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# ONE MEGAHERTZ CURRENT-MODE CONTROL

## DESCRIPTION

The CS-320/1 family of integrated circuits is designed for use with the most preferred types of current-mode control: Hysteretic, Constant-OFF Time, and Constant-Frequency. Careful consideration was given to each of the circuit blocks to allow operation at switching frequencies up to one megahertz.

Several protection features are included to ensure "bullet-proof" operation under severe operating conditions. When used in the Constant-OFF Time mode, a unique circuit (patent-pending) continually monitors the inductor current and extends the OFF time to prevent a current-runaway situation during overload conditions.

The precision timer circuit gives the power supply designer complete freedom in selecting the maximum ON/OFF time of the output drivers.

A programmable UVLO is optimized for either OFF-line Boot-Strap or low voltage/battery operation.

The high-bandwidth voltage-type error amplifier has a novel bidirectional interface port that allows paralleling power modules without the need to assign "master/slave" status.

In the CS-320 the output is ACTIVE-HIGH, while the CS-321 is ACTIVE-LOW.

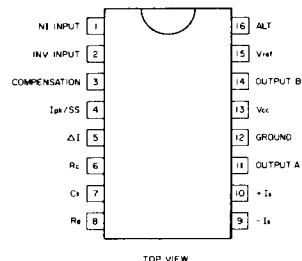
## ABSOLUTE MAXIMUM RATINGS

Supply voltage.....	20V
Output current.....	±1A
Analog Inputs.....	-0.25 to V <sub>CC</sub> -4V

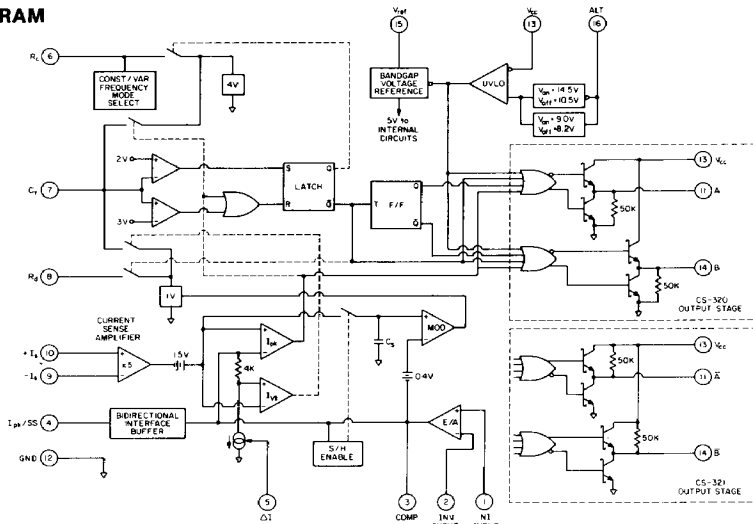
## FEATURES:

- One Megahertz Operation
- Programmable Under-Voltage Lockout
- Inherent protection against Current Runaway During Short Circuit Conditions
- Operates in Hysteretic, Constant-OFF time and Constant Frequency Modes
- Allows Parallel Operation of Power Modules without "Master/Slave" Status
- Optimized for interfacing with Current-Sensing MOSFETs

## PIN CONNECTIONS



## BLOCK DIAGRAM



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**ELECTRICAL CHARACTERISTICS** Unless otherwise stated, specifications apply at  $-25^{\circ}\text{C} \leq T_a \leq 85^{\circ}\text{C}$  for the CS320/1 I,  $0^{\circ}\text{C} \leq T_a \leq 70^{\circ}\text{C}$  for the CS320/1 C.  $V_{cc}=20\text{V}$

PARAMETER	PIN	TEST CONDITIONS	CS-320/1 I			CS-320/1 C			UNIT
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	

#### Reference Section

Output Voltage	15	$T_J=25^{\circ}\text{C}$ $I_O=1\text{mA}$	4.95	5.00	5.05	4.90	5.00	5.10	V
Line Regulation	15	$V_{I6}=5\text{V}$ , $9.5 < V_{in} < 20\text{V}$		5	20		5	20	mV
Load Regulation	15	$1 < I_O < 10\text{mA}$		6	25		6	25	mV
Temp Stability	15	(Note 1)		0.2	0.6		0.2	0.6	mV/C
Total Output Variation	15	Line, Load, Temp	4.90		5.10	4.82		5.18	V
Output Noise Voltage	15	$10\text{Hz} < f < 10\text{kHz}$ $T_J=25^{\circ}\text{C}$ (Note 1)		50			50		$\mu\text{V}$
Long Term Stability	15	$T_a=125^{\circ}\text{C}$ , 1000 Hrs, (Note 1)		5	25		5	25	mV
Output Short Circuit	15	$T_a=25^{\circ}\text{C}$ $V_{I5}=0\text{V}$	25		120	25		125	mA

#### Timer Section Note: $R_C=3.9\text{k}$ , $R_D=4.7\text{k}$ , $C_I=2000\text{pF}$ unless otherwise noted

Maximum ON Time	7	$T_J=25^{\circ}\text{C}$	4.50	5.00	5.50	4.50	5.00	5.50	$\mu\text{S}$
Maximum OFF Time	7	$T_J=25^{\circ}\text{C}$	4.50	5.00	5.50	4.50	5.00	5.50	$\mu\text{S}$
Voltage Stability	7	$V_{I6}=5\text{V}$ , $9.5 < V_{in} < 20\text{V}$		1			1		%
Temp. Stability	7	$T_{min} < T_a < T_{max}$ (Note 1)		5			5		%
Vpeak	7			2.9			2.9		V
Vvalley	7			2.0			2.0		V
Vcharge	6	$I_6=1\text{mA}$ , $V_7=1.5\text{V}$		4.0			4.0		V
Vdischarge	8	$I_8=1\text{mA}$ , $V_7=3.5\text{V}$		1.0			1.0		V
Maximum Charge Current	6	$V_6=2\text{V}$ , $V_7=1.5\text{V}$	1.0			1.0			mA
Maximum Discharge Current	8	$V_8=3\text{V}$ , $V_7=3.5\text{V}$	1.0			1.0			mA

#### Error Amp. Section

Input Offset Voltage	1,2	$V_1=2.5\text{V}$ , $V_2=V_3$			10			15	mV
Input Bias Current	1,2	$V_1=V_2=2.5\text{V}$		-0.3	-1		-0.3	-2	$\mu\text{A}$
Input Offset Current	1,2	$V_1=V_2=2.5\text{V}$		0.1	1		0.1	1	$\mu\text{A}$
AVol	3	$1 < V_O < 3.5\text{V}$	65	90		65	90		dB
Unity Gain Bandwidth	3	(Note 1)	3	6		3	6		MHz
Vout High	3		3.8	4		3.8	4		V
Vout Low	3			0.7	1.1		0.7	1.1	V
Common Mode Voltage Range	1,2		1.5		5.5	1.5		5.5	V

#### Current Sense Section

Gain	9,10	$V_9=1\text{V}$ , $V_3=V_2$ , (Note 2)	4.35	5.0	5.65	4.35	5.0	5.65	V/V
Max. Diff. Input Signal	9,10				400			400	mV
PSRR	9,10			70			70		dB
Input Bias Current	9,10			-40	-65		-40	-65	$\mu\text{A}$
Delay To Output	11,14	(Note 1)		100	150		100	150	nS
Com.-Mode Voltage Range	9,10		-0.25		$V_{cc}-4$	-0.25		$V_{cc}-4$	V
CMRR	9,10		60	80		60	80		dB

#### Current Hysteresis Input

$\Delta I$ Current	5	$V_s=0\text{V}$		0.5	50		0.5	50	$\mu\text{A}$
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#### Under-Voltage Lockout Section

Start-Up Current	13			0.8	2		0.8	2	mA
Operating Supply Current	13			26	35		26	35	mA
Start Threshold (Hi)	13	$V_{I6}=0\text{V}$	13.5	14.5	15.5	13.5	14.5	15.5	V
Start Threshold (Lo)	13	$V_{I6}=\text{OPEN}$	8.5	9.0	9.5	8.5	9.0	9.5	V
Stop Threshold (Hi)	13	$V_{I6}=0\text{V}$	9.5	10.5	11.5	9.5	10.5	11.5	V
Stop Threshold (Lo)	13	$V_{I6}=\text{OPEN}$	7.4	8.2	8.8	7.4	8.2	8.8	V
Alt. Start Input Current	16	$V_{I6}=0\text{V}$	35	60	100	35	60	100	$\mu\text{A}$

#### Output Section (Note 3)

Output Low Level	11,14	$I_{\text{sink}}=20\text{mA}$		0.25	0.4		0.25	0.4	V
		$I_{\text{sink}}=200\text{mA}$		1.5	2.2		1.5	2.2	V
Output High Level	11,14	$I_{\text{sink}}=20\text{mA}$	18	18.5		18	18.5		V
		$I_{\text{sink}}=200\text{mA}$	17.5	18		17.5	18		V
Rise Time	11,14	$T_J=25^{\circ}\text{C}$ $C_I=1\text{nF}$ (Note 1)		60	100		60	100	nS
Fall Time	11,14	$T_J=25^{\circ}\text{C}$ $C_I=1\text{nF}$ (Note 1)		30	60		30	60	nS
Output Resistance	11,14	$V_{in} < V_{in}(\text{Start})$	35K	50K	65K	35K	50K	65K	Ohm

#### Peak/Soft-Start Section

S/S Cap. Charge Current	4	$V_4=0\text{V}$	40	75	115	40	75	115	$\mu\text{A}$
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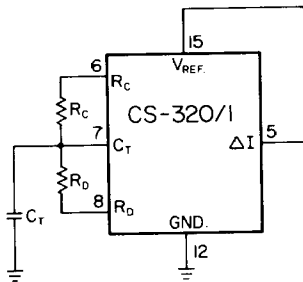
Note 1: Although guaranteed, these parameters are not 100% tested in production.

Note 2: Gain is defined as:  $A = \frac{V_{32}-V_{31}}{V_{I02}-V_{I01}}$  Where:  $V_{31}=2.5\text{V}$   
 $V_{32}=3.5\text{V}$

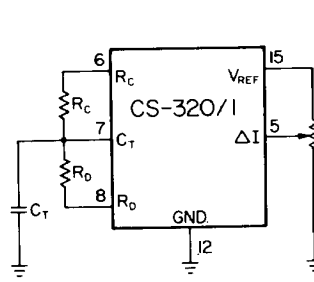
Measure  $V_{I01}$  and  $V_{I02}$  at turn OFF of output.

Note 3: CS-320 Output is active HIGH  
CS-321 Output is active LOW

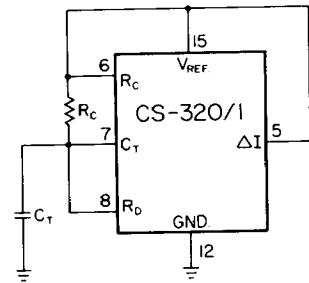
## TYPICAL TIMER CONFIGURATIONS FOR THE THREE CURRENT-MODE CONTROLLERS



CONSTANT OFF TIME



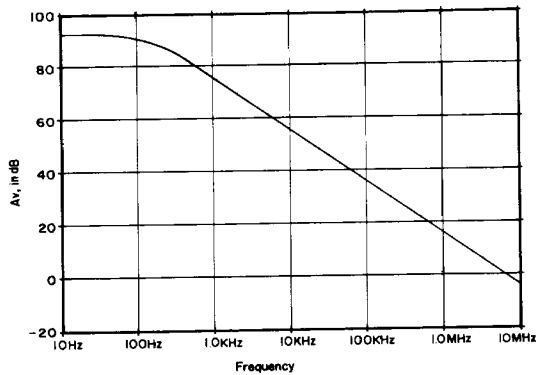
HYSTERETIC



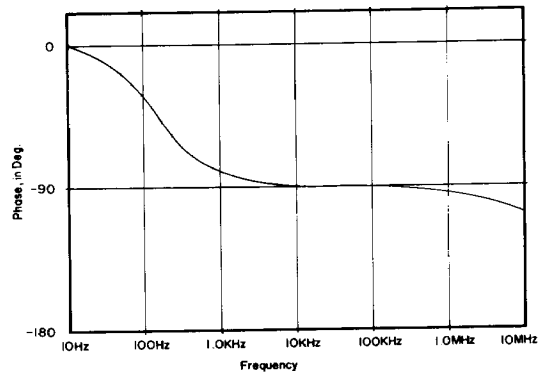
CONSTANT FREQUENCY

4

## ERROR AMPLIFIER TYPICAL CHARACTERISTICS



ERROR AMPLIFIER OPEN LOOP GAIN vs FREQUENCY



ERROR AMPLIFIER OPEN LOOP PHASE vs FREQUENCY

MANUFACTURED UNDER U.S. PATENT NO. 4,456,872

The circuit diagram shows a differential amplifier using two 2N3904 transistors. The base of the first transistor is connected to a 5V supply through a 43Ω resistor (R12) and a 500Ω resistor (R13). The base of the second transistor is connected to the same 5V supply through a 43Ω resistor (R12) and a 500Ω resistor (R13). The emitters of both transistors are connected to a common emitter resistor (R14, 34Ω) which is connected to ground. The collector of the first transistor is connected to a 5V supply through a 10Ω resistor (R15) and a 2N3904 diode (D2). The collector of the second transistor is connected to a 5V supply through a 10Ω resistor (R15) and a 2N3904 diode (D2). The output of the first transistor is connected to the non-inverting input (INV INPUT) of the AD534CJ op-amp. The output of the second transistor is connected to the inverting input (IN INPUT) of the AD534CJ op-amp. The op-amp is configured with a feedback resistor (R2, 2K) and a compensation capacitor (C2, 1000 pF). The op-amp's output is connected to a load resistor (R4, 5.0K) and a capacitor (C4, 6.0 nF). The op-amp's ground is connected to a 4.7 nF capacitor (C7) and a 10 μF capacitor (C9). The op-amp's Vcc is connected to a 5V supply through a 10 μF capacitor (C9) and a 1K resistor (R14). The op-amp's Vref is connected to a 2.2 μF capacitor (C5) and a 10 μF capacitor (C9). The op-amp's Ipr/SS is connected to a 10K resistor (R10) and a 1 μF capacitor (C6). The op-amp's ΔI is connected to a 10K resistor (R10) and a 1 μF capacitor (C6). The op-amp's output B is connected to a 10 μF capacitor (C9) and a 1K resistor (R14). The op-amp's output A is connected to a 10 μF capacitor (C9) and a 1K resistor (R14). The op-amp's output is connected to a 10 μF capacitor (C9) and a 1K resistor (R14).

## ORDERING INFORMATION

PART NO.	0°C to 70°C	-25°C to 85°C	PACKAGE
CS-320CJ	*		16L CDIP
CS-320CN	*		16L PDIP
CS-321CJ	*		16L CDIP
CS-321CN	*		16L PDIP
CS-320IJ		*	16L CDIP
CS-320IN		*	16L PDIP
CS-321IJ		*	16L CDIP
CS-321IN		*	16L PDIP

**CSC™ CHERRY! SEMICONDUCTOR.**

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