

## General Description

The MIC38C4x and MIC38HC4x are fixed frequency, high performance, current-mode PWM controllers. Micrel's BiCMOS devices are pin compatible with 384x bipolar devices but feature several improvements. 'HC' versions support even faster rise and fall times than 'C' versions.

Undervoltage lockout circuitry allows the '42 and '44 versions to start up at 14.5V and operate down to 9V, and the '43 and '45 versions start at 8.4V with operation down to 7.6V. All versions operate up to 20V.

When compared to bipolar 384x devices operating from a 15V supply, start-up current has been reduced to 50µA typical and operating current has been reduced to 4.0 mA typical. Decreased output rise and fall times drive larger MOSFETs, and rail-to-rail output capability increases efficiency, especially at lower supply voltages. The MIC38C4x and MIC38HC4x also feature a trimmed oscillator discharge current and bandgap reference.

MIC38x4x denotes 8-pin plastic DIP and SOIC packages. MIC38HC4x-1 denotes 14-pin plastic DIP and SOIC packages. Devices identified as MIC18x4x and MIC18x4x-1 are military temperature range 8- and 14-pin ceramic DIPs, respectively. 8-pin devices feature small size, while 14-pin devices separate the analog and power connections for improved performance and power dissipation.

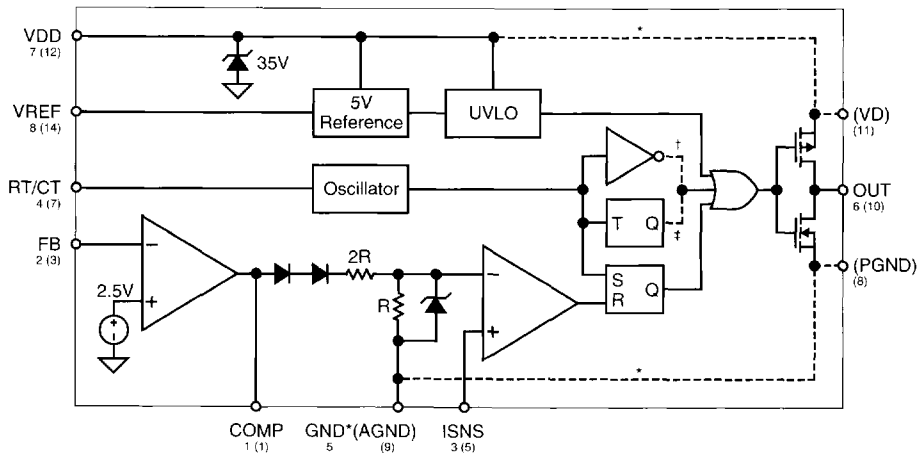
## Features

- Fast output rise/fall times:
  - 40ns rise/30ns fall for the MIC38C42
  - 20ns rise/15ns fall for the MIC38HC42
- -40°C to +85°C temperature range meets UC284x specifications
- High-performance, low-power BiCMOS Process
- Ultra-low start-up current (50µA typical)
- Low operating current (4mA typical)
- High output drive (1A peak current, HC version)
- CMOS outputs with rail-to-rail swing
- Current-mode operation ≥500kHz
- Trimmed 5V bandgap reference
- Pin-for-pin compatible with UC3842/3843/3844/3845(A)
- Trimmed oscillator discharge current
- UVLO with hysteresis
- Low cross-conduction currents

## Applications

- Current-mode, off-line, switched-mode power supplies
- Current-mode, dc-to-dc converters.
- Step-down "buck" regulators
- Step-up "boost" regulators
- Flyback, isolated regulators
- Forward converters
- Synchronous FET converters

## Functional Diagram



( ) pins are on MICx8C/HC4x-1 (14-lead) versions only  
 \* MICx8C/HC4x (8-lead) versions only  
 † MICx8C/HC42, MICx8C/HC43 (96% max. duty cycle) versions only  
 ‡ MICx8C/HC44, MICx8C/HC45 (50% max. duty cycle) versions only

## Ordering Information

Part Number	Temperature Range	Package
MIC18C42AJ	-55°C to +125°C	8-pin CerDIP
MIC18C43AJ	-55°C to +125°C	8-pin CerDIP
MIC18C44AJ	-55°C to +125°C	8-pin CerDIP
MIC18C45AJ	-55°C to +125°C	8-pin CerDIP
MIC18C42-1AJ	-55°C to +125°C	14-pin CerDIP
MIC18C43-1AJ	-55°C to +125°C	14-pin CerDIP
MIC18C44-1AJ	-55°C to +125°C	14-pin CerDIP
MIC18C45-1AJ	-55°C to +125°C	14-pin CerDIP
MIC38C42BN	-40°C to +85°C	8-pin Plastic DIP
MIC38C43BN	-40°C to +85°C	8-pin Plastic DIP
MIC38C44BN	-40°C to +85°C	8-pin Plastic DIP
MIC38C45BN	-40°C to +85°C	8-pin Plastic DIP
MIC38C42-1BN	-40°C to +85°C	14-pin Plastic DIP
MIC38C43-1BN	-40°C to +85°C	14-pin Plastic DIP
MIC38C44-1BN	-40°C to +85°C	14-pin Plastic DIP
MIC38C45-1BN	-40°C to +85°C	14-pin Plastic DIP
MIC38C42BM	-40°C to +85°C	8-pin SOIC
MIC38C43BM	-40°C to +85°C	8-pin SOIC
MIC38C44BM	-40°C to +85°C	8-pin SOIC
MIC38C45BM	-40°C to +85°C	8-pin SOIC
MIC38C42-1BM	-40°C to +85°C	14-pin SOIC
MIC38C43-1BM	-40°C to +85°C	14-pin SOIC
MIC38C44-1BM	-40°C to +85°C	14-pin SOIC
MIC38C45-1BM	-40°C to +85°C	14-pin SOIC

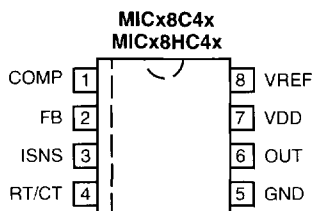
Part Number	Temperature Range	Package
MIC18HC42AJ	-55°C to +125°C	8-pin CerDIP
MIC18HC43AJ	-55°C to +125°C	8-pin CerDIP
MIC18HC44AJ	-55°C to +125°C	8-pin CerDIP
MIC18HC45AJ	-55°C to +125°C	8-pin CerDIP
MIC18HC42-1AJ	-55°C to +125°C	14-pin CerDIP
MIC18HC43-1AJ	-55°C to +125°C	14-pin CerDIP
MIC18HC44-1AJ	-55°C to +125°C	14-pin CerDIP
MIC18HC45-1AJ	-55°C to +125°C	14-pin CerDIP
MIC38HC42BN	-40°C to +85°C	8-pin Plastic DIP
MIC38HC43BN	-40°C to +85°C	8-pin Plastic DIP
MIC38HC44BN	-40°C to +85°C	8-pin Plastic DIP
MIC38HC45BN	-40°C to +85°C	8-pin Plastic DIP
MIC38HC42-1BN	-40°C to +85°C	14-pin Plastic DIP
MIC38HC43-1BN	-40°C to +85°C	14-pin Plastic DIP
MIC38HC44-1BN	-40°C to +85°C	14-pin Plastic DIP
MIC38HC45-1BN	-40°C to +85°C	14-pin Plastic DIP
MIC38HC42BM	-40°C to +85°C	8-pin SOIC
MIC38HC43BM	-40°C to +85°C	8-pin SOIC
MIC38HC44BM	-40°C to +85°C	8-pin SOIC
MIC38HC45BM	-40°C to +85°C	8-pin SOIC
MIC38HC42-1BM	-40°C to +85°C	14-pin SOIC
MIC38HC43-1BM	-40°C to +85°C	14-pin SOIC
MIC38HC44-1BM	-40°C to +85°C	14-pin SOIC
MIC38HC45-1BM	-40°C to +85°C	14-pin SOIC

Refer to the Part Number Cross Reference for a listings of Micrel devices equivalent to UC284x and UC384x devices.

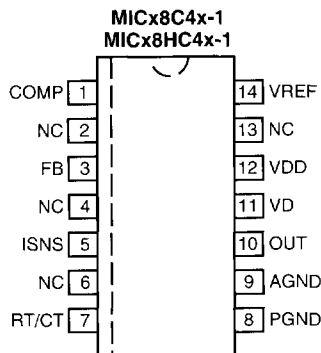
## Selection Guide

Duty Cycle	UVLO Thresholds	
	Startup 8.4V Minimum Operating 7.6V	Startup 14.5V Minimum Operating 9V
0% to 96%	MIC18C43/HC43 MIC38C43/HC43	MIC18C42/HC42 MIC38C42/HC42
0% to 50%	MIC18C45/HC45 MIC38C45/HC45	MIC18C44/HC44 MIC38C44/HC44

## Pin Configuration



**8-Pin DIP (N, J)**  
**8-Lead SOIC (M)**



**14-Pin DIP (-1xN, -1xJ)**  
**14-Lead SOIC (-1xM)**

## Pin Description

Pin Number N, J, M	Pin Number -1xN, -1xJ, -1xM	Pin Name	Pin Function
1	1	COMP	Compensation: Connect external compensation network to modify the error amplifier output.
	2	NC	Not internally connected.
2	3	FB	Feedback (Input): Error amplifier input. Feedback is 2.5V at desired output voltage.
	4	NC	Not internally connected.
3	5	ISNS	Current Sense (Input): Current sense comparator input. Connect to current sensing resistor or current transformer.
	6	NC	Not internally connected.
4	7	RT/CT	Timing Resistor/Timing Capacitor: Connect external RC network to select switching frequency.
5		GND	Ground: Combined analog and power ground.
	8	PGND	Power Ground: N-channel driver transistor ground.
	9	AGND	Analog Ground: Controller circuitry ground.
6	10	OUT	Power Output: Totem-pole output.
	11	VD	Power Supply (Input): P-channel driver transistor supply input. Return to power ground (PGND).
7	12	VDD	Analog Supply (Input): Controller circuitry supply input. Return to analog ground (AGND).
	13	NC	Not internally connected.
8	14	VREF	5V Reference (Output): Connect external RC network.

**Absolute Maximum Ratings**

Zener Current ..... 30mA

**Operation at  $\geq 18V$  may require****special precautions (see Applications Information).**

VDD ..... 20V

VD (x8C4x-1, x8HC4x-1) ..... 20V

ISNS ..... -0.3V to 5.5V

FB ..... -0.3V to 5.5V

Output Current (x8C42/43/44/45) ..... 0.5A

Output Current (x8HC42/43/44/45) ..... 1A

Operating Junction Temperature ..... 150°C

Package Thermal Resistance

 $\theta_{JA}$  8-Pin Plastic DIP ..... 100°C/W $\theta_{JA}$  8-Pin Ceramic DIP ..... 125°C/W $\theta_{JA}$  8-Pin SOIC ..... 170°C/W $\theta_{JA}$  14-Pin Plastic DIP ..... 90°C/W $\theta_{JA}$  14-Pin Ceramic DIP ..... 110°C/W $\theta_{JA}$  14-Pin SOIC ..... 145°C/W

Storage Temperature ..... -65°C to 150°C

**Electrical Characteristics**  $V_{DD} = 15V$  (Note 4),  $R_T = 10k\Omega$ ,  $C_T = 3.3nF$ -55  $\leq T_A \leq 125^\circ C$  for MIC18C42/43/44/45, 18HC42/43/44/45; -40  $\leq T_A \leq 85^\circ C$  for MIC38C42/43/44/45, 38HC42/43/44/45

Parameter	Test Conditions	MIC18C42/43/44/45 MIC18HC42/43/44/45			MIC38C42/43/44/45 MIC38HC42/43/44/45			Units
		Min	Typ	Max	Min	Typ	Max	
<b>Reference Section</b>								
Output Voltage	$T_A = 25^\circ C$ , $I_O = 1mA$	4.95	5.00	5.05	4.90	5.00	5.10	V
Line Regulation	$12V \leq V_{DD} \leq 18V$ , $I_O = 5\mu A$ (Note 6)		2	20		2	20	mV
Load Regulation	$1 \leq I_O \leq 20mA$		1	25		1	25	mV
Temp. Stability	(Note 1)		0.2			0.2		mV/°C
Total Output Variation	Line, Load, Temp. (Note 1)	4.9		5.1	4.82		5.18	V
Output Noise Voltage	$10Hz \leq f \leq 10kHz$ , $T_A = 25^\circ C$ (Note 1)		50			50		$\mu V$
Long Term Stability	$T_A = 125^\circ C$ , 1000 Hrs. (Note 1)		5	25		5	25	mV
Output Short Circuit		-30	-80	-180	-30	-80	-180	mA
<b>Oscillator Section</b>								
Initial Accuracy	$T_A = 25^\circ C$ (Note 5)	49	52	55	49	52	55	kHz
Voltage Stability	$12 \leq V_{DD} \leq 18V$ (Note 6)		0.2	1.0		0.2	1.0	%
Temp. Stability	$T_{MIN} \leq T_A \leq T_{MAX}$ (Note 1)		0.04			0.04		%/°C
Clock Ramp	$T_A = 25^\circ C$ , $V_{RT/CT} = 2V$	7.7	8.4	9.0	7.7	8.4	9.0	mA
Reset Current	$T_A = T_{MIN}$ to $T_{MAX}$	7.2	8.4	9.5	7.2	8.4	9.5	mA
Amplitude	$V_{RT/CT}$ peak to peak		1.9			1.9		Vp-p
<b>Error Amp Section</b>								
Input Voltage	$V_{COMP} = 2.5V$	2.45	2.50	2.55	2.42	2.50	2.58	V
Input Bias Current	$V_{FEEDBACK} = 5.0V$		-0.1	-1		-0.1	-2	$\mu A$
$A_{VOL}$	$2 \leq V_O \leq 4V$	65	90		65	90		dB
Unity Gain Bandwidth	(Note 1)	0.7	1.0		0.7	1.0		MHz
PSRR	$12 \leq V_{DD} \leq 18V$	60			60			dB
Output Sink Current	$V_{FEEDBACK} = 2.7V$ , $V_{COMP} = 1.1V$	2	14		2	14		mA
Output Source Current	$V_{FEEDBACK} = 2.3V$ , $V_{COMP} = 5V$	-0.5	-1		-0.5	-1		mA
$V_{OUT}$ High	$V_{FEEDBACK} = 2.3V$ , $R_L = 15k$ to ground	5	6.8		5	6.8		V
$V_{OUT}$ Low	$V_{FEEDBACK} = 2.7V$ , $R_L = 15k$ to $V_{REF}$		0.1	1.1		0.1	1.1	V

Parameter	Test Conditions	MIC18C42/43/44/45 MIC18HC42/43/44/45			MIC38C42/43/44/45 MIC38HC42/43/44/45			Units
		Min	Typ	Max	Min	Typ	Max	
<b>Current Sense</b>								
Gain	(Notes 2 & 3)	2.85	3.0	3.15	2.85	3.0	3.15	V/V
Maximum Threshold	$V_{COMP} = 5V$ (Note 2)	0.9	1	1.1	0.9	1	1.1	V
PSRR	$12 \leq V_{DD} \leq 18V$ (Note 2)		70			70		dB
Input Bias Current			-0.1	-1		-0.1	-2	$\mu A$
Delay to Output			120	250		120	250	ns
<b>Output</b>								
$R_{DS(ON)}$ 'C' High	$I_{SOURCE} = 200 mA$		20			20		$\Omega$
$R_{DS(ON)}$ 'C' Low	$I_{SINK} = 200 mA$		11			11		$\Omega$
$R_{DS(ON)}$ 'HC' High	$I_{SOURCE} = 200 mA$		10			10		$\Omega$
$R_{DS(ON)}$ 'HC' Low	$I_{SINK} = 200 mA$		5.5			5.5		$\Omega$
Rise Time: 'C' version	$T_A = 25^\circ C, C_L = 1 nF$		40	80		40	80	ns
Fall Time: 'C' version	$T_A = 25^\circ C, C_L = 1 nF$		30	60		30	60	ns
Rise Time: 'HC' version	$T_A = 25^\circ C, C_L = 1 nF$		20	50		20	50	ns
Fall Time: 'HC' version	$T_A = 25^\circ C, C_L = 1 nF$		15	40		15	40	ns
<b>Undervoltage Lockout</b>								
Start Threshold	38C42/4, 18C42/4, 38HC42/4, 18HC42/4	13.5	14.5	15.5	13.5	14.5	15.5	V
	38C43/5, 18C43/5, 38HC43/5, 18HC43/5	7.8	8.4	9.0	7.8	8.4	9.0	V
Min. Operating Voltage	38C42/4, 18C42/4, 38C42/4, 18HC42/4	8	9	10	8	9	10	V
	38C43/5, 38C43/5, 38HC43/5, 38HC43/5	7.0	7.6	8.2	7.0	7.6	8.2	V
<b>Pulse Width Modulator</b>								
Maximum Duty Cycle	38C42/3, 18C42/3, 38HC42/3, 18HC42/3	94	96		94	96		%
	38C44/5, 18C44/5, 38HC44/5, 18HC44/5	46	50		46	50		%
Minimum Duty Cycle				0			0	%
<b>Total Standby Current</b>								
Start-Up Current	$V_{DD} = 13V$ for x8C42/44, x8HC42/44 $V_{DD} = 7.5V$ for x8C43/45, x8HC43/45		50	150		50	200	$\mu A$
Operating Supply Current	$V_{FEEDBACK} = V_{I SENSE} = 0V$		4.0	6.0		4.0	6.0	mA
Zener Voltage ( $V_{DD}$ )	$I_{DD} = 25mA$ (Note 6)	30	37		30	37		V

**Note 1:** These parameters, although guaranteed, are not 100% tested in production.

**Note 2:** Parameter measured at trip point of latch with  $V_{EA} = 0$ .

**Note 3:** Gain defined as:

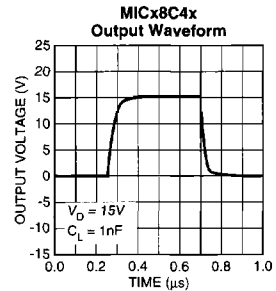
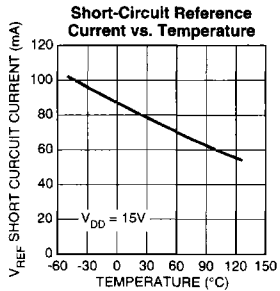
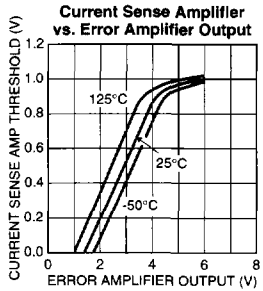
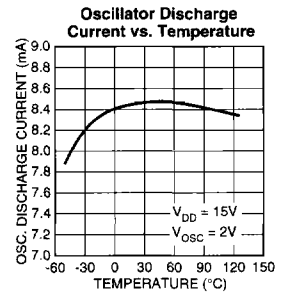
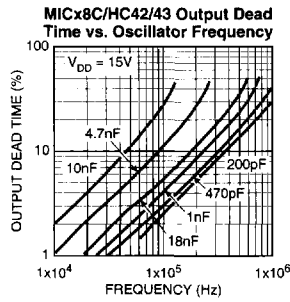
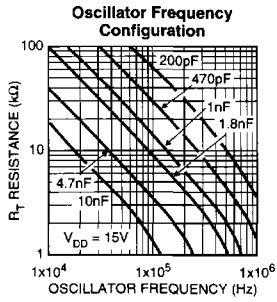
$$A = \frac{\Delta V_{PIN1}}{V_{TH}(I_{SENSE})}; 0 \leq V_{TH}(I_{SENSE}) \leq 0.8V$$

**Note 4:** Adjust  $V_{DD}$  above the start threshold before setting at 15V.

**Note 5:** Output frequency equals oscillator frequency for the '8C42 and '8C43. Output frequency for the '8C44, and '8C45 equals one half the oscillator frequency.

**Note 6:** On 8-pin version, 20V is maximum input on pin 7, as this is also the supply pin for the output stage. On 14-pin version, 40V is maximum for pin 12 and 20V maximum for pin 11.

Typical Characteristics





Using a high-value inductance for L1 and a low-ESR capacitor for C3 permits small capacitance with minimum output ripple. This inductance value also improves circuit efficiency by reducing the flux swing in L1.

Magnetic components are carefully chosen for minimal loss at 500kHz. CT1 and T1 are wound on Magnetics, Inc. P-type material toroids. L1 is wound on a Siemens N49 EFD core.

Test	Conditions	Results
Line Regulation	$V_{IN} = 26V$ to $80V$ , $I_O = 2A$	0.5%
Load Regulation	$V_{IN} = 48V$ , $I_O = 0.2A$ to $2A$	0.6%
Efficiency	$V_{IN} = 48V$ , $I_O = 2A$	90%
Output Ripple	$V_{IN} = 48V$ , $I_O = 2A$ (20MHz BW)	100mV

Symbol	Custom Coil <sup>1</sup>	ETS <sup>2</sup>
CT1	4923	ETS 92420
T1	4924	ETS 92419
L1	4925	ETS 92421

1. Custom Coils, Alcester, SD tel: (605) 934-2460
2. Energy Transformation Systems, Inc. tel: (415) 324-4949.

### Synchronous Buck Converter

Refer to figure 2. This MIC38C43 synchronous buck converter uses an MIC5022 half-bridge driver to alternately drive the PWM switch MOSFET (driven by GATEH, or high-side output) and a MOSFET which functions as a synchronous rectifier (driven by the GATEL, or low-side output).

The low-side MOSFET turns on when the high-side MOSFET is off, allowing current to return from ground. Current flows through the low-side MOSFET in the source to drain direction.

The on-state voltage drop of the low-side MOSFET is lower than the forward voltage drop of an equivalent Schottky rectifier. This lower voltage drop results in higher efficiency. A sense resistor ( $5m\Omega$ ) is connected to the driver's high-side current sense inputs to provide overcurrent protection. Refer to the MIC5020, MIC5021, and MIC5022 data sheets for more information.

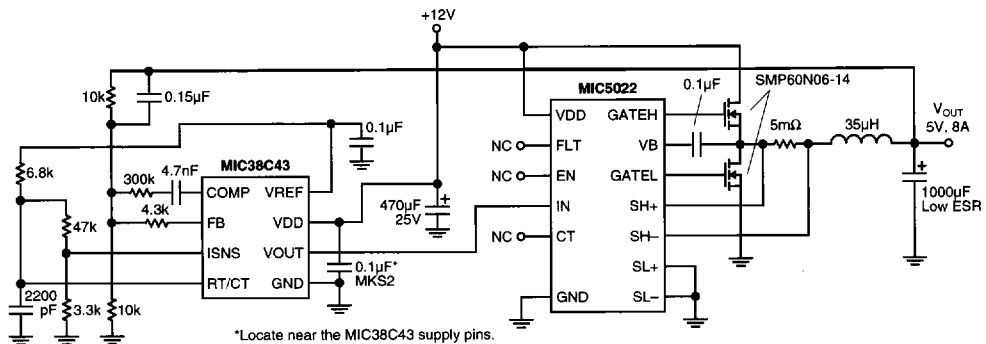


Figure 2. 100kHz, Synchronous Buck Converter