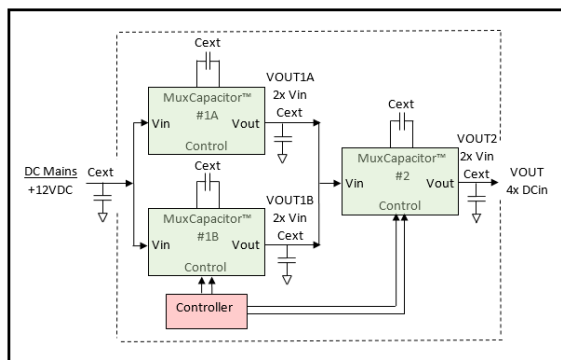


## 2U\_012\_010A 12V 3W DC-DC Converter

The Helix Semiconductors MuxCapacitor® 2U\_012\_010A is a member of the MxC® 200 family of monolithic configurable high voltage switch capacitor DC-DC converters targeted for use in both non-isolated and isolated, buck or boost converter applications. The 2U\_012\_010A supports seamless interface to low voltage PoL regulators to provide highly efficient DC-DC converter solutions with 6V to 14V input voltages for regulated or non-regulated PoL solutions. Consisting of two unique capacitive conversion stages, each capable of providing a separate output voltage, the 2U\_012\_010A can easily be configured to support systems with multiple voltage requirements. Intelligent timing & control optimize power delivery efficiency from no-load to maximum power.

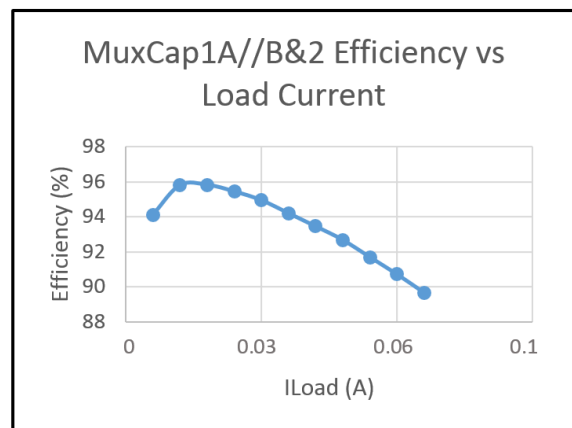
### Applications

- PoE: Wireless Access Points, Security Cameras, VoIP Phones
- IoT & IIoT Gateways
- Electric & Hybrid Automobiles
- Industrial Controllers, HVAC
- Telecom, Data Center Functions



### Features

- 12V to 48V Input/Output Voltage
  - 2-stage MuxCap™, G=2 each
  - Up to 14V Input Voltage
  - Up to 2 outputs
- Up to 3W Output
  - $P_{out} = P_{out1A} + P_{out1B} + P_{out2}$
- Idle Operation: Active, No-Load
  - 1mW Non-Switching
  - 48mW Switching
- 12V to 48V peak efficiency of >96%
  - > 90% Efficiency @ 3W
- Maximizes PoL regulator efficiency
- Fault Detection
  - Output Over Current
  - Thermal Shutdown
- Evaluation Boards, Reference Designs
  - Voltage Boost
  - Unregulated and Regulated
- Package Options
  - 32 pin QFN, 5mm x 5mm
  - Wire Bond Die



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## 1 Pin Configuration and Description

Figure 1: 2U\_012\_010A QFN32 Pinout

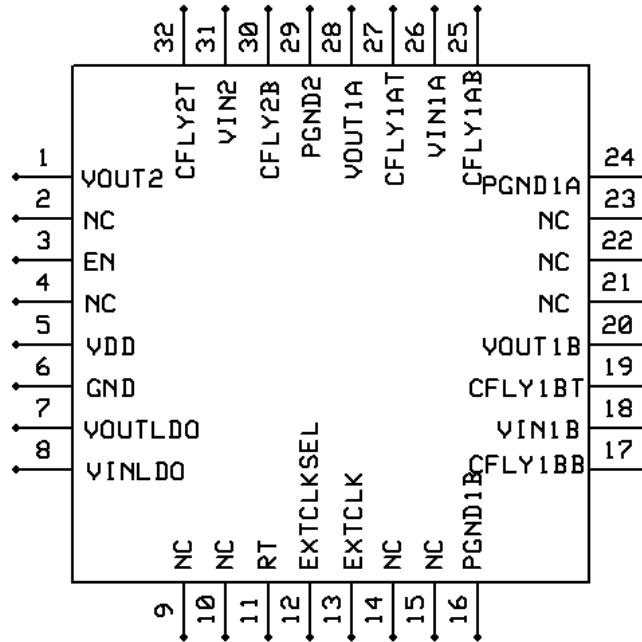


Table 1: 2U\_012\_010A Pin Assignments

Pin No.	Name	Description
1	VOUT2	MuxCapacitor 2: Output Pin Attach output capacitor from VOUT1 to PGND1.
3	EN	Device Enable: Input Pin, Internal 2MΩ Pull-Down, 60Vmax 0 = Disable, 1 = Enable
5	VDD	Pre-Regulator: Output supply voltage pin Attach 0.1μF capacitor from VDD pin to GND
6	GND	GND for internal reference and analog circuitry
7	VOUTLDO	LDO: 5V Analog Output pin Attach 4.7μF capacitor from VOUTLDO pin to GND
8	VINLDO	LDO: Input supply voltage pin Connect VINLDO pin to VOUT1
11	RT	Charge Pump Frequency: Input Pin Add external resistor from RT pin to GND.
12	EXTCLKSEL	External Clock Sync Enable: Input Pin, Internal 2MΩ Pull-Down, 30Vmax 0 = Internal Clock, 1 = External Clock

13	EXTCLK	External Clock Sync: Input pin, Internal 2MΩ Pull-Down
16	PGND1B	Power GND
17	CFLY1BB	MuxCapacitor 1B: Bottom of flying capacitor
18	VIN1B	MuxCapacitor 1B: DC input voltage supply pin
19	CFLY1BT	MuxCapacitor 1B: Top of flying capacitor
20	VOUT1B	MuxCapacitor 1B: Output Pin Attach output capacitor from VOUT1B to PGND1B.
24	PGND1A	Power GND
25	CFLY1AB	MuxCapacitor 1A: Bottom of flying capacitor
26	VIN1A	MuxCapacitor 1A: DC input voltage supply pin
27	CFLY1AT	MuxCapacitor 1A: Top of flying capacitor
28	VOUTA1	MuxCapacitor 1A: Output Pin Attach output capacitor from VOUT1A to PGND1A.
29	PGND2	Power GND
30	CFLY2B	MuxCapacitor 2: Bottom of flying capacitor
31	VIN2	MuxCapacitor 2: DC input voltage supply pin
32	CFLY2T	MuxCapacitor 2: Top of flying capacitor
2,4,9,10, 14,15,21, 22,23	NC	No Connect
	Thermal Pad	Power GND

## 2 Absolute Maximum Ratings

The 2U\_012\_010A can be exposed to the following extremes without permanent damage to device operation. Performance is not guaranteed at these extremes. Continuous operation at these extremes reduces long term reliability.

**Table 2: 2U\_012\_010A Absolute Maximum Ratings**

Pin	Min	Max	Unit
VIN1, EN	-0.3	62	V
VIN2, VIN3	-0.3	31	V
VINLDO	-0.3	15	V
EXTCLK	-0.3	30	V
VOUPLDO, VDD, EXTCLKSEL, RT	-0.3	6	V
GND to PGND	-0.3	0.3	V
ESD Voltage: Human Body Model		2	kV
ESD Voltage: Charge coupled Model		500	V
ESD Voltage: Machine Model		200	V
Storage temperature	-40	125	°C
Junction Temperature	-40	125	°C

## 3 Recommended Operating Conditions

The 2U\_12\_03A chip is designed to operate within the design limits specified in the Parametric Specifications when the conditions of the following table are not exceeded.

**Table 3: 2U\_012\_010A Recommended Operating Conditions**

Definition	Min	Max	Unit
Input Voltage	20	57	V
Output Power	0	15	W
EN	0	57	V
EXTCLK	0	29	V
EXTCLKSEL, RT	0	5.5	V
Junction Temperature	-40	125	°C

## 4 Electrical Specifications

The electrical characteristics of the Helix Semiconductors 2U\_012\_010A is tested according to the following criteria:

Unless otherwise stated, these specifications apply over:

10V < VIN2 < 28.5V, 5V < VIN1A & VIN1B < 14V,  
4.5V < VOUTLDO < 5.5, Fsw=100kHz, -40°C < TJ < 85°C.

Notes:

1. Min and Max values are valid over Operating Conditions, unless otherwise stated.
2. Typ values are valid at typical Operating Conditions and typical process Parameters.
3. Guaranteed by Design.

**Table 4: 2U\_012\_010A Electrical Characteristics**

Symbol	Parameter	Condition	Min	Typ	Max	Unit
<b>60V MuxCapacitor Voltage Divider: VIN2/VOUT2</b>						
Vout	Output Voltage	VIN=24V, Po=0W, Note 3.		48		V
Iout	Output Current	Note 3.			0.1	A
Rsw	Switch Rdson			600		mΩ
<b>30V MuxCapacitor Voltage Divider: VIN1A/VOUT1A and VIN1B/VOUT1B</b>						
Vout	Output Voltage	VIN=12V, Po=0W, Note 3.		24		V
Iout	Output Current	Note 3.			0.2	A
Rsw	Switch Rdson			300		mΩ
<b>VOUTLDO</b>						
VoutLDO	Output Voltage			5		V
<b>Under Voltage Lockout</b>						
UVVoutS+	VOUTLDO Start	5V Rising Trip Level	4.4	4.6	4.8	V
UVVoutS-	VOUTLDO Stop	5V Falling Trip Level	4.1	4.2	4.3	V
EN+	Enable On Thresh.	Enable Rising Trip Level	1.14	1.2	1.26	V
EN1	Enable Off Thresh.	Enable Falling Trip Level	0.95	1.0	1.05	V
<b>Clock Generator</b>						
Fsw	Switching Frequency	RT=402KΩ, 95kHz RT=174KΩ, 220kHz		95	230	kHz
<b>Thermal Shutdown</b>						
TSD	Thermal Shutdown	Note 3.		145		°C
Hyst	Hysteresis	Note 3.		20		°C

Figure 2: VOUT1A, VOUT1B, VOUT2

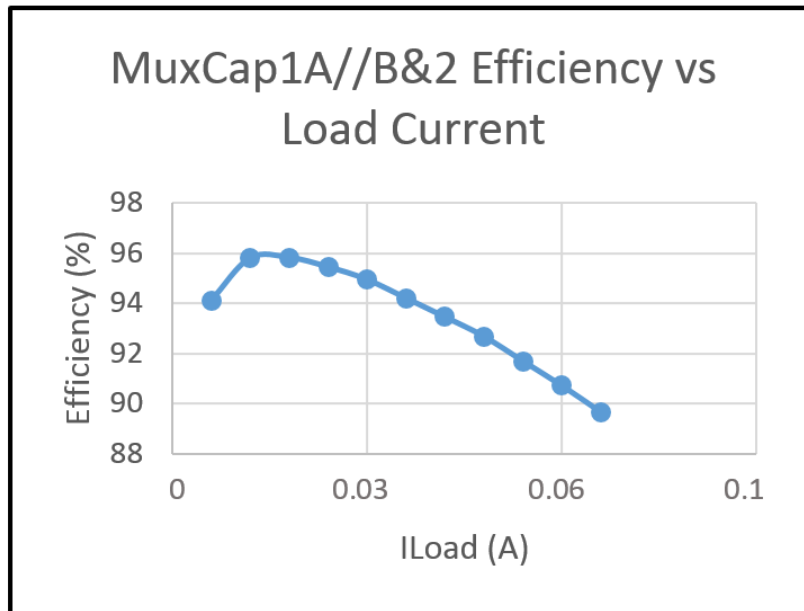


Figure 3: VOUT vs Frequency Efficiency

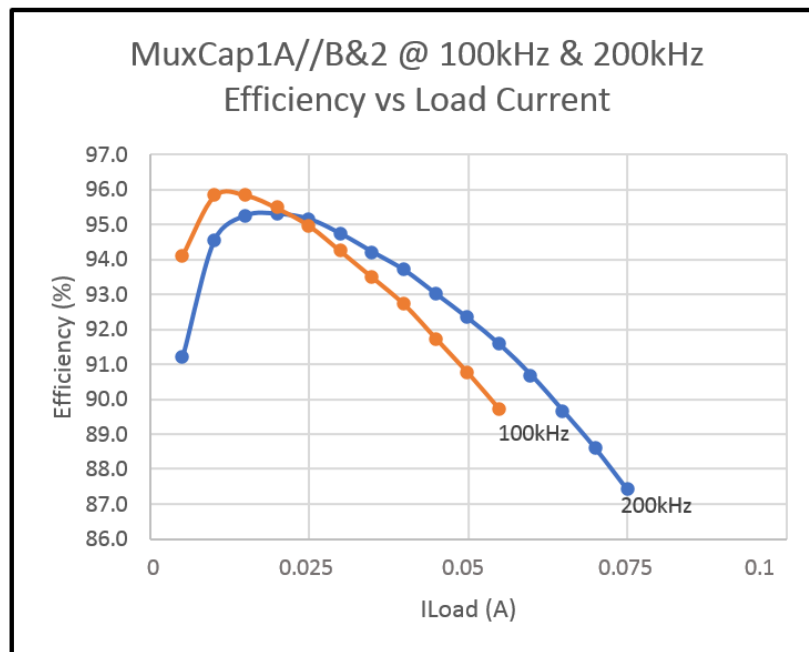
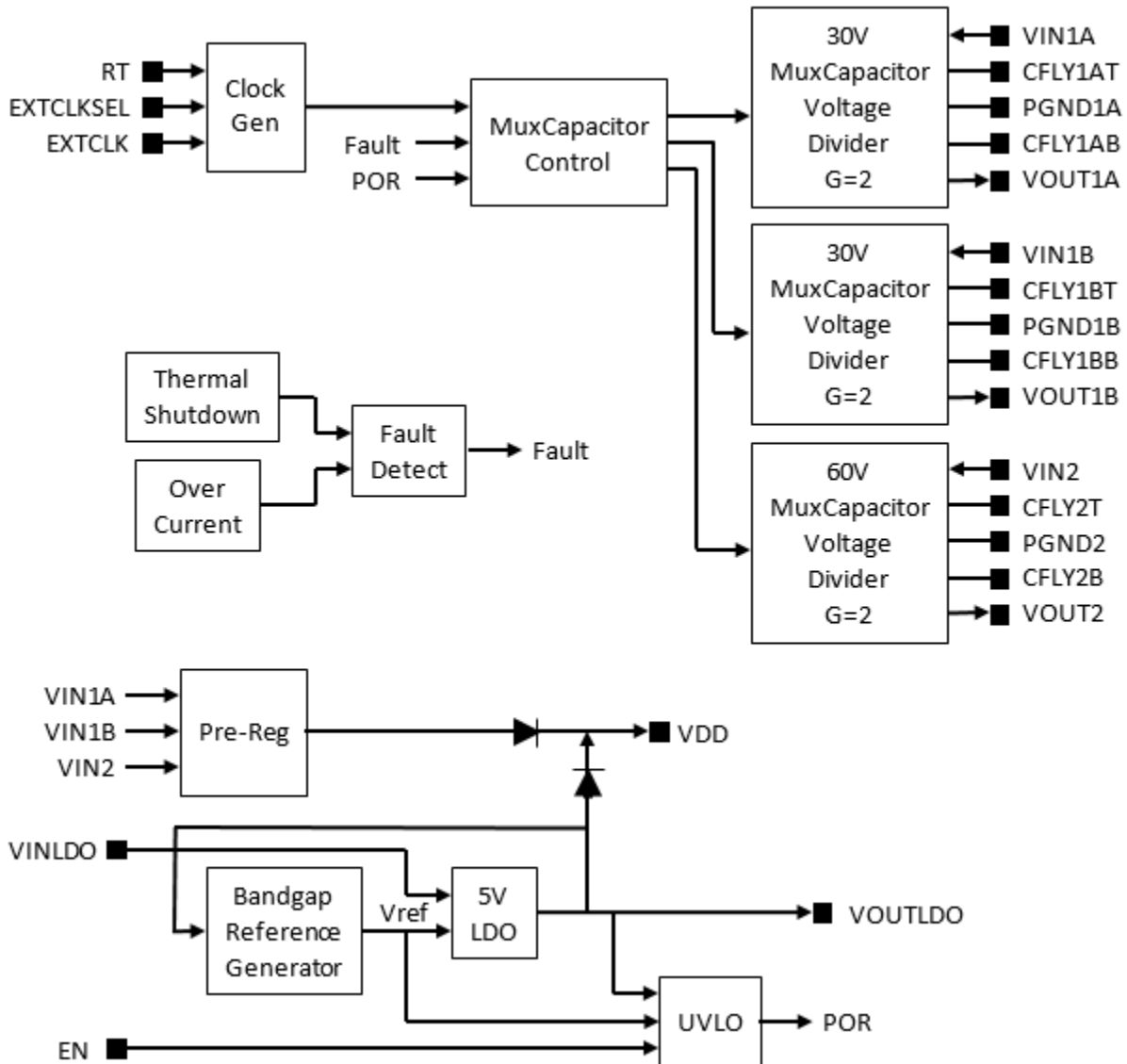


Figure 4: 2U\_012\_010A Block Diagram

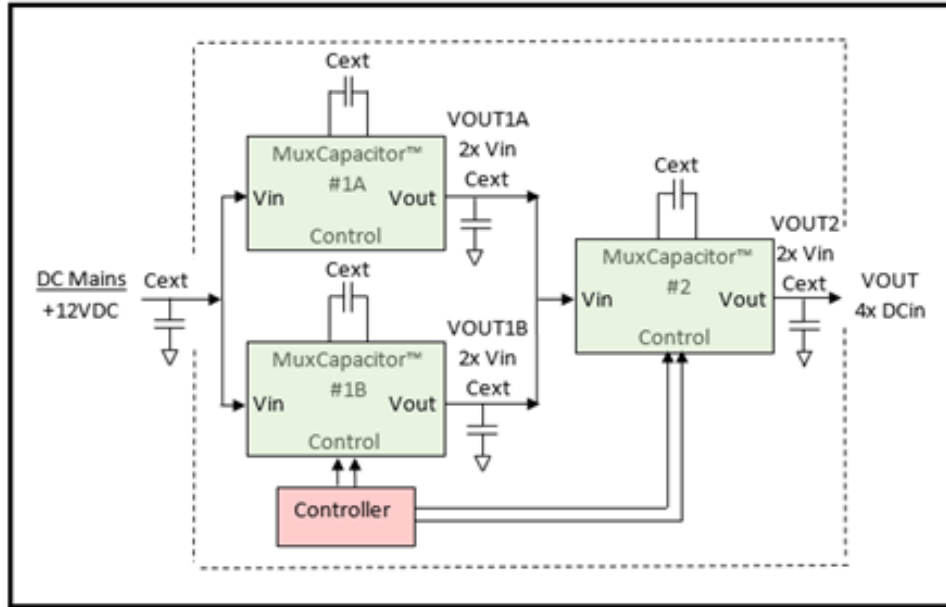




## 5 Functional Description

The Helix Semiconductors 2U\_012\_010A DC-DC MuxCapacitor IC is an easy to use, highly efficient DC voltage multiplier. It combines three MuxCapacitor Voltage Multipliers to increase the input voltage allowing the use of lower voltage sources.

Figure 5: 2U\_012\_010A Functional Block Diagram



Each MuxCapacitor stage has its own input and output pins allowing for multiple configurations. All three stages can be connected in series for access to intermediate voltage multiplication outputs. Or, the MuxCapacitor stages can be wired in parallel (MuxCapacitor 1A and 1B) for added output current capability and efficiency as shown above.

### 5.1 MuxCapacitor Voltage Multiplier

The 2U\_012\_010A Muxcapacitor Voltage Multipliers (MCVM) multiply the DC voltage present at the VIN1 pin to increased voltages at the VOUT1A, VOUT1B, and VOUT2 pins which provides the input voltage to an external device.

The MCVM is comprised of three stages, each with a gain of 2.

Each MCVM uses an external flying capacitor, an internal switching circuit, and an external hold capacitor. The switching device is configured to operate the corresponding voltage multiplication circuit at charging and discharging phases from a two-phase non-overlapping on-chip clock generator.

Each MuxCapacitor contains over-current protection. The over-current protection automatically resets once the over-current condition clears. This feature is active at startup enhancing the soft-start ramp-up at each VOUTx.

## 5.2 Low Drop-Out Voltage Regulator

An integrated 5V LDO provides the supply voltage for the analog circuits. The 5V LDO is powered from the VINLDO pin. The VINLDO supply voltage range is 7-15V and limits the minimum voltage that can be multiplied when supplied by VIN.

The 5V LDO uses the bandgap output as the reference voltage to generate the desired output voltage.

## 5.3 Under-Voltage Lockout and POR

The integrated under-voltage lockout circuit monitors the voltages at the 5V LDO output, and the Enable pin. It ensures that the MuxCapacitor outputs remain in the off state whenever one of these signals drop below the set thresholds. Normal operation resumes once these signals rise above their thresholds. The Power-On Ready (POR) signal is generated when each signal reaches their valid logic level. When the POR is asserted the Soft-Start sequence starts. All the UVLO comparators except the enable circuit are disabled when enable is low to achieve the ultra-low power dissipation.

## 5.4 Clock Generator

The integrated clock generator's switching frequency is programmed with an external resistor (402KΩ typical) connected from the RT pin to GND. The MuxCapacitor switching frequency (Fsw) is calculated as:

$$F_{sw} \text{ (kHz)} = 38,190 / \text{External RT Resistor (Kohms)}$$

This clock signal can be synchronized to an external clock by using the EXTCLK pin. Switching activity at the EXTCLK pin enables the internal synchronizer. When the synchronizer is enabled (EXTCLKSEL = 1), the MuxCapacitor clock will track the EXTCLK pin switching rate. As the EXTCLK pin frequency slows down, the MuxCapacitor clock slows down. The EXTCLK signal is derived from the external POL's switch drive signal. This allows the MuxCapacitors to save power as the external switcher slows down due to reduced load demand. The MuxCapacitor switching frequency is ¼ the EXTCLK frequency.

## 5.5 Thermal Shutdown

Temperature sensing is included and provides the signal to an over temperature detector. The trip threshold is set to 145°C. When trip threshold is exceeded, thermal shutdown turns off the MuxCapacitor outputs and resets the internal soft start.

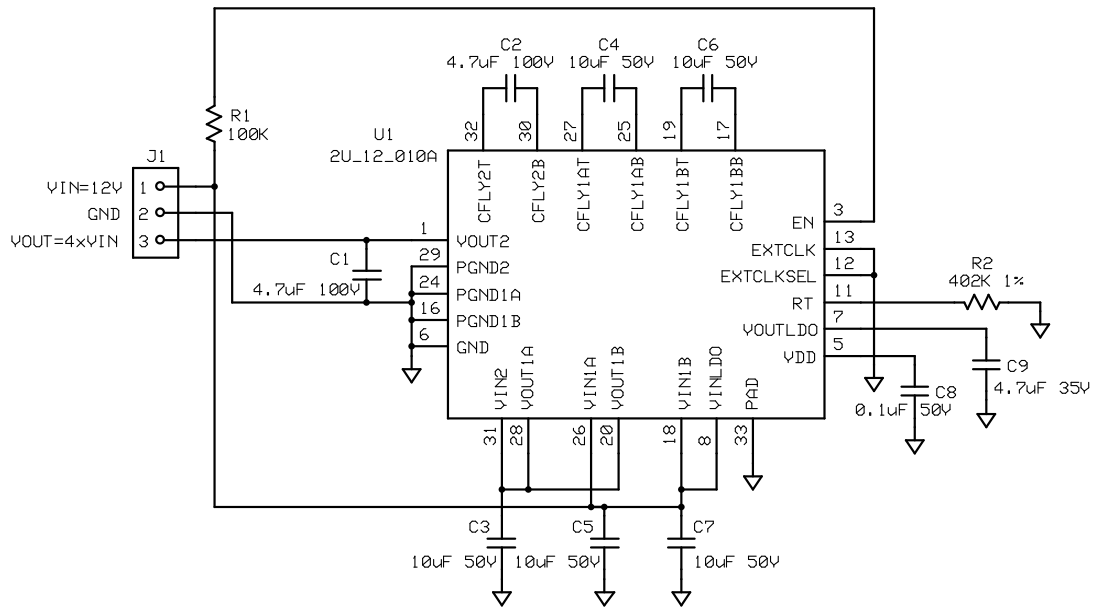
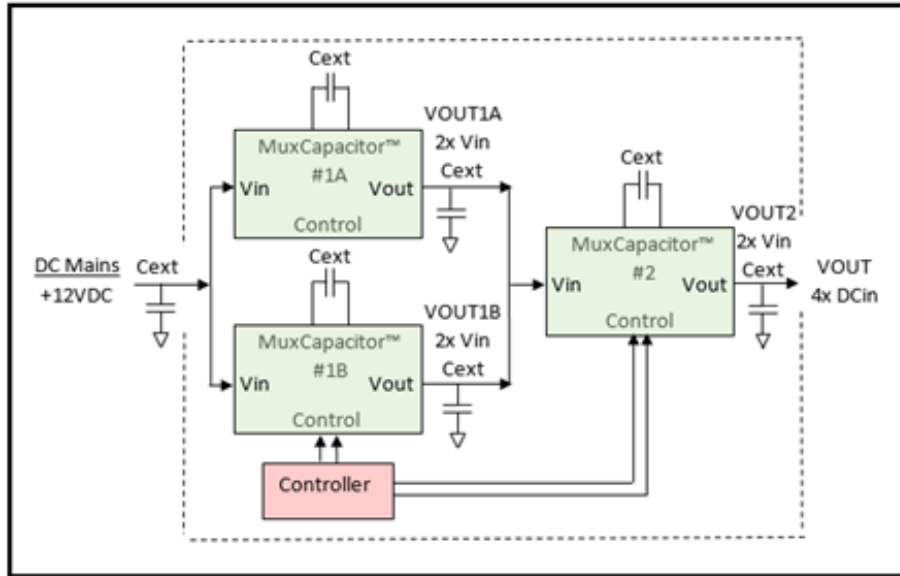
The restart is automatically initiated when the sensed temperature drops down within the normal operating range. A 20°C hysteresis is incorporated into the thermal shutdown threshold. The thermal shutdown circuit is disabled when enable is low to achieve the ultra-low power dissipation.

## 6 Reference System Application

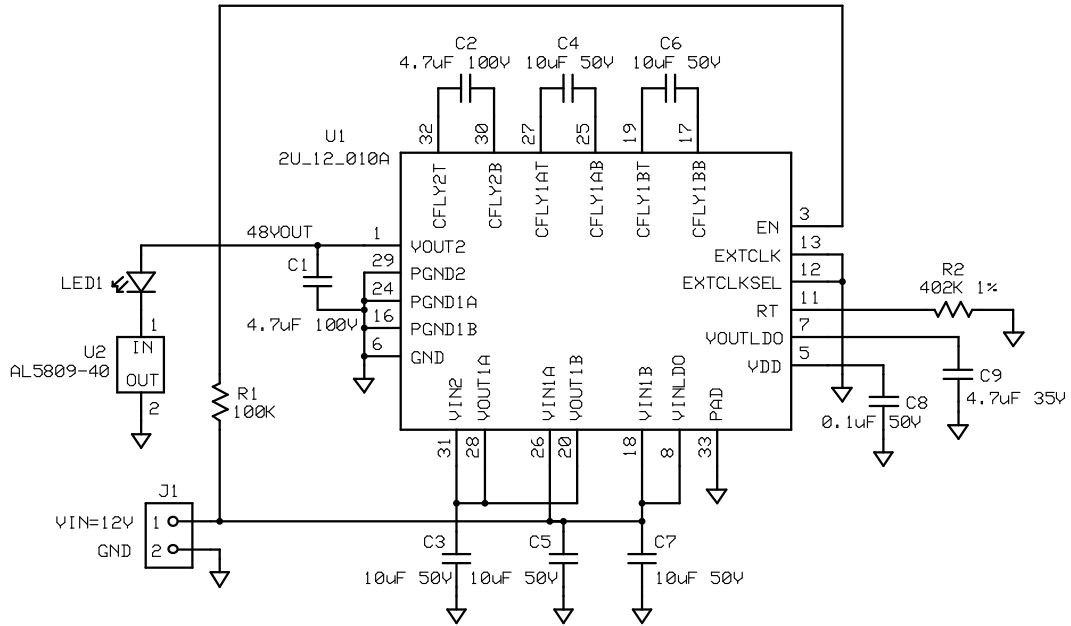
The following system diagrams provide G=4x 3W application schematics. The 2U\_012\_010A is shown as a simple DC-DC voltage multiplication circuit. Each MuxCapacitor stage performs a G=2 voltage multiplication. Additionally, each MuxCapacitor output can be tapped to provide an intermediate voltage. While the total power drawn from the 2U\_012\_010A cannot exceed 3W where  $P_{out} = P_{out1A} + P_{out1B} + P_{out2}$ , each MuxCapacitor cell has a maximum output current. The  $I_{out\_max}$  for VOUT1A and VOUT1B cannot exceed 0.2A. The  $I_{out\_max}$  for VOUT2 cannot exceed 0.1A. MuxCapacitor stages 1A and 1B are wired in parallel for improved efficiency. The two stages are 180° out of phase to reduce ripple. This example provides a compact, efficient voltage multiplication for 12VIN to 48VOUT.

Efficiency and delivered power are dependent on application circuit implementation, capacitor components, RT frequency and thermal management. Consult the factory for additional design information.

Figure 6: 2U\_012\_010A Application Schematic



Mx281-EB3-C



**MxC 284-EB2-C**

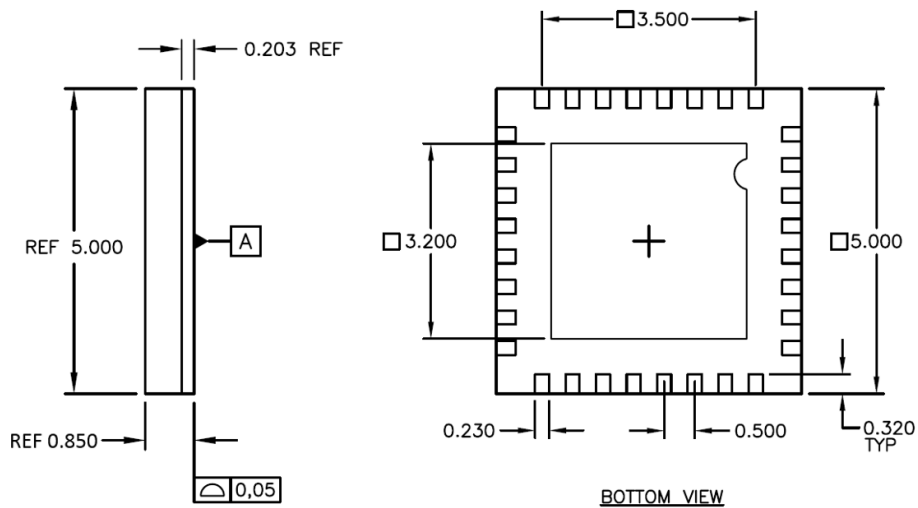
## 7 Package Drawings

The available packages for the 2U\_012\_010A are shown in the following drawings.

### 7.1 QFN32 Package

The 2U\_012\_010A is packaged in a 32-pin 5mm x 5mm QFN package as shown below.

**Figure 7: 2U\_012\_010A QFN32 Package Drawing**



### 7.2 Wire-bond Die

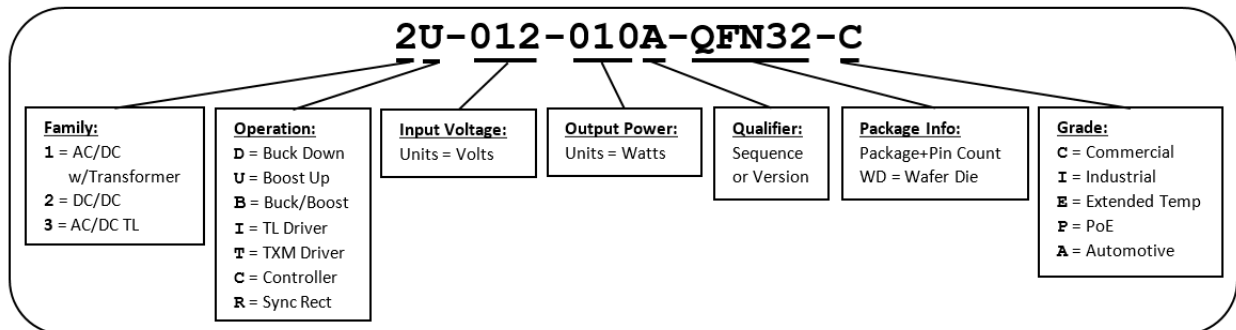
The 2U\_012\_010A is available in die form. Please contact factory for information regarding die sales.

## 8 Ordering Information

Refer to the following table for package option ordering information.

Table 5: 2U\_012\_010A Ordering Information

Part Number	Description	Package
2U-012-010A-QFN32-C	32 pin 5mm x 5mm QFN	QFN
2U-012-010A-WD-C	Wire Bond Die	Die
MxC 281-EB3-C	3-Pin 12V to 48V Unregulated Evaluation Board	Eval Board
MxC 284-EB2-C	2-Pin 9V to LED Evaluation Board	Eval Board



This product is covered by one or more Helix Semiconductors patents.

Patent <http://www.helixsemiconductors.com/pages/company/trademarksandpatents>

**Table 6: Revision History**

Date	Revision	Description
1.30.19	1	Initial Release
2.2.19	2	Miscellaneous edits
2.6.19	3	Update Figure 6 schematics
3.4.19	4	Patent disclosure

## Operational Headquarters

9980 Irvine Center Drive  
 Suite 100  
 Irvine, CA 92618

### Information & Sales

949-748-6057  
[sales@helixsemiconductors.com](mailto:sales@helixsemiconductors.com)

### Technical Support

949-748-7026  
[support@helixsemiconductors.com](mailto:support@helixsemiconductors.com)

## Engineering & Design Office

5475 Mark Dabling Blvd.  
 Suite 206  
 Colorado Springs, CO 80918

719-594-7098  
[designs@helixsemiconductors.com](mailto:designs@helixsemiconductors.com)

## Corporate Headquarters

4808 West Utica Ave.  
 Broken Arrow, OK 74011