



# Current Mode PWM Control Circuit with 50% Max Duty Cycle

## Description

The CS3844/45 provides all the necessary features to implement off-line fixed frequency current-mode control with a minimum number of external components.

The CS3844 family incorporates a new precision temperature-controlled oscillator to minimize variations in frequency. An internal toggle flip-flop, which blanks the output every other clock cycle, limits the duty-cycle range to less than 50%. An undervoltage lockout ensures that  $V_{REF}$  is stabilized

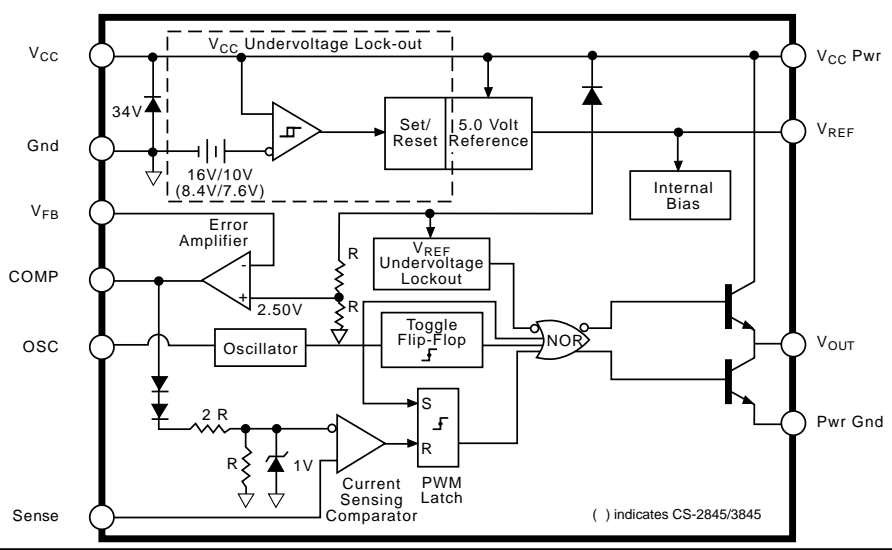
before the output stage is enabled. In the CS2844/CS3844 turn on occurs at 16V and turn off at 10V. In the CS2845/CS3845 turn on is at 8.4V and turn off at 7.6V.

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.

## Absolute Maximum Ratings

Supply Voltage ( $I_{CC} < 30mA$ ).....	Self Limiting
Supply Voltage (Low Impedance Source) .....	30V
Output Current.....	$\pm 1A$
Output Energy (Capacitive Load).....	$5\mu J$
Analog Inputs ( $V_{FB}$ , $V_{SENSE}$ ) .....	-0.3V to 5.5V
Error Amp Output Sink Current .....	10mA
Lead Temperature Soldering	
Wave Solder (through hole styles only) .....	10 sec. max, 260°C peak
Reflow (SMD styles only) .....	60 sec. max above 183°C, 230°C peak

## Block Diagram

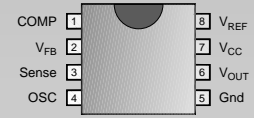


## Features

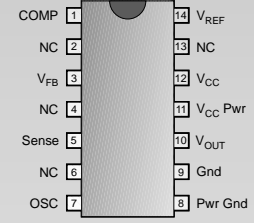
- Optimized for Offline Control
- Temp. Compensated Oscillator
- 50% Max Duty-cycle Clamp
- $V_{REF}$  Stabilized before Output Stage is Enabled
- Low Start-up Current
- Pulse-by-pulse Current Limiting
- Improved Undervoltage Lockout
- Double Pulse Suppression
- 1% Trimmed Bandgap Ref.
- High Current Totem Pole Output

## Package Options

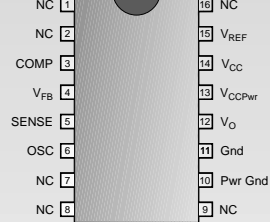
### 8 Lead PDIP & SO Narrow



### 14 Lead SO Narrow



### 16 Lead SO Wide



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Electrical Characteristics:  $-25 \leq T_A \leq 85^\circ\text{C}$  for CS2844/2845,  $0 \leq T_A \leq 70^\circ\text{C}$  for CS3844/3845.  $V_{CC} = 15\text{V}$  (Note 1);  $R_T = 10\text{k}\Omega$ ,  $C_T = 3.3\text{nF}$  for sawtooth mode., unless otherwise stated.

PARAMETER	TEST CONDITIONS	CS2844/CS2845			CS3844/CS3845			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
<b>Reference Section</b>								
Output Voltage	$T_J=25^\circ\text{C}$ , $I_{REF}=1\text{mA}$	4.95	5.00	5.05	4.90	5.00	5.10	V
Line Regulation	$12 \leq V_{CC} \leq 25\text{V}$		6	20		6	20	mV
Load Regulation	$1 \leq I_{REF} \leq 20\text{mA}$		6	25		6	25	mV
Temperature Stability	(Note 2)		0.2	0.4		0.2	0.4	mV/ $^\circ\text{C}$
Total Output Variation	Line, Load, Temp. (Note 2)	4.90		5.10	4.82		5.18	V
Output Noise Voltage	$10\text{Hz} \leq f \leq 10\text{kHz}$ , $T_J=25^\circ\text{C}$ (Note 2)		50			50		$\mu\text{V}$
Long Term Stability	$T_A=125^\circ\text{C}$ , 1000 Hrs. (Note 2)		5	25		5	25	mV
Output Short Circuit	$T_A=25^\circ\text{C}$	-30	-100	-180	-30	-100	-180	mA
<b>Oscillator Section</b>								
Initial Accuracy	Sawtooth Mode, $T_J=25^\circ\text{C}$	47	52	57	47	52	57	kHz
Voltage Stability	$12 \leq V_{CC} \leq 25\text{V}$		0.2	1.0		0.2	1.0	%
Temperature Stability	Sawtooth Mode $T_{MIN} \leq T_A \leq T_{MAX}$ (Note 2)		5			5		%
Amplitude	$V_{OSC}$ (peak to peak)		1.7			1.7		V
<b>Error Amp Section</b>								
Input Voltage	$V_{COMP}=2.5\text{V}$	2.45	2.50	2.55	2.42	2.50	2.58	V
Input Bias Current	$V_{FB}=0\text{V}$		-0.3	-1.0		-0.3	-2.0	$\mu\text{A}$
$A_{VOL}$	$2 \leq V_{OUT} \leq 4\text{V}$	65	90		65	90		dB
Unity Gain Bandwidth	(Note 2)	0.7	1.0		0.7	1.0		MHz
PSRR	$12 \leq V_{CC} \leq 25\text{V}$	60	70		60	70		dB
Output Sink Current	$V_{FB}=2.7\text{V}$ , $V_{COMP}=1.1\text{V}$	2	6		2	6		mA
Output Source Current	$V_{FB}=2.3\text{V}$ , $V_{COMP}=5\text{V}$	-0.5	-0.8		-0.5	-0.8		mA
$V_{OUT}$ HIGH	$V_{FB}=2.3\text{V}$ , $R_L=15\text{k}\Omega$ to Gnd	5	6		5	6		V
$V_{OUT}$ LOW	$V_{FB}=2.7\text{V}$ , $R_L=15\text{k}\Omega$ to $V_{REF}$		0.7	1.1		0.7	1.1	V
<b>Current Sense Section</b>								
Gain	(Notes 3 & 4)	2.85	3.00	3.15	2.85	3.00	3.15	V/V
Maximum Input Signal	$V_{COMP}=5\text{V}$ (Note 3)	0.9	1.0	1.1	0.9	1.0	1.1	V
PSRR	$12 \leq V_{CC} \leq 25\text{V}$ (Note 3)		70			70		dB
Input Bias Current	$V_{sense}=0\text{V}$		-2	-10		-2	-10	$\mu\text{A}$
Delay to Output	$T_J=25^\circ\text{C}$ (Note 2)		150	300		150	300	ns
<b>Output Section</b>								
Output Low Level	$I_{SINK}=20\text{mA}$		0.1	0.4		0.1	0.4	V
	$I_{SINK}=200\text{mA}$		1.5	2.2		1.5	2.2	V
Output High Level	$I_{SOURCE}=20\text{mA}$	13.0	13.5		13.0	13.5		V
	$I_{SOURCE}=200\text{mA}$	12.0	13.5		12.0	13.5		V
Rise Time	$T_J=25^\circ\text{C}$ , $C_L=1\text{nF}$ (Note 2)		50	150		50	150	ns
Fall Time	$T_J=25^\circ\text{C}$ , $C_L=1\text{nF}$ (Note 2)		50	150		50	150	ns

Electrical Characteristics:  $-25 \leq T_A \leq 85^\circ\text{C}$  for CS2844/2845,  $0 \leq T_A \leq 70^\circ\text{C}$  for CS3844/3845.  $V_{CC}=15\text{V}$  (Note 1);  $R_T=10\text{k}\Omega$ ,  $C_T=3.3\text{nF}$  for sawtooth mode., unless otherwise stated.

PARAMETER	TEST CONDITIONS	CS2844/CS2845			CS3844/CS3845			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
<b>■ Total Standby Current</b>								
Start-Up Current			0.5	1.0		0.5	1.0	mA
Operating Supply Current	$V_{FB}=V_{Sense}=0\text{V}$ $R_T=10\text{k}\Omega$ , $C_T=3.3\text{nF}$		11	17		11	17	mA
$V_{CC}$ Zener Voltage	$I_{CC}=25\text{mA}$		34			34		V

**■ PWM Section**

Maximum Duty Cycle		46	48	50	46	48	50	%
Minimum Duty Cycle				0			0	%

PARAMETER	TEST CONDITIONS	CS2844			CS3844			CS2845/CS3845			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	

**■ Under-Voltage Lockout Section**

Start Threshold		15	16	17	14.5	16	17.5	7.8	8.4	9.0	V
Min. Operating Voltage	After Turn On	9	10	11	8.5	10	11.5	7.0	7.6	8.2	V

Notes: 1. Adjust  $V_{CC}$  above the start threshold before setting at 15V.

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

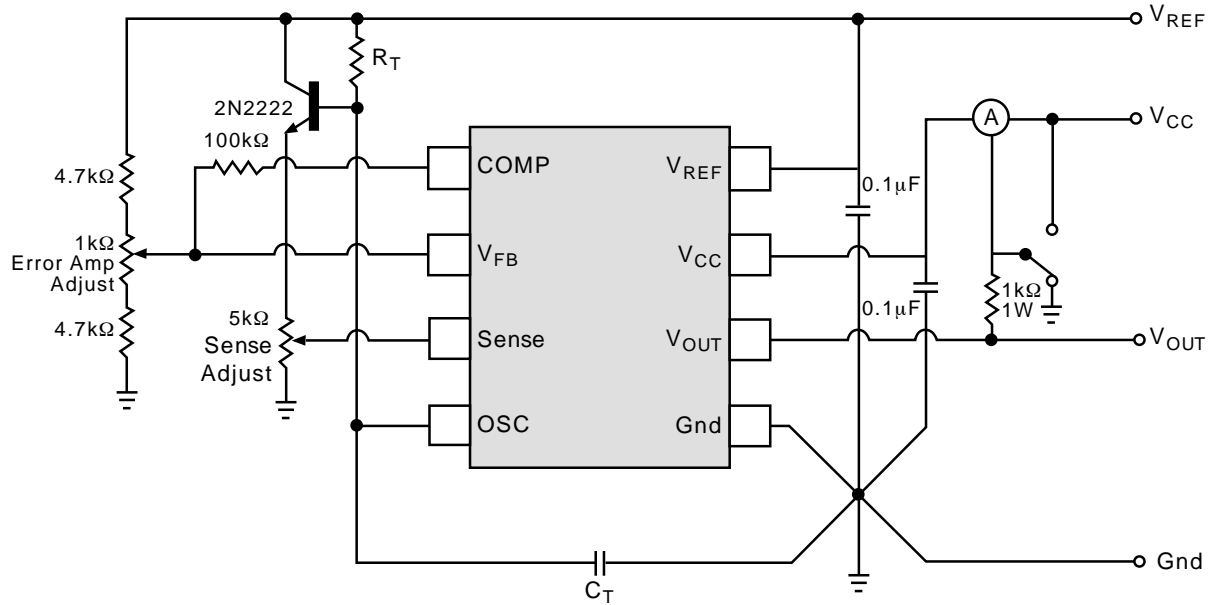
3. Parameter measured at trip point of latch with  $V_{FB}=0$ .

4. Gain defined as:

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

**Package Pin Description**

PACKAGE PIN #			PIN SYMBOL	FUNCTION
8L PDIP/SO	14L SO Narrow	16L SO Wide		
1	1	3	COMP	Error amp output, used to compensate error amplifier.
2	3	4	$V_{FB}$	Error amp inverting input.
3	5	5	Sense	Noninverting input to Current Sense Comparator.
4	7	6	OSC	Oscillator timing network with Capacitor to Ground, resistor to $V_{REF}$ .
5	9	11	Gnd	Ground.
	8	10	Pwr Gnd	Output driver Ground.
6	10	12	$V_{OUT}$	Output drive pin.
	11	13	$V_{CCPwr}$	Output driver positive supply.
7	12	14	$V_{CC}$	Positive power supply.
8	14	15	$V_{REF}$	Output of 5V internal reference.
	2,4,6,13	1,2,7,8,9,16	NC	No Connection.



Circuit Description

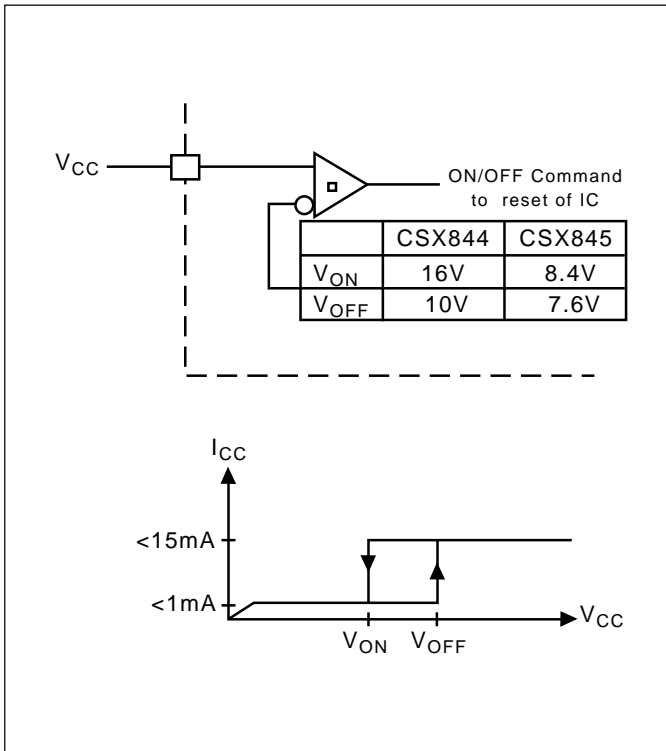


Figure 1: Startup voltage for CSX844 and CSX845.

Undervoltage Lockout

During Undervoltage Lockout (Figure 1), 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 2). An increase in V<sub>CC</sub> 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 OSC components.

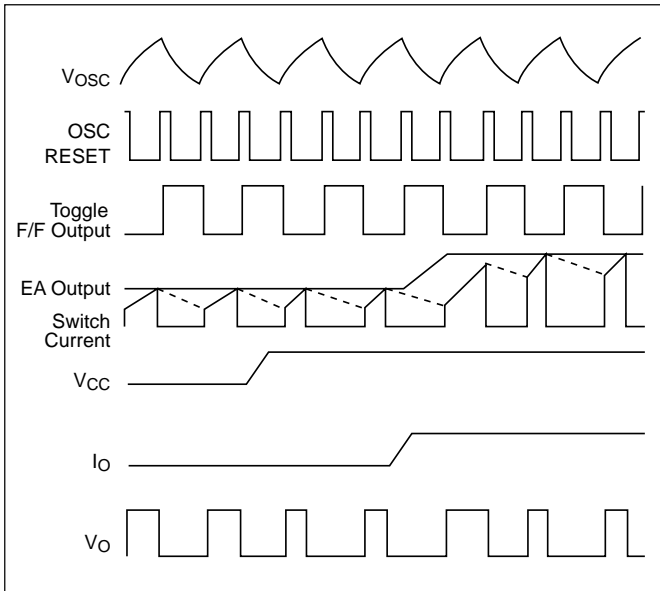


Figure 2: Timing Diagram

### Setting the Oscillator

The times  $T_c$  and  $T_d$  can be determined as follows:

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

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

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

then  $V_{REF} = 5.0V, V_{upper} = 2.7V, V_{lower} = 1.0V, I_d = 8.3mA,$

$$t_c \approx 0.5534 R_T C_T$$

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

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

### 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  $5k\Omega$  potentiometer are used to sample the oscillator waveform and apply an adjustable ramp to Sense.

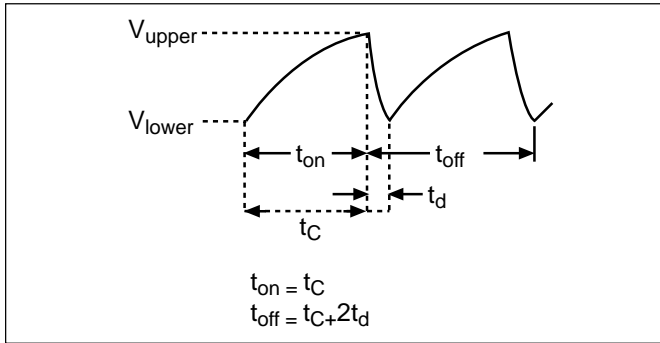


Figure 3: Duty Cycle parameters.

## Package Specification

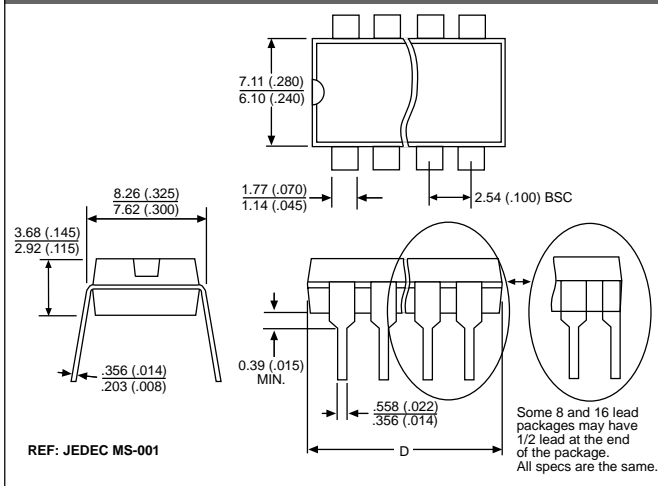
### PACKAGE DIMENSIONS IN mm (INCHES)

Lead Count	D			
	Metric		English	
	Max	Min	Max	Min
8 Lead PDIP	10.16	9.02	.400	.355
8 Lead SO Narrow	5.00	4.80	.197	.189
14L SO Narrow	8.75	8.55	.344	.337
16L SO Wide	10.50	10.10	.413	.398

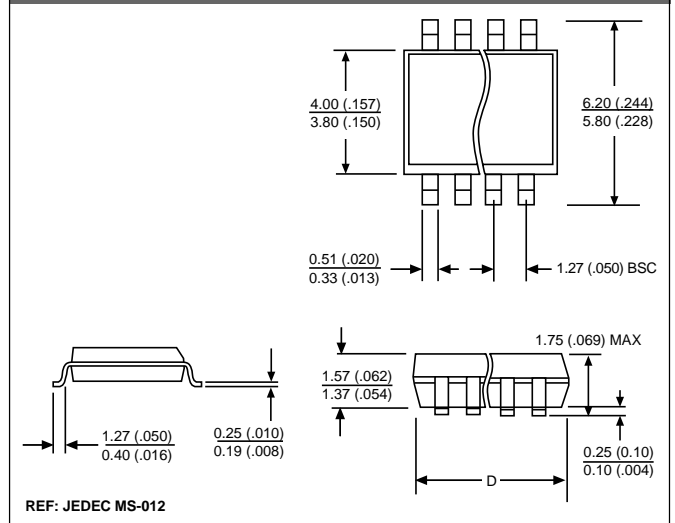
### PACKAGE THERMAL DATA

Thermal Data		8 L PDIP	8L SO Narrow	14 L SO Narrow	16L SO Wide	
$R_{\theta JC}$	typ	52	45	30	23	°C/W
$R_{\theta JA}$	typ	100	165	125	105	°C/W

#### Plastic DIP (N); 300 mil wide



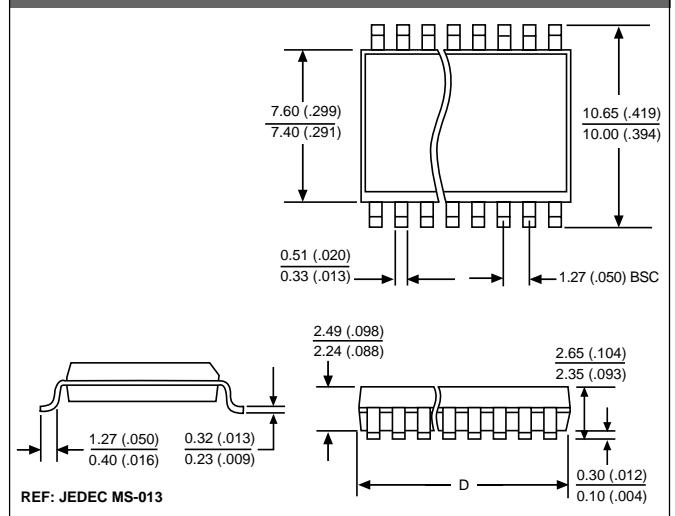
#### Surface Mount Narrow Body (D); 150 mil wide



#### Ordering Information

Part Number	0°C to 70°C	-25°C to 85°C	Description
CS2844LN8		•	8L PDIP
CS2844LD14		•	14L SO
CS2844LDR14		•	14L SO (Tape & Reel)
CS2844LDW16		•	16L SO Wide
CS2844LDWR16		•	16L SO Wide (Tape & Reel)
CS2845LN8		•	8L PDIP
CS2845LDW16		•	16L SO Wide
CS2845LDWR16		•	16L SO Wide (Tape & Reel)
CS3844GN8	•		8L PDIP
CS3844GD8	•		8L SO
CS3844GDR8	•		8L SO (Tape & Reel)
CS3844GD14	•		14L SO
CS3844GDR14	•		14L SO (Tape & Reel)
CS3844GDW16	•		16L SO Wide
CS3844GDWR16	•		16L SO Wide (Tape & Reel)
CS3845GN8	•		8L PDIP
CS3845GD8	•		8L SO
CS3845GDR8	•		8L SO (Tape & Reel)
CS3845GD14	•		14L SO
CS3845GDR14	•		14L SO (Tape & Reel)
CS3845GDW16	•		16L SO Wide
CS3845GDWR16	•		16L SO Wide (Tape & Reel)

#### Surface Mount Wide Body (DW); 300 mil wide



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