |  |
| Line Regulation        | 12 ≤ V <sub>CC</sub> ≤ 25 V  | -        | 6.0        | 20         | mV         |  |
| Load Regulation        | 1.0 ≤ I <sub>REF</sub> ≤ 20 mA   | -        | 6.0        | 25         | mV         |  |
| Temperature Stability  | Note 2.  | -        | 0.2        | 0.4        | mV/°C      |  |
| Total Output Variation | Line, Load, Temp. Note 2.  | 4.82     | _          | 5.18       | V          |  |
| Output Noise Voltage   | 10 Hz $\leq$ f $\leq$ 10 kHz, T <sub>J</sub> = 25°C, Note 2.   | -        | 50         | -          | μV         |  |
| Long Term Stability    | T <sub>A</sub> = 125°C, 1000 Hrs. Note 2.  | -        | 5.0        | 25         | mV         |  |
| Output Short Circuit   | T <sub>A</sub> = 25°C  | -30      | -100       | -180       | mA         |  |
| Oscillator Section     | ·  | 1        |            |            |            |  |
| Initial Accuracy       | Sawtooth Mode, $T_J = 25^{\circ}C$ , Note 2.<br>Triangle Mode, $T_J = 25^{\circ}C$                   | 47<br>44 | 52<br>52   | 57<br>60   | kHz<br>kHz |  |
| Voltage Stability      | 12 ≤ V <sub>CC</sub> ≤ 25 V  | _        | 0.2        | 1.0        | %          |  |
| Temperature Stability  | Sawtooth Mode $T_{MIN} \le T_A \le T_{MAX}$<br>Triangle Mode $T_{MIN} \le T_A \le T_{MAX}$ , Note 2. |          | 5.0<br>8.0 | _<br>_     | %<br>%     |  |
| Amplitude              | V <sub>OSC</sub> (peak to peak)  | -        | 1.7        | -          | V          |  |
| Discharge Current      | $T_{J} = 25^{\circ}C$ $T_{MIN} \le T_{A} \le T_{MAX}$  |          | 8.3<br>-   | 9.3<br>9.8 | mA<br>mA   |  |
| Error Amp Section      |  | 1        | 1          | JI.        | 1          |  |
| Input Voltage          | V <sub>COMP</sub> = 2.5 V  | 2.42     | 2.50       | 2.58       | V          |  |
| Input Bias Current     | V <sub>FB</sub> = 0 V  | -        | -0.3       | -2.0       | μА         |  |
| A <sub>VOL</sub>       | 2.0 ≤ V <sub>OUT</sub> ≤ 4.0 V   | 65       | 90         | _          | dB         |  |
| Unity Gain Bandwidth   | Note 2.  | 0.7      | 1.0        | _          | MHz        |  |
| PSRR                   | 12 ≤ V <sub>CC</sub> ≤ 25 V  | 60       | 70         | _          | dB         |  |
| Output Sink Current    | V <sub>FB</sub> = 2.7 V, V <sub>COMP</sub> = 1.1 V   | 2.0      | 6.0        | _          | mA         |  |
| Output Source Current  | V <sub>FB</sub> = 2.3 V, V <sub>COMP</sub> = 5.0 V   | -0.5     | -0.8       | _          | mA         |  |
| V <sub>OUT</sub> HIGH  | $V_{FB}$ = 2.3 V, $R_L$ = 15 k $\Omega$ to GND   | 5.0      | 6.0        | -          | V          |  |
| V <sub>OUT</sub> LOW   | $V_{FB}$ = 2.7 V, $R_L$ = 15 k $\Omega$ to $V_{REF}$   | -        | 0.7        | 1.1        | V          |  |
| Current Sense Section  |  |          |            |            |            |  |
| Gain                   | nin Notes 3 & 4.   |          | 3.0        | 3.15       | V/V        |  |
| Maximum Input Signal   | V <sub>COMP</sub> = 5.0 V, Note 3.   | 0.9      | 1.0        | 1.1        | V          |  |
| PSRR                   | $12 \le V_{CC} \le 25 \text{ V, Note } 3.$   | -        | 70         | -          | dB         |  |
| Input Bias Current     | V <sub>SENSE</sub> = 0 V   | -        | -2.0       | -10        | μА         |  |
| Delay to Output        | T <sub>J</sub> = 25°C, Note 2.   | -        | 150        | 300        | ns         |  |

<sup>2.</sup> These parameters, although guaranteed, are not 100% tested in production.

4. Gain defined as: A = 
$$\frac{\Delta VCOMP}{\Delta VSENSE}$$
; 0  $\leq$  VSENSE  $\leq$  0.8 V

<sup>3.</sup> Parameter measured at a trip point of latch with  $V_{\text{FB}} = 0$ .

**ELECTRICAL CHARACTERISTICS (continued)** ( $-40^{\circ}C \le T_A \le 85^{\circ}C$ ;  $V_{CC} = 15 \text{ V (Note 2.)}$ ;  $R_T = 680 \Omega$ ;  $C_T = 0.022 \,\mu\text{F}$  for triangle mode,  $R_T = 10 \text{ k}\Omega$ ;  $C_T = 3.3 \text{ nF}$  sawtooth mode; unless otherwise specified.)

| Parameter                     | Test Conditions  | Min      | Тур          | Max        | Unit   |
|-------------------------------|--|----------|--------------|------------|--------|
| Output Section                |  | <u>.</u> |              |            |        |
| Output Low Level              | I <sub>SINK</sub> = 20 mA<br>I <sub>SINK</sub> = 200 mA                                | _<br>_   | 0.1<br>1.5   | 0.4<br>2.2 | V<br>V |
| Output High Level             | Output High Level   Isource = 20 mA   Isource = 200 mA                                 |          | 13.5<br>13.5 | _<br>_     | V<br>V |
| Rise Time                     | T <sub>J</sub> = 25°C, C <sub>L</sub> = 1.0 nF, Note 5.                                | -        | 50           | 150        | ns     |
| Fall Time                     | T <sub>J</sub> = 25°C, C <sub>L</sub> = 1.0 nF, Note 5.                                |          | 50           | 150        | ns     |
| Output Leakage                | UVLO Active V <sub>OUT</sub> = 0   | -        | -0.01        | -10        | μА     |
| Total Standby Current         |  |          |              |            |        |
| Start-Up Current              | -  | _        | 300          | 500        | μА     |
| Operating Supply Current      | $V_{FB} = V_{SENSE} = 0 \text{ V, R}_{T} = 10 \text{ k}\Omega; C_{T} = 3.3 \text{ nF}$ | -        | 11           | 17         | mA     |
| V <sub>CC</sub> Zener Voltage | I <sub>CC</sub> = 25 mA  | -        | 34           | -          | V      |
| Undervoltage Lockout Section  | 1  | •        |              |            |        |
| Start Threshold               | -  | 7.8      | 8.4          | 9.0        | V      |
| Min. Operating Voltage        | After Turn On  | 7.0      | 7.6          | 8.2        | V      |

<sup>5.</sup> These parameters, although guaranteed, are not 100% tested in production.

#### **PACKAGE PIN DESCRIPTION**

| Package L | Package Lead Number |                     |   |
|-----------|---------------------|---------------------|---|
| SO-8      | SO-14               | Lead Symbol         | Function  |
| 1         | 1                   | COMP                | Error amp output, used to compensate error amplifier.                 |
| 2         | 3                   | V <sub>FB</sub>     | 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 VREF. |
| 5         | 8                   | GND                 | Ground.   |
| _         | 9                   | Pwr GND             | Output driver ground.   |
| 6         | 10                  | V <sub>OUT</sub>    | Output drive pin.   |
| _         | 11                  | V <sub>CC</sub> Pwr | Output driver positive supply.  |
| 7         | 12                  | V <sub>CC</sub>     | Positive power suppy.   |
| 8         | 14                  | V <sub>REF</sub>    | Output of 5.0 V internal reference.                                   |
| _         | 2, 4, 6, 13         | NC                  | No Connection.  |

#### TYPICAL PERFORMANCE CHARACTERISTICS

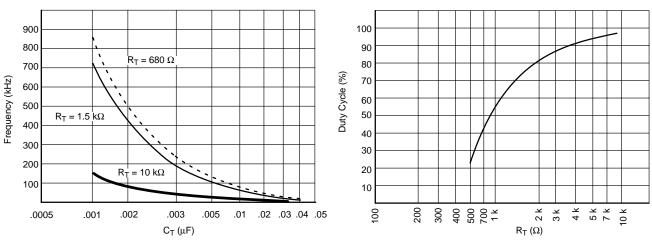


Figure 2. Oscillator Frequency vs C<sub>T</sub>

Figure 3. Oscillator Duty Cycle vs R<sub>T</sub>

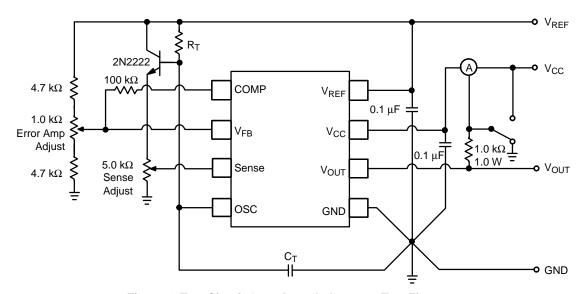


Figure 4. Test Circuit Open Loop Laboratory Test Fixture

#### **CIRCUIT DESCRIPTION**

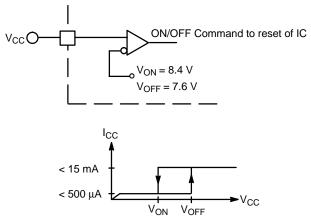


Figure 5. Startup Voltage for the CS52843

#### **Undervoltage Lockout**

During Undervoltage Lockout (Figure 5), the output driver is biased to sink minor amounts of current. The output should be shunted to ground with a resistor to prevent activating the power switch with extraneous leakage currents.

#### **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  $V_{\rm CC}$  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.

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 oscillator timing components.

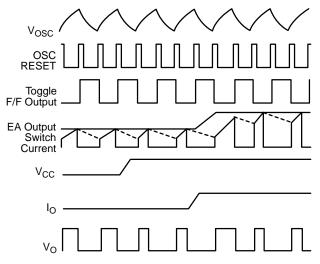
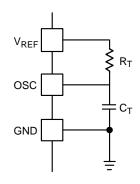
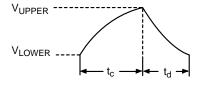


Figure 6. Timing Diagram





#### **Setting the Oscillator**

The times  $t_c$  and  $t_d$  can be determined as follows:

$$t_{C} = R_{T}C_{T}In\left(\frac{V_{REF} - V_{LOWER}}{V_{REF} - V_{UPPER}}\right)$$

$$t_{d} = R_{T}C_{T}In\bigg(\frac{V_{REF} - I_{d}R_{T}V_{LOWER}}{V_{REF} - I_{d}R_{T} - V_{UPPER}}\bigg)$$

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

$$V_{REF} = 5.0 V, V_{UPPER} = 2.7 V,$$

$$V_{LOWER} = 1.0 V, I_{d} = 8.3 mA$$

then

$$t_{\text{C}} \approx 0.5534 \text{R}_{\text{T}} \text{C}_{\text{T}}$$

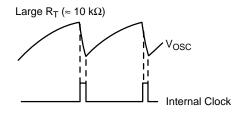
$$t_d = R_T C_T \ln \left( \frac{2.3 - 0.0083 R_T}{4.0 - 0.0083 R_T} \right)$$

For better accuracy  $R_T$  should be  $\geq 10 \text{ k}\Omega$ .

#### Grounding

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

The transistor and 5.0 k $\Omega$  potentiometer are used to sample the oscillator waveform and apply an adjustable ramp to Sense.



Sawtooth Mode

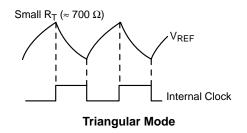
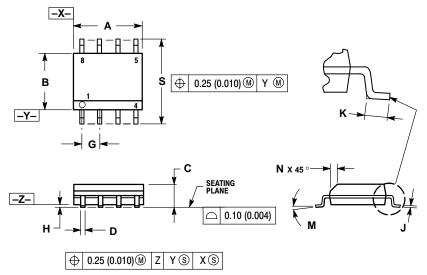


Figure 7. Oscillator Timing Network and Parameters

#### **PACKAGE DIMENSIONS**

#### **SO-8 DF SUFFIX** CASE 751-07 ISSUE W



#### NOTES:

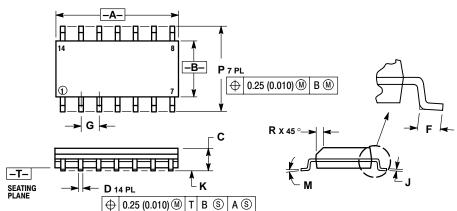
- DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
- CONTROLLING DIMENSION: MILLIMETER.
   DIMENSION A AND B DO NOT INCLUDE MOLD
- PROTRUSION.

  4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER
- 4. MAXIMUM MOLD PHOTHUSION 0.15 (0.006) PEH SIDE.
  5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTHUSION ALLOWABLE DAMBAR PROTHUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL COLUMNION. MATERIAL CONDITION.

|     | MILLIMETERS |      | INCHES    |       |
|-----|-------------|------|-----------|-------|
| DIM | MIN         | MAX  | MIN       | MAX   |
| Α   | 4.80        | 5.00 | 0.189     | 0.197 |
| В   | 3.80        | 4.00 | 0.150     | 0.157 |
| С   | 1.35        | 1.75 | 0.053     | 0.069 |
| D   | 0.33        | 0.51 | 0.013     | 0.020 |
| G   | 1.27 BSC    |      | 0.050 BSC |       |
| Н   | 0.10        | 0.25 | 0.004     | 0.010 |
| J   | 0.19        | 0.25 | 0.007     | 0.010 |
| K   | 0.40        | 1.27 | 0.016     | 0.050 |
| M   | 0 °         | 8 °  | 0 °       | 8 °   |
| N   | 0.25        | 0.50 | 0.010     | 0.020 |
| S   | 5.80        | 6.20 | 0.228     | 0 244 |

#### SO-14 **D SUFFIX**

CASE 751A-03 ISSUE F



#### NOTES:

- IOTES:

  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   |
| Α   | 8.55        | 8.75     | 0.337  | 0.344 |
| В   | 3.80        | 4.00     | 0.150  | 0.157 |
| С   | 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        | 1.27 BSC |        | BSC   |
| J   | 0.19        | 0.25     | 0.008  | 0.009 |
| K   | 0.10        | 0.25     | 0.004  | 0.009 |
| M   | 0 °         | 7°       | 0°     | 7°    |
| Р   | 5.80        | 6.20     | 0.228  | 0.244 |
| R   | 0.25        | 0.50     | 0.010  | 0.019 |

#### **PACKAGE THERMAL DATA**

| Parameter       |         | SO-8 | SO-14 | Unit |
|-----------------|---------|------|-------|------|
| $R_{\Theta JC}$ | Typical | 45   | 30    | °C/W |
| $R_{\Theta JA}$ | Typical | 165  | 125   | °C/W |

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