MIC38C42A/43A/44A/45A

BiCMOS Current-Mode PWM Controllers

Features

- Fast 40 ns Output Rise and 30 ns Output Fall Times
- –40°C to +85°C Ambient Temperature Range Meets UC284x Specifications
- High-Performance, Low-Power BiCMOS Process
- Ultra-Low Start-Up Current (100 µA Typical)
- Low Quiescent Operating Current (4 mA Typical)
- CMOS Outputs with Rail-to-Rail Swing
- Up to 500 kHz Current-Mode Operation
- Trimmed 5V Bandgap Reference
- Pin-for-Pin Compatible with UC3842/3843/3844/3845
- Trimmed Oscillator Discharge Current
- UVLO with Hysteresis
- Low Cross-Conduction Currents

Applications

- Current-Mode, Offline, 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

General Description

The MIC38C4xA are fixed-frequency, high performance, current-mode PWM controllers. Microchip's BiCMOS devices are pin compatible with 384x bipolar devices, but feature several improvements.

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

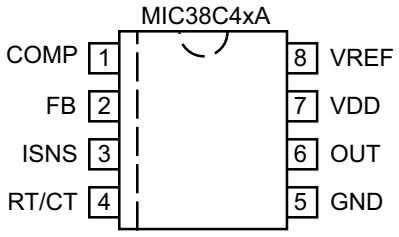
When compared to bipolar 384x devices operating from a 15V supply, start-up current has been reduced to 100 µA typical and operating current has been reduced to 4.0 mA typical. Decreased output rise and fall times drive larger MOSFETs, and rail-to-rail output capability increases efficiency, especially at lower supply voltages. The MIC38C4xA also features a trimmed oscillator discharge current and bandgap reference.

The MIC38C4xA family is available in 8-pin SOIC and MSOP-8 package options.

For fast rise and fall times and higher output drive, refer to the MIC38HC4x.

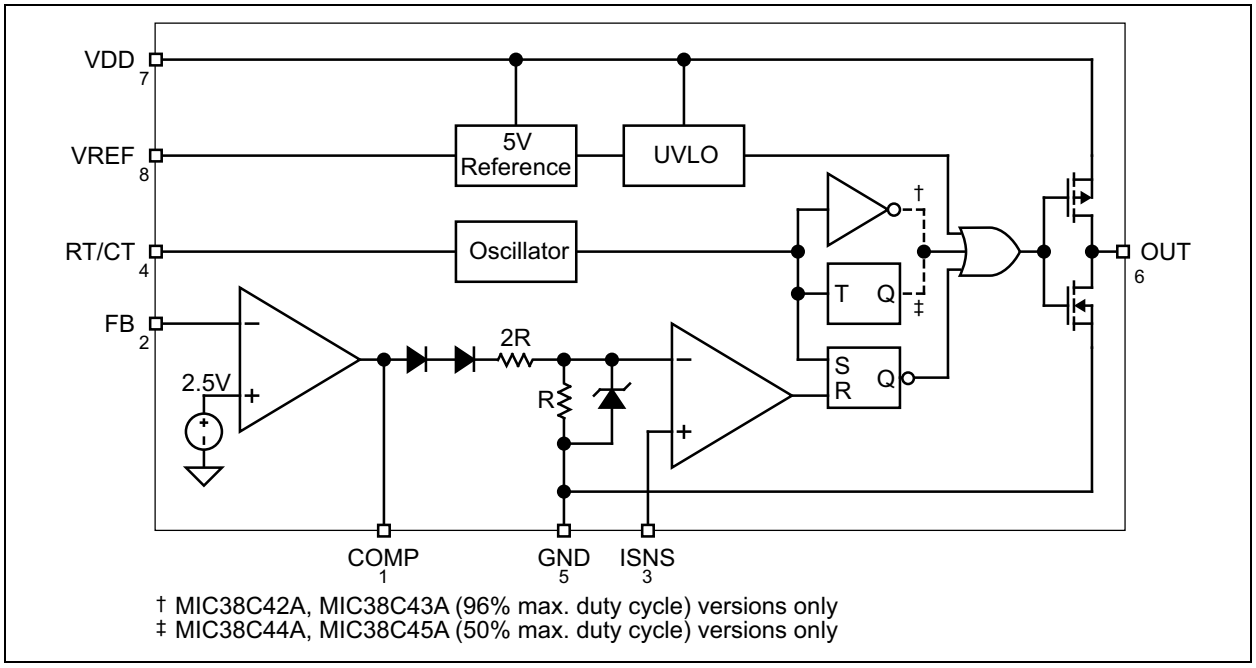
Package Type

MIC38C42A/43A/44A/45A
8-Lead SOIC (M)
8-Lead MSOP (MM)



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Functional Diagram



† MIC38C42A, MIC38C43A (96% max. duty cycle) versions only
‡ MIC38C44A, MIC38C45A (50% max. duty cycle) versions only

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1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{DD}) ..... +20V
Switch Supply Voltage (V_D) ..... +20V
Current Sense Voltage (V_{ISNS}) ..... –0.3V to +5.5V
Feedback Voltage (V_{FB}) ..... –0.3V to +5.5V
Output Current (I_{OUT}) 0.5A

† Notice: Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

Electrical Characteristics: V_{DD} = 15V, Adjust V_{DD} above the start threshold before setting at 15V; R_T = 11.0 kΩ; C_T = 3.3 nF; –40°C ≤ T_A ≤ +85°C; unless noted. Note 1

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Reference						
Output Voltage	V_{REF}	4.90	5.00	5.10	V	T_A = +25°C, I_{VREF} = 1 mA
Line Regulation	$\Delta V_{REF(LINE)}$	—	2	20	mV	12V ≤ V_{DD} ≤ 18V, I_{VREF} = 5 µA
Load Regulation	$\Delta V_{REF(LOAD)}$	—	1	25	mV	1 mA ≤ I_{VREF} ≤ 20 mA
Temperature Stability	TC_{VREF}	—	0.2	—	mV/°C	Note 2
Total Output Variation	$\Delta V_{REF(TOT)}$	4.82	—	5.18	V	Line, Load, Temperature, Note 2
Output Noise Voltage	V_{NOISE}	—	50	—	µV	10 Hz ≤ f ≤ 10 kHz, T_A = +25°C, Note 2
Long-Term Stability	$\Delta V_{REF(LT)}$	—	5	25	mV	T_A = +125°C, 1000 hours, Note 2
Output Short-Circuit	$I_{VREF(SC)}$	–30	–80	–180	mA	—
Oscillator						
Initial Accuracy	$\Delta f_{OSC(INIT)}$	47	53	59	kHz	T_A = +25°C, Note 3
Voltage Stability	$\Delta f_{OSC(VS)}$	—	0.2	1.0	%	12V ≤ V_{DD} ≤ 18V
Temperature Stability	TC_{FOSC}	—	0.04	—	%/°C	T_{MIN} ≤ T_A ≤ T_{MAX}, Note 2
Clock Ramp Reset Current	I_{DISCHG}	6.0	8.4	9.0	mA	T_A = +25°C, $V_{RT/CT}$ = 2V, Note 2
Amplitude	V_{AMP}	—	1.9	—	V_{PP}	$V_{RT/CT}$ peak-to-peak
Error Amp						
Input Voltage	$V_{IN(EA)}$	2.4	2.50	2.58	V	V_{COMP} = 2.5V
Input Bias Current	$I_{BIAS(EA)}$	—	–0.1	–2	µA	V_{FB} = 5.0V
Open Loop Voltage Gain	A_{VOL}	65	90	—	dB	2V ≤ V_{COMP} ≤ 4V
Unity Gain Bandwidth	GBW	0.7	1.0	—	MHz	Note 2
Power Supply Rejection Ratio	$PSRR_{EA}$	60	—	—	dB	12V ≤ V_{DD} ≤ 18V
Output Sink Current	$I_{COMP(SINK)}$	2	14	—	mA	V_{FB} = 2.7V, V_{COMP} = 1.1V
Output Source Current	$I_{COMP(SRC)}$	–0.3	–1	—	mA	V_{FB} = 2.3V, V_{COMP} = 5V
COMP High Voltage	V_{COMP_H}	5	6.8	—	V	V_{FB} = 2.3V, R_{LOAD} = 15 kΩ to ground
COMP Low Voltage	V_{COMP_L}	—	0.1	1.1	V	V_{FB} = 2.7V, R_{LOAD} = 15 kΩ to V_{REF}
Current Sense						
Divider Gain Input-to-Output	A_{DIV}	2.85	3.0	3.15	V/V	Note 4, Note 5
Maximum Threshold	$V_{TH(MAX)}$	0.9	1	1.1	V	V_{COMP} = 5V, Note 4
Power Supply Rejection Ratio	$PSRR_{CS}$	—	70	—	dB	12V ≤ V_{DD} ≤ 18V, Note 4
Input Bias Current	$I_{BIAS(CS)}$	—	–0.1	–2	µA	—
Delay to Output	t_D	—	120	250	ns	—
Output						
$R_{DS(ON)}$ Pull High	R_{DSON_H}	—	20	—	Ω	I_{SOURCE} = 200 mA
$R_{DS(ON)}$ Pull Low	R_{DSON_L}	—	11	—	Ω	I_{SINK} = 200 mA
Rise Time	t_R	—	40	80	ns	T_A = +25°C, C_{LOAD} = 1 nF
Fall Time	t_F	—	30	60	ns	T_A = +25°C, C_{LOAD} = 1 nF

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ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: V_{DD} = 15V, Adjust V_{DD} above the start threshold before setting at 15V; R_T = 11.0 kΩ; C_T = 3.3 nF; –40°C ≤ T_A ≤ +85°C; unless noted. Note 1

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Undervoltage Lockout						
Start Threshold	$V_{TH(ST)}$	13.5	14.5	15.5	V	MIC38C42A/4A
		7.8	8.4	9.0	V	MIC38C43A/5A
Minimum Operating Voltage	$V_{DD(MIN)}$	8	9	10	V	MIC38C42A/4A
		7.0	7.6	8.2	V	MIC38C43A/5A
Pulse Width Modulator						
Maximum Duty Cycle	D_{MAX}	94	96	—	%	MIC38C42A/3A
		46	50	—	%	MIC38C44A/5A
Minimum Duty Cycle	D_{MIN}	—	—	0	%	—
Total Standby Current						
Start-Up Current	$I_{DD(START)}$	—	100	230	µA	V_{DD} = 13V for MIC38C42A/44A
						V_{DD} = 7.5V for MIC38C43A/45A
Operating Supply Current	$I_{DD(Q)}$	—	4.0	6.0	mA	V_{FB} = V_{ISNS} = 0V

Note 1: Specification for packaged product only.

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

3: Output frequency equals oscillator frequency for the MIC38C42A and MIC38C43A. Output frequency for the MIC38C44A and MIC38C45A equals one-half the oscillator frequency.

4: Parameter measured at trip point of latch with V_{FB} = 0V.

5: Gain defined as Equation 1-1; 0V ≤ $V_{TH(ISNS)}$ ≤ 0.8V.

EQUATION 1-1:

$$A_{DIV} = \frac{\Delta V_{COMP}}{\Delta V_{TH(ISNS)}}$$

TEMPERATURE SPECIFICATIONS (Note 1)

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Storage Temperature Range	T_S	–65	—	+150	°C	—
Operating Ambient Temperature Range	T_A	–40	—	+85	°C	—
Operating Junction Temperature Range	T_J	–40	—	+125	°C	—
Maximum Junction Temperature	$T_{J(MAX)}$	—	—	+150	°C	—
Package Thermal Resistance						
Thermal Resistance MSOP-8	θ_{JA}	—	250	—	°C/W	—
Thermal Resistance SOIC-8	θ_{JA}	—	170	—	°C/W	—

Note 1: The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature and the thermal resistance from junction to air (i.e., T_A, T_J, θ_{JA}). Exceeding the maximum allowable power dissipation will cause the device operating junction temperature to exceed the maximum +125°C rating. Sustained junction temperatures above +125°C can impact the device reliability.

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2.0 TYPICAL PERFORMANCE CURVES

Note: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

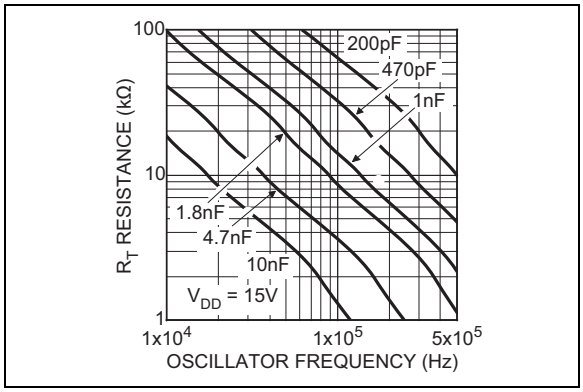


FIGURE 2-1: *Oscillator Frequency Configuration.*

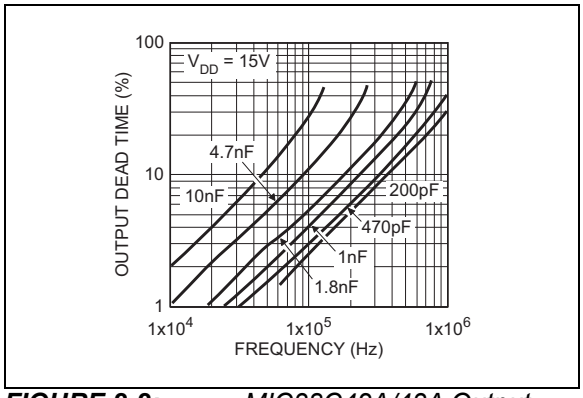


FIGURE 2-2: *MIC38C42A/43A Output Dead Time vs. Oscillator Frequency.*

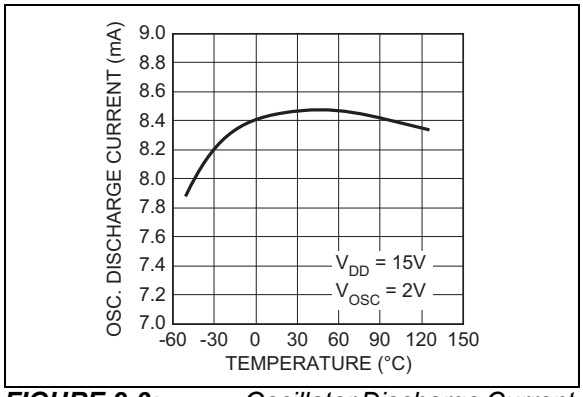


FIGURE 2-3: *Oscillator Discharge Current vs. Temperature.*

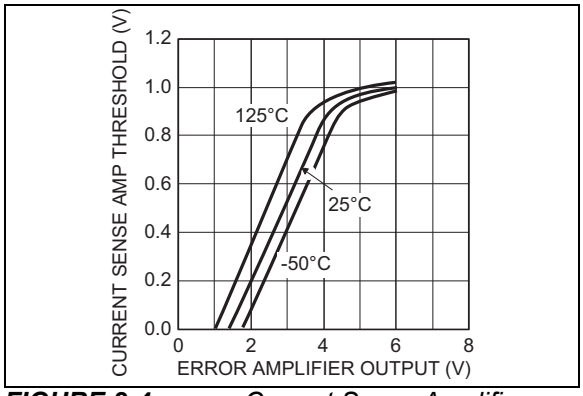


FIGURE 2-4: *Current Sense Amplifier Threshold vs. Error Amplifier Output.*

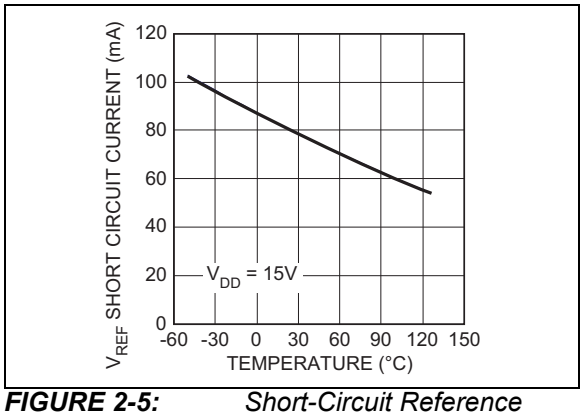


FIGURE 2-5: *Short-Circuit Reference Current vs. Temperature.*

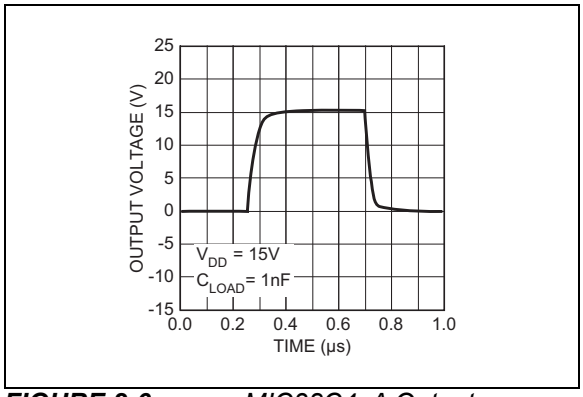


FIGURE 2-6: *MIC38C4xA Output Waveform.*

3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 3-1.

TABLE 3-1: PIN FUNCTION TABLE

Pin Number	Pin Name	Description
1	COMP	Compensation: Connect external compensation network to modify the error amplifier output.
2	FB	Feedback (Input): Error amplifier input. Feedback is 2.5V at desired output voltage.
3	ISNS	Current Sense (Input): Current sense comparator input. Connect to current sensing resistor or current transformer.
4	RT/CT	Timing Resistor/Timing Capacitor: Connect external RC network to select switching frequency.
5	GND	Ground: Combined analog and power ground.
6	OUT	Gate Driver Output: Totem-pole output.
7	VDD	Analog Supply (Input): Controller circuitry supply input. Return to analog ground (GND).
8	VREF	5V Reference (Output): Connect external RC network.

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4.0 FUNCTIONAL DESCRIPTION

Familiarity with 384x converter designs is assumed.

4.1 MIC38C4xA Advantages

4.1.1 START-UP CURRENT

Start-up current has been reduced to an ultra-low 100 µA (typical) permitting higher-resistance, lower-wattage, start-up resistors (powers controller during power supply start-up). The reduced resistor wattage reduces cost and printed circuit space.

4.1.2 OPERATING CURRENT

Quiescent operating current has been reduced to 4 mA compared to 11 mA for a typical bipolar controller. The controller runs cooler and the V_{DD} hold-up capacitance required during start-up may be reduced.

4.1.3 OUTPUT DRIVER

Complementary internal P-channel and N-channel MOSFETs produce rail-to-rail output voltages for better performance driving external power MOSFETs. The driver transistor's low on resistance and high peak current capability can drive gate capacitances of greater than 1000 pF. The value of output capacitance which can be driven is determined only by the rise/fall time requirements. Within the restrictions of output capacity and controller power dissipation, maximum switching frequency can approach 500 kHz.

4.2 Design Precautions

When operating near 20V, circuit transients can easily exceed the 20V absolute maximum rating, permanently damaging the controller's CMOS construction. To reduce transients, connect a 0.1 µF low-ESR capacitor to next to the controller's supply V_{DD} and ground connections. Film type capacitors, such as Wima MKS2, are recommended.

When designing high-frequency converters, avoid capacitive and inductive coupling of the switching waveform into high impedance circuitry such as the error amplifier, oscillator, and current sense amplifier. Avoid long printed-circuit traces and component leads. Locate oscillator and compensation circuitry near the IC. Use high frequency decoupling capacitors on V_{REF}, and if necessary, on V_{DD}. Return high di/dt currents directly to their source and use large area ground planes.

4.3 Buck Converter

Refer to Figure 4-1. When at least 26V is applied to the input, C5 is charged through R2 until the voltage V_{DD} is greater than 14.5V (the undervoltage lockout value of the MIC38C42A). Output switching begins when Q1 is turned on by the gate drive transformer T1, charging the output filter capacitor C3 through L1. D5 supplies a regulated +12V to V_{DD} once the circuit is running.

Current sense transformer CT1 provides current feedback to ISNS for current-mode operation and cycle-by-cycle current limiting. This is more efficient than a high-power sense resistor and provides the required ground-referenced level shift.

When Q1 turns off, current flow continues from ground through D1 and L1 until Q1 is turned on again.

The 100V Schottky diode D1 reduces the forward voltage drop in the main current path, resulting in higher efficiency than could be accomplished using an ultra-fast-recovery diode. R1 and C2 suppress parasitic oscillations from D1.

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 500 kHz. CT1 and T1 are wound on Magnetics, Inc. P-type material toroids. L1 is wound on a Siemens N49 EFD core.

TABLE 4-1: MAGNETIC COMPONENTS

Symbol	Custom Coils (Note 1)	ETS (Note 2)
CT1	4923	ETS 92420
T1	4924	ETS 92419
L1	4925	ETS 92421

Note 1: Custom Coils, Alcester, SD. Tel: (605) 934-2460.

2: Energy Transformation Systems, Inc. Tel: (510) 656-2012.

TABLE 4-2: COMPONENT TEST RESULTS

Test	Conditions	Results
Line Regulation	V_{IN} = 26V to 80V, V_{OUT} = 12V, I_O = 2A	0.5%
Load Regulation	V_{IN} = 48V, V_{OUT} = 12V, I_O = 0.2A to 2A	0.6%
Efficiency	V_{IN} = 48V, V_{OUT} = 12V, I_O = 2A	90%
Output Ripple	V_{IN} = 48V, V_{OUT} = 12V, I_O = 2A (20 MHz BW)	100 mV

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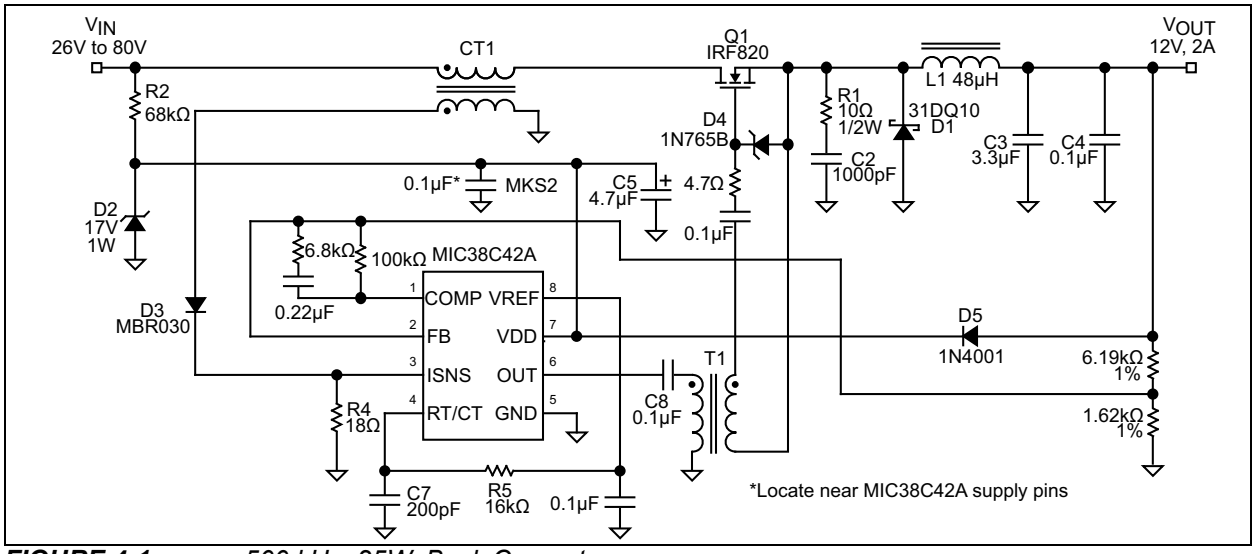


FIGURE 4-1: *500 kHz, 25W, Buck Converter.*

4.4 Synchronous Buck Converter

Refer to Figure 4-2. This MIC38C43A 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 (5 mΩ) 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.

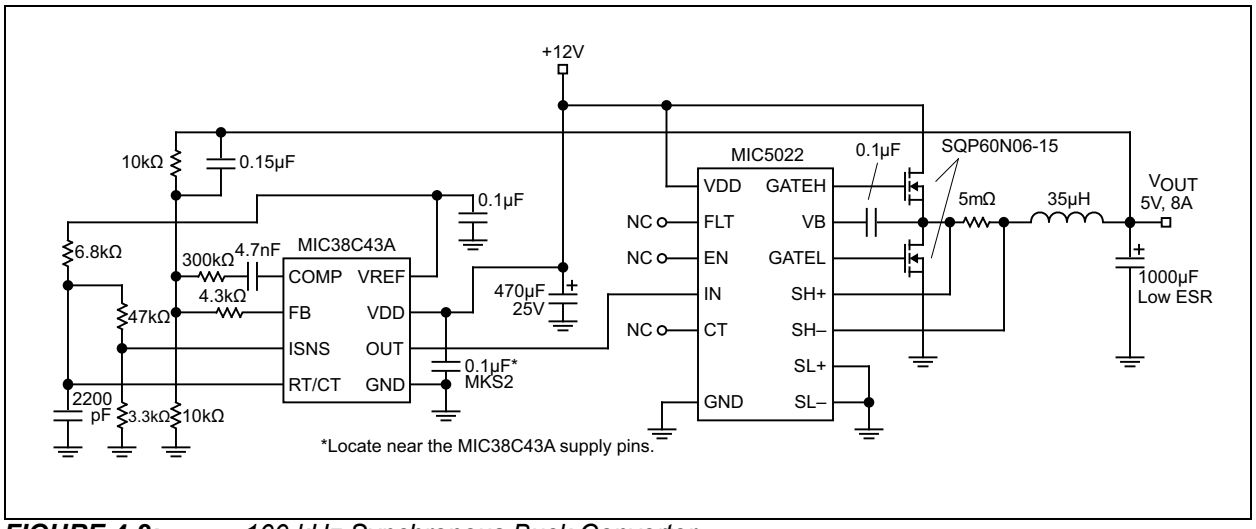


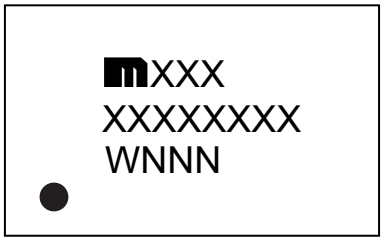
FIGURE 4-2: *100 kHz Synchronous Buck Converter.*

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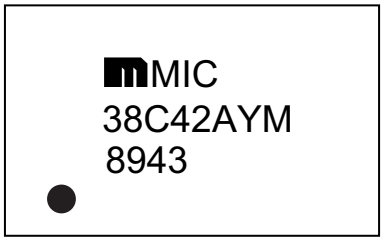
5.0 PACKAGING INFORMATION

5.1 Package Marking Information

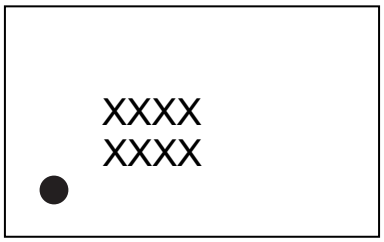
8-Pin SOIC*



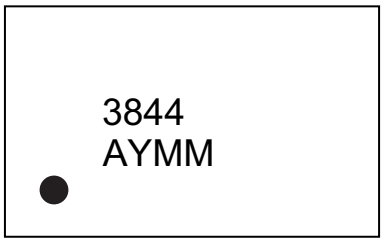
Example



8-Pin MSOP*



Example

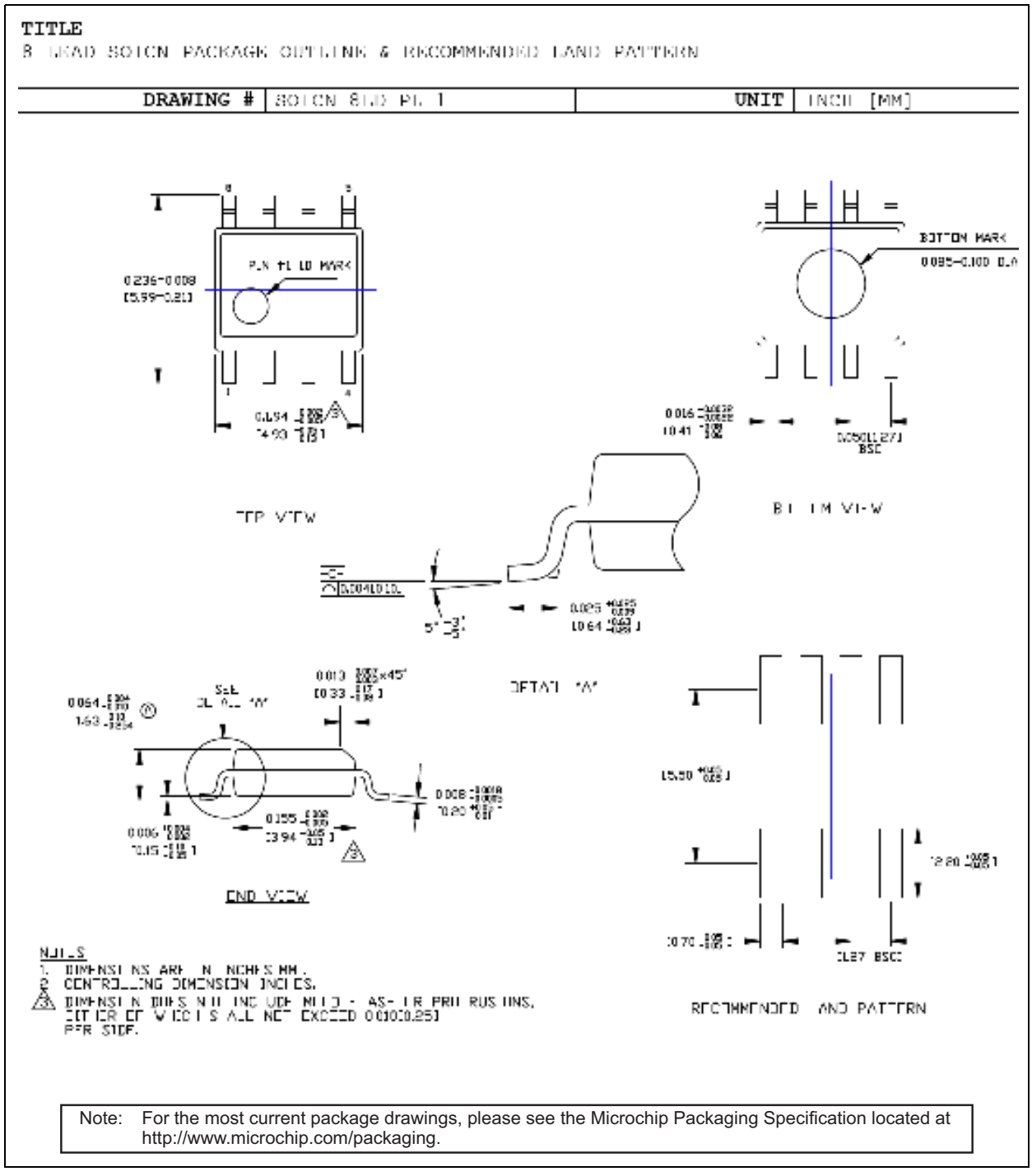


Legend:	XX...X	Product code or customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package.
	●, ▲, ▼	Pin one index is identified by a dot, delta up, or delta down (triangle mark).

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.

Underbar (_) and/or Overbar (¯) symbol may not be to scale.

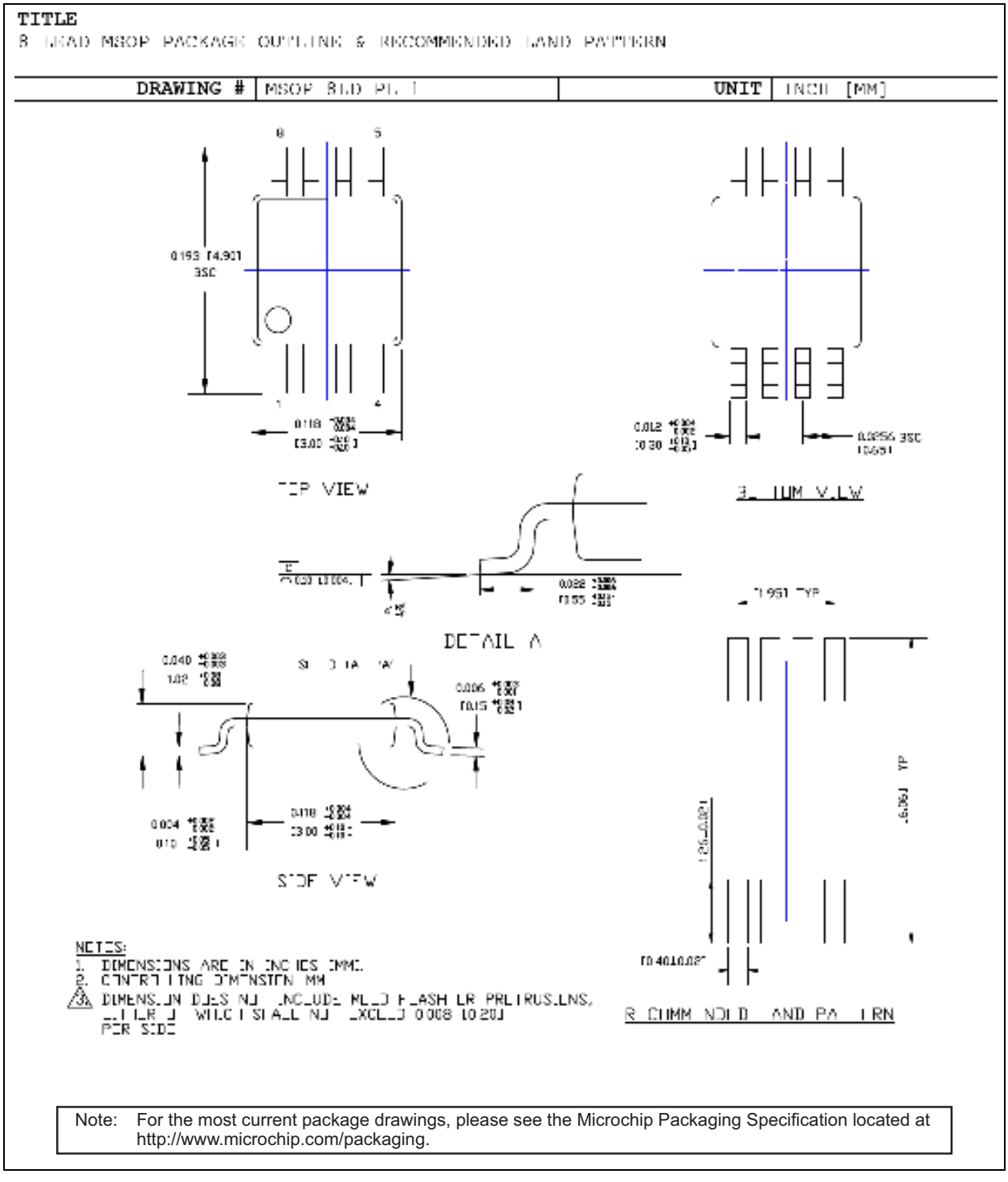
8-Lead SOIC Package Outline and Recommended Land Pattern



Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging.

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8-Lead MSOP Package Outline and Recommended Land Pattern



Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging.

NOTES:

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APPENDIX A: REVISION HISTORY

Revision A (October 2020)

- Converted Micrel document MIC38C42A/43A/44A/45A to Microchip data sheet DS20006437A.
- Minor text changes throughout.

NOTES:

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PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

Device	X	XX	[-XX]
Part No.	Temp. Range	Package	Media Type

Device:	MIC38C4xA:	BiCMOS Current-Mode PWM Controller (See Selection Guide Below for Part-Specific Detail)
	MIC38C42A:	96% Max. Duty Cycle, UVLO Threshold Startup 14.5V, Min. Operating 9V
	MIC38C43A:	96% Max. Duty Cycle, UVLO Threshold Startup 8.4V, Min. Operating 7.6V
	MIC38C44A:	50% Max. Duty Cycle, UVLO Threshold Startup 14.5V, Min. Operating 9V
	MIC38C45A:	50% Max. Duty Cycle, UVLO Threshold Startup 8.4V, Min. Operating 7.6V
Junction Temperature Range:	Y =	–40°C to +125°C, RoHS-Compliant
Package:	M =	8-Lead SOIC
	MM =	8-Lead MSOP
Media Type:	TR =	2,500/Reel
	(blank)=	95/Tube for M Package
	(blank)=	100/Tube for MM Package

Selection Guide

Duty Cycle	UVLO Thresholds	
—	Start-Up 8.4V Min. Operating 7.6V	Start-Up 14.5V Min. Operating 9V
0% to 96%	MIC38C43A	MIC38C42A
0% to 50%	MIC38C45A	MIC38C44A

Examples:

a) MIC38C42A: BiCMOS Current-Mode PWM Controller, 96% Max. Duty Cycle, UVLO Threshold Startup 14.5V, Min. Operating 9V, –40°C to +125°C Junction Temperature Range

MIC38C42AYM:	8-Lead SOIC, 95/Tube
MIC38C42AYM-TR:	8-Lead SOIC, 2,500/Reel
MIC38C42AYMM:	8-Lead MSOP, 100/Tube
MIC38C42AYMM-TR:	8-Lead MSOP, 2,500/Reel

b) MIC38C43A: BiCMOS Current-Mode PWM Controller, 96% Max. Duty Cycle, UVLO Threshold Startup 8.4V, Min. Operating 7.6V, –40°C to +125°C Junction Temperature Range

MIC38C43AYM:	8-Lead SOIC, 95/Tube
MIC38C43AYM-TR:	8-Lead SOIC, 2,500/Reel
MIC38C43AYMM:	8-Lead MSOP, 100/Tube
MIC38C43AYMM-TR:	8-Lead MSOP, 2,500/Reel

c) MIC38C44A: BiCMOS Current-Mode PWM Controller, 50% Max. Duty Cycle, UVLO Threshold Startup 14.5V, Min. Operating 9V, –40°C to +125°C Junction Temperature Range

MIC38C44AYM:	8-Lead SOIC, 95/Tube
MIC38C44AYM-TR:	8-Lead SOIC, 2,500/Reel
MIC38C44AYMM:	8-Lead MSOP, 100/Tube
MIC38C44AYMM-TR:	8-Lead MSOP, 2,500/Reel

d) MIC38C45A: BiCMOS Current-Mode PWM Controller, 50% Max. Duty Cycle, UVLO Threshold Startup 8.4V, Min. Operating 7.6V, –40°C to +125°C Junction Temperature Range

MIC38C45AYM:	8-Lead SOIC, 95/Tube
MIC38C45AYM-TR:	8-Lead SOIC, 2,500/Reel
MIC38C45AYMM:	8-Lead MSOP, 100/Tube
MIC38C45AYMM-TR:	8-Lead MSOP, 2,500/Reel

Note 1: Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is not printed on the device package. Check with your Microchip Sales Office for package availability with the Tape and Reel option.

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