MxC™ 200 Evaluation Boards

Helix Semiconductors offers four MxC 200 DC-DC PoL (Point of Load) Evaluation Board configurations: Single 12V output, Triple 24V/12V/6V outputs, regulated 5V output and a 4x voltage boost output. Additionally, a voltage boost+LED driver is offered. Each evaluation board is self- contained and ready for use.

Wiring connection diagram, schematic and BOM for each board are included in this manual. Gerber files are available upon request.

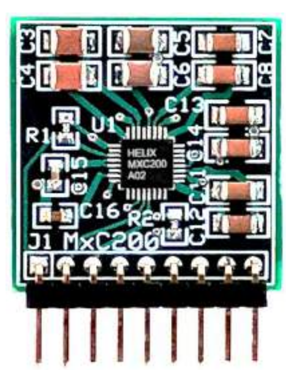
Target Applications

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

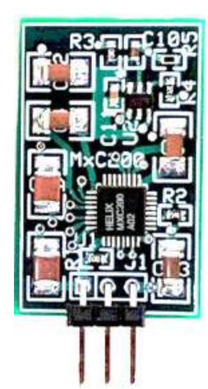
Features

- Four Configurations
  - Single 12V Output
  - Triple 24V/12V/6V Outputs
  - Regulated 5V Output
  - Voltage Boost
- 15W Output (Multiple Outputs)
  - Pout = Pout1 + Pout2 + Pout3
- Idle Operation: Active, No-Load
  - 1mW Non-Switching
  - 48mW Switching
- > 97% Efficiency @ 2.6W
- > 90% Efficiency @ 15W
- Fault Detectors
  - Output Over Current
  - Thermal Shutdown
- External Control Signals
  - Enable
  - External Clock Enable
  - External Clock Input

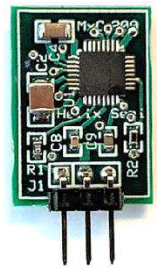
Single 12V Output
P/N: MxC 291C-EB3-1



Triple 24/12/6V Outputs
P/N: MxC 290C-EB9-1



Regulated 5V Output
P/N: MxC 292C-EB3-1



4x Voltage Boost Output
P/N: MxC 281C-EB3-1

4x Voltage Boost + LED
P/N: MxC 284C-EB2-1

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4. MxC 200 Single 12V Output EVB

The MxC 291C-EB3-1 Single 12V Output EVB can be operated as a standalone Divide-By-4 voltage reducer (Figure 2) or synchronized with a SMPS (Figure 3).

When the MxC 200 is providing power to a SMPS, the synchronization feature of the MxC 200 allows the MxC 200 MuxCapacitor switching to slow down as the SMPS enters pulse skipping. This operation reduces switching power losses at no-load to light-load conditions. The EXTCLK can be provided by either a FET gate drive signal or a buck regulator's switched output. Both the EXTCLKSEL and EXTCLK inputs accept up to 30V signals.

The MxC 200 Single 12V Output EVB provides the highest efficiency 12 Volt output configuration.

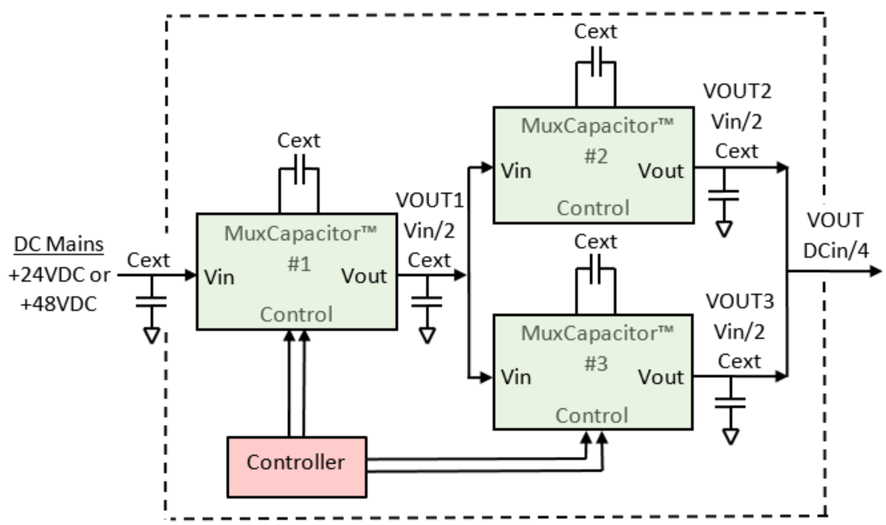


Figure 1: MxC 200 Single 12V Output EVB Block Diagram

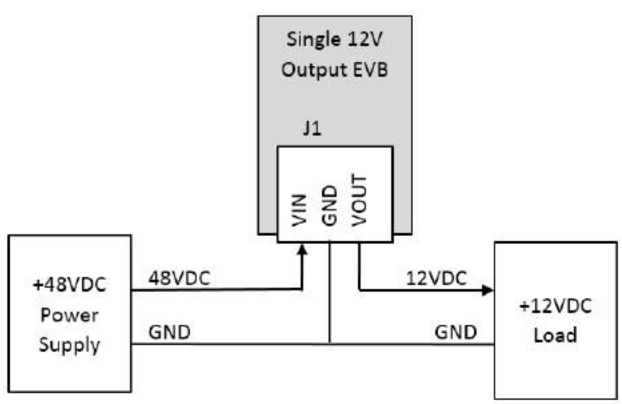


Figure 2: MxC 200 Single 12V Output EVB Standalone Wiring Diagram

Warning: Do not "Hot-Plug" the power supply or electronic load.

Recommended start-up procedure:

1) With power supply off, attach power supply wires.
2) With electronic load disabled (monitor mode), attach electronic load wires.
3) Turn on power supply.
4) Enable electronic load with no load current, and then ramp up load current.

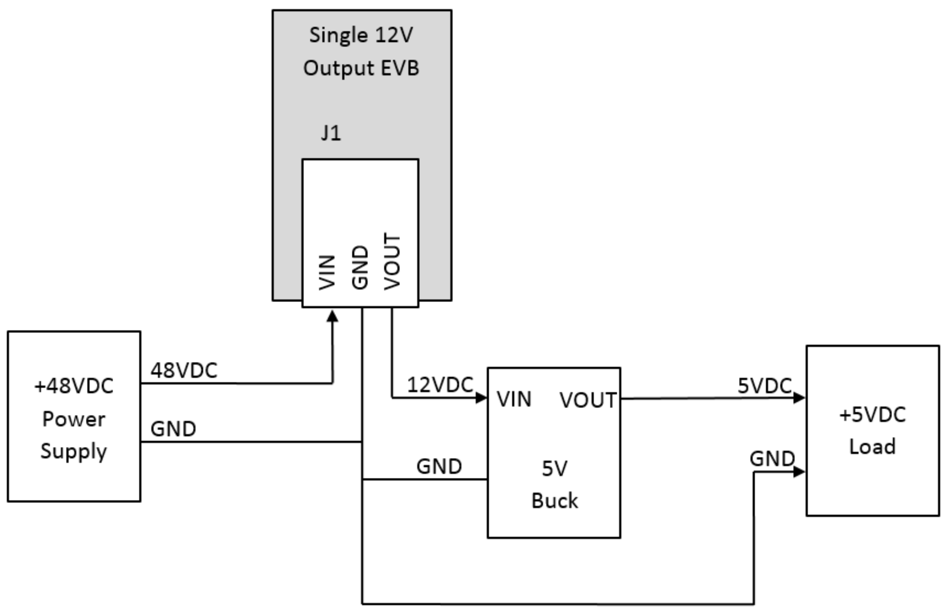


Figure 3: MxC 200 Single 12V Output EVB SMPS Wiring Diagram

Table 1: MxC 200 Single 12V Output EVB Connector – J1

Pin No.	Name	Description
1	VIN	+48VDC Input Power Pin
2	GND	Power GND Pin
3	VOUT	+12VDC Output Power Pin

Note:

1) Due to board's small size, thermal dissipation is limited and may exceed the over-temperature shutdown threshold.
2) The MxC 200 can be powered from 24V delivering 6Vout.

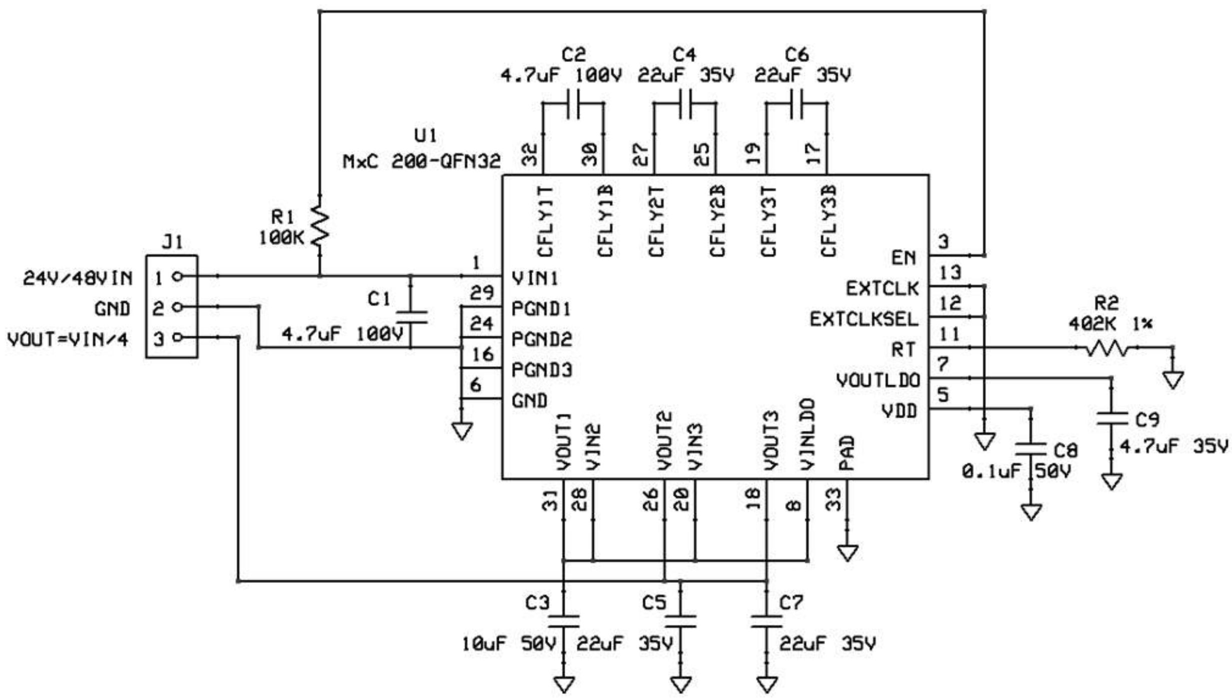


Figure 4: MxC 200 Single 12V Output EVB Schematic

Table 2: MxC 200 Single 12V Output EVB Bill of Materials (BOM)

Qty	Ref. No.	Description	Package	Manufacturer
1	C8	CAP, 0.1µF±10%, 50V	0603 1608 Metric	Wurth Elektronik WCAP-CSGP 885012206095
1	C9	CAP, 4.7µF±10%, 35V	0603 1608 Metric	TDK C1608X5R1V475M080AC
1	C3	CAP, 10µF±10%, 50V	1210 3225 Metric	TDK C3225X7S1H106M250AB
4	C4, C5, C6, C7	CAP, 22µF±10%, 35V	1206 3216 Metric	TDK C3216X5R1V226M160AC
2	C1, C2	CAP, 4.7µF±10%, 100V	1210 3225 Metric	TDK C3225X7S2A475M200AB
1	R1	RES, 100KΩ±10%	0603 1608 Metric	Rohm ESR03EZPJ104
1	R2	RES, 402 KΩ±1%	0603 1608 Metric	Rohm MCR03ERTF4023
1	U1	IC, MxC 200, QFN5x5, 32P 0.5	QFN32	Helix Semiconductors MxC 200C-QFN32-1
1	J1	CONN, 6P, M, R/A, 0.100	SIP100P6	Wurth Elektronik WR-PHD 61300611021

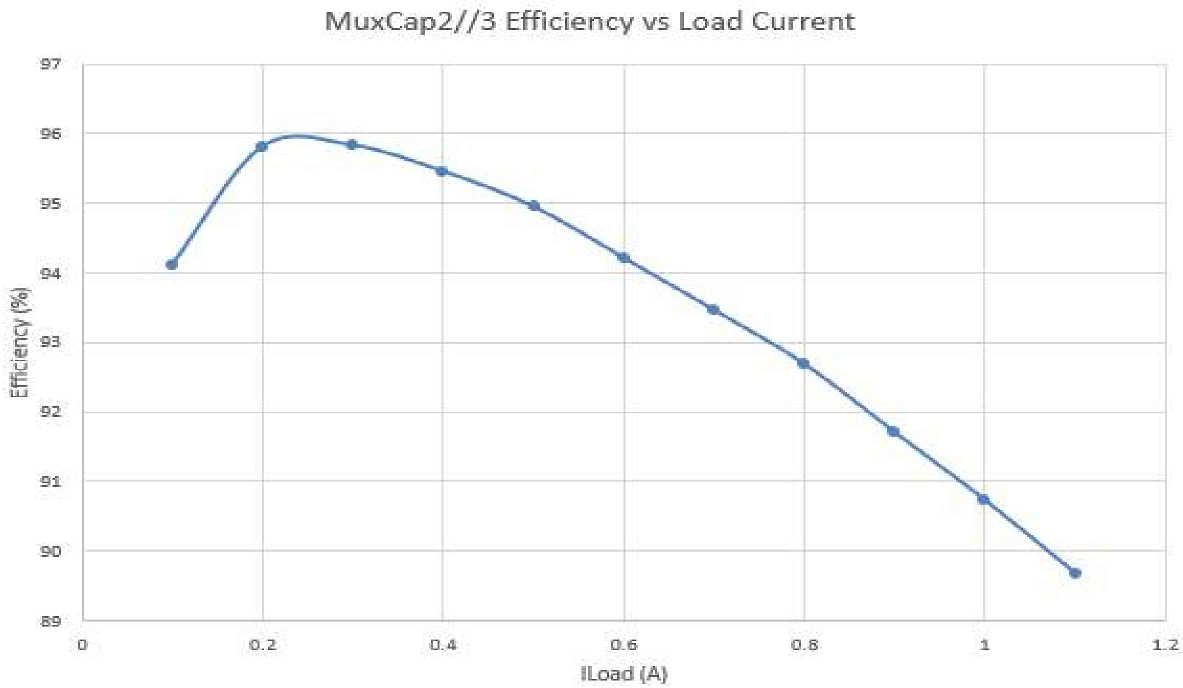


Figure 5: MxC 200 Single 12V Output EVB Efficiency Curve

5. MxC 200 Triple 24V/12V/6V Output EVB

The MxC 290C-EB9-1 Triple 24V/12V/6V Output EVB can be operated as a standalone fixed frequency voltage reducer (Figure 7) or synchronized with a SMPS (Figure 8).

When the MxC 200 is providing power to a SMPS, the synchronization feature of the MxC 200 allows the MxC 200 MuxCapacitor switching to slow down as the SMPS enters pulse skipping. This operation reduces switching power losses at no-load to light-load conditions. The EXTCLK can be provided by either a FET gate drive signal or a buck regulator's switched output. Both the EXTCLKSEL and EXTCLK inputs accept up to 30V signals.

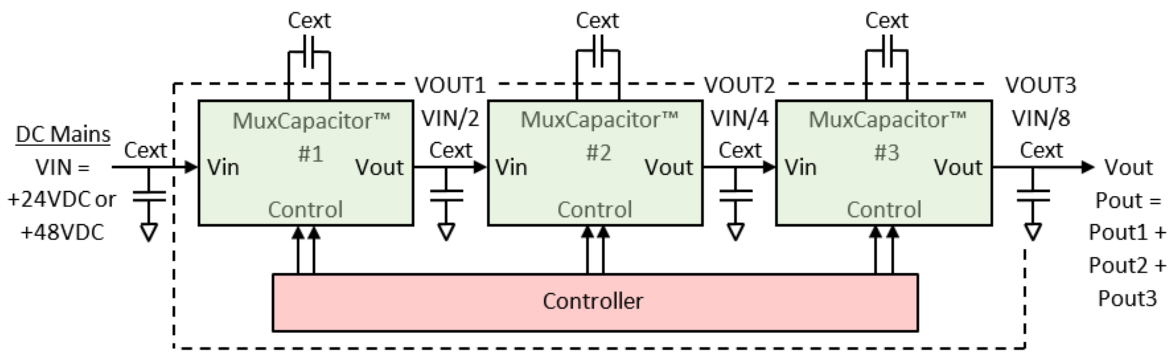


Figure 6: MxC 200 Triple Output EVB Block Diagram

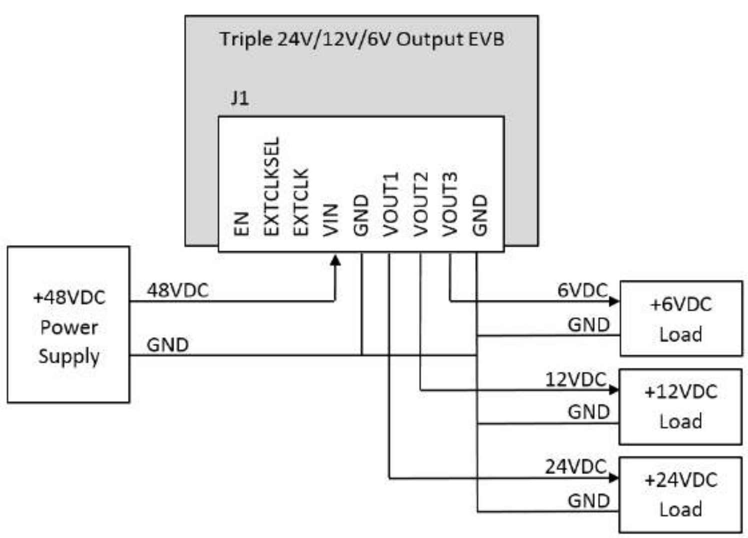


Figure 7: MxC 200 Triple Output EVB Standalone Wiring Diagram

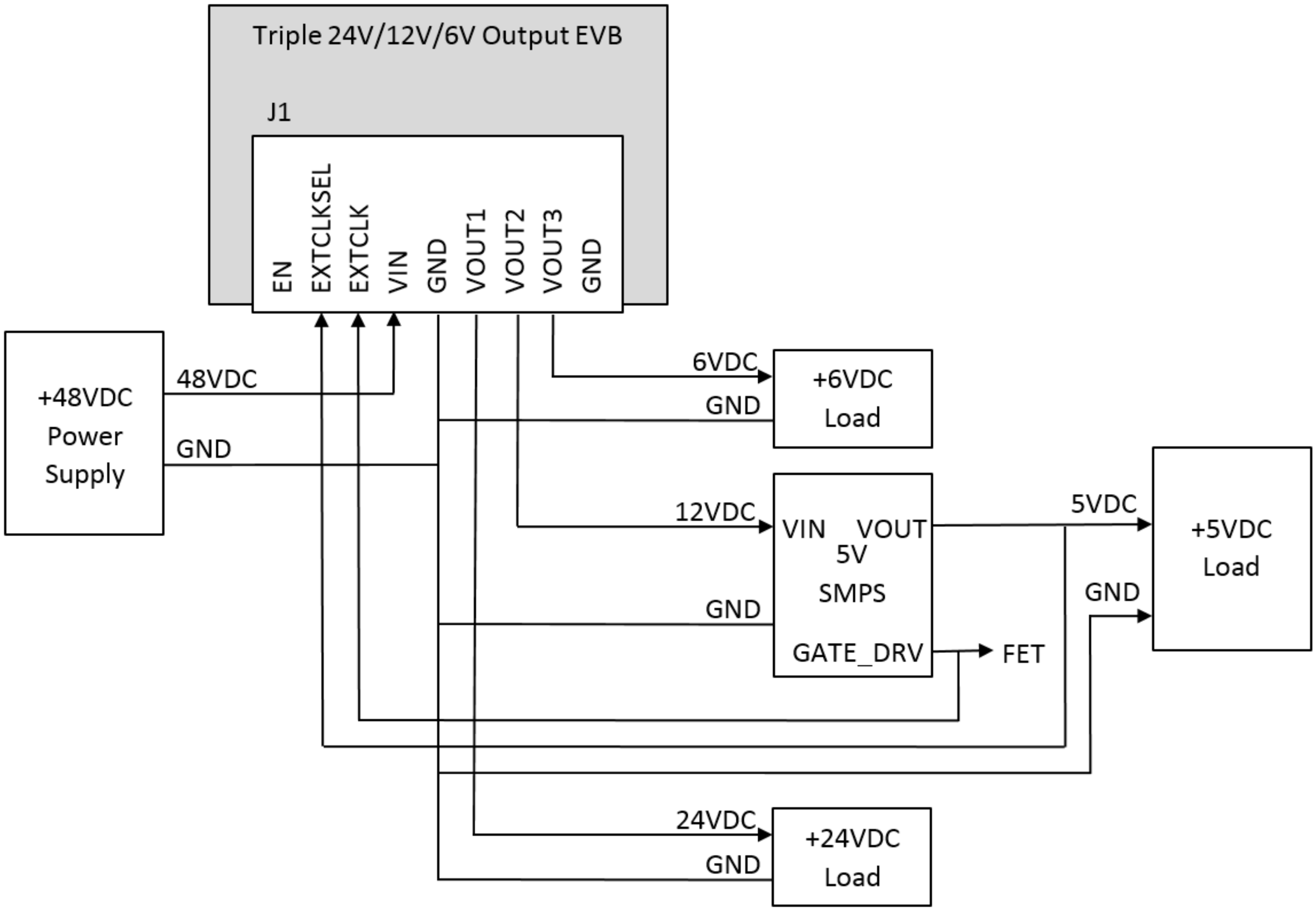


Figure 8: MxC 200 Triple Output Evaluation Board Synchronized to SMPS Wiring Diagram

Warning: Do not "Hot-Plug" the power supply or electronic load.

Recommended start-up procedure:

1) With power supply off, attach power supply wires.
2) With electronic load disabled (monitor mode), attach electronic load wires.
3) Turn on power supply.
4) Enable electronic load with no load current, and then ramp up load current.

Table 3: MxC 200 Triple 24V/12V/6V Output EVB Connector – J1

Pin No.	Name	Description
1	EN	Device Enable: Input Pin, On-board 100KΩ Pull-Up, 60Vmax 0 = Disable, 1 = Enable
2	EXTCLKSEL	External Clock Sync Enable: Input Pin, Internal 2MΩ Pull-Down, 30Vmax 0 = Internal Clock, 1 = External Clock
3	EXTCLK	External Clock Sync: Input pin, Internal 2MΩ Pull-Down, 30Vmax
4	VIN	+48VDC Input Power Pin
5	GND	Power GND Pin
6	24VOUT	+24VDC Output Power Pin, See Note 2.
7	12VOUT	+12VDC Output Power Pin, See Note 2.
8	6VOUT	+6VDC Output Power Pin, See Note 2.
9	GND	Power GND Pin

Note:

1) Maximum thermal dissipation occurs when high currents are drawn from 6VOUT. Due to board's small size, thermal dissipation is limited and may exceed the over-temperature shutdown threshold.
2) The 24VOUT output provides 0.5A and 12VOUT/6VOUT outputs provide 1A. Actual delivered power depends on the output voltage of each stage.
3) The MxC 200 can be powered from 24V delivering one-half the output voltage at pins 6-8 as stated in Table 3.

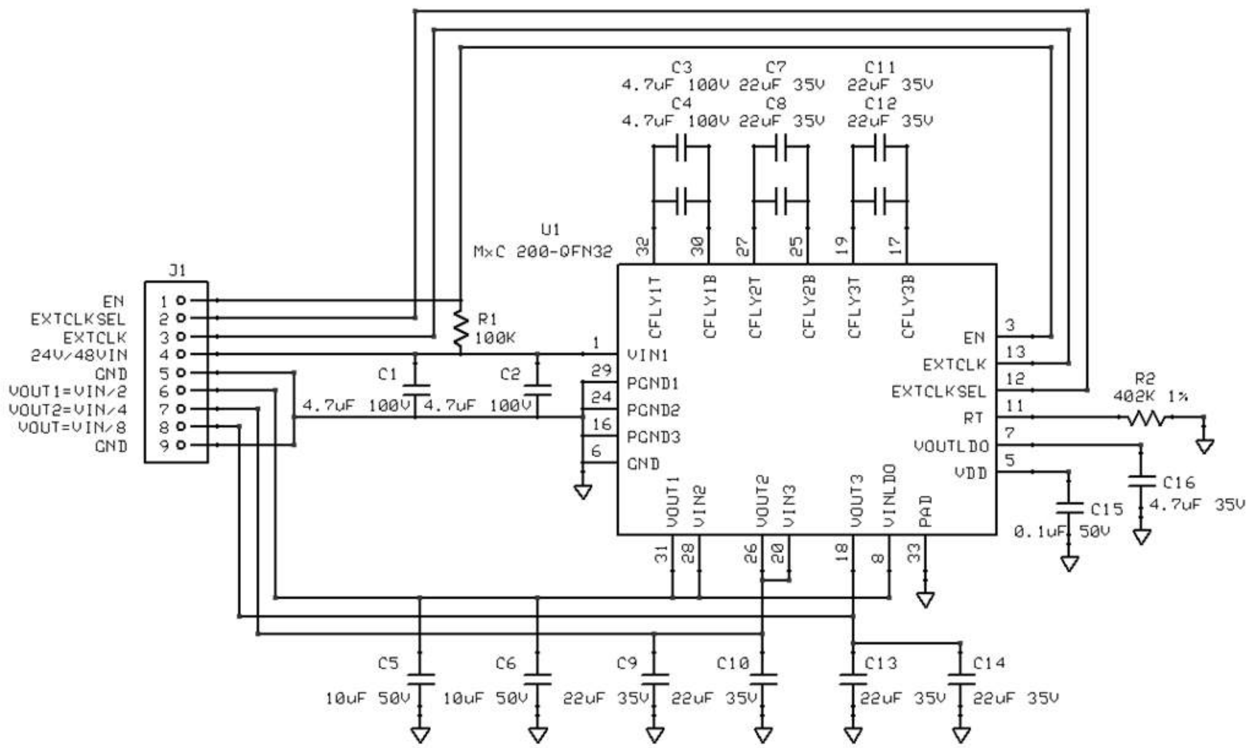


Figure 9: MxC 200 Triple 24V/12V/6V Output EVB Schematic

Table 4: MxC 200 Triple 24V/12V/6V Output EVB Bill of Materials (BOM)

Qty	Ref. No.	Description	Package	Manufacturer
1	C15	CAP, 0.1µF±10%, 10V	0603 1608 Metric	Wurth Elektronik WCAP-CSGP 885012206095
1	C16	CAP, 4.7µF±10%, 35V	0603 1608 Metric	TDK C1608X5R1V475M080AC
2	C5, C6	CAP, 10µF±10%, 50V	1210 3225 Metric	TDK C3225X7S1H106M250AB
8	C7, C8, C9, C10, C11, C12, C13, C14	CAP, 22µF±10%, 35V	1206 3216 Metric	TDK C3216X5R1V226M160AC
4	C1, C2, C3, C4	CAP, 4.7µF±10%, 100V	1210 3225 Metric	TDK C3225X7S2A475M200AB
1	R1	RES, 100KΩ±10%	0603 1608 Metric	Rohm ESR03EZPJ104
1	R2	RES, 402 KΩ±1%	0603 1608 Metric	Rohm MCR03ERTF4023
1	U1	IC, MxC 200, QFN5x5, 32P 0.5	QFN32	Helix Semiconductors MxC 200C-QFN32-1
1	J1	CONN, 9P, M, R/A, 0.100	SIP100P9	Wurth Elektronik WR-PHD 61300911021

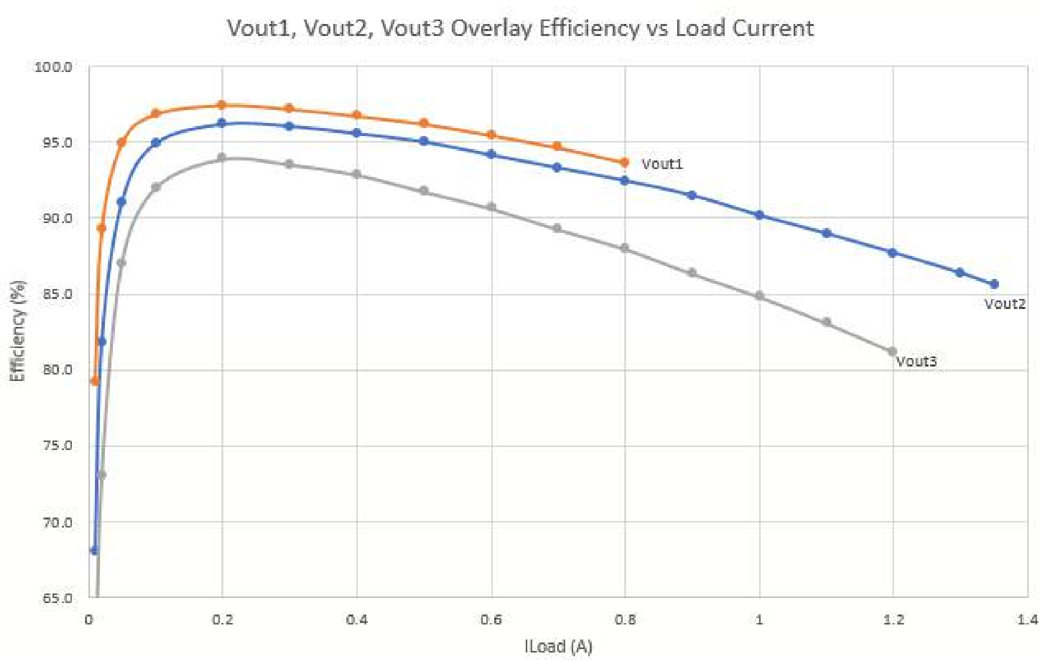


Figure 10: MxC 200 Triple 24V/12V/6V Output EVB Efficiency Curve

6. MxC 200+5V Buck Reg. Output EVB

The MxC 292C-EB3-1 +5V Buck Reg. Output EVB can be operated as a standalone regulated 5V output board (Figure 12).

When the MxC 200 is providing power to another SMPS, the synchronization feature of the MxC 200 allows the MxC 200 MuxCapacitor switching to slow down as the SMPS enters pulse skipping. This operation reduces switching power losses at no-load to light-load conditions. The EXTCLK can be provided by either a FET gate drive signal or a buck regulator's switched output to enhance light-load efficiency. Both the EXTCLKSEL and EXTCLK inputs accept up to 30V signals.

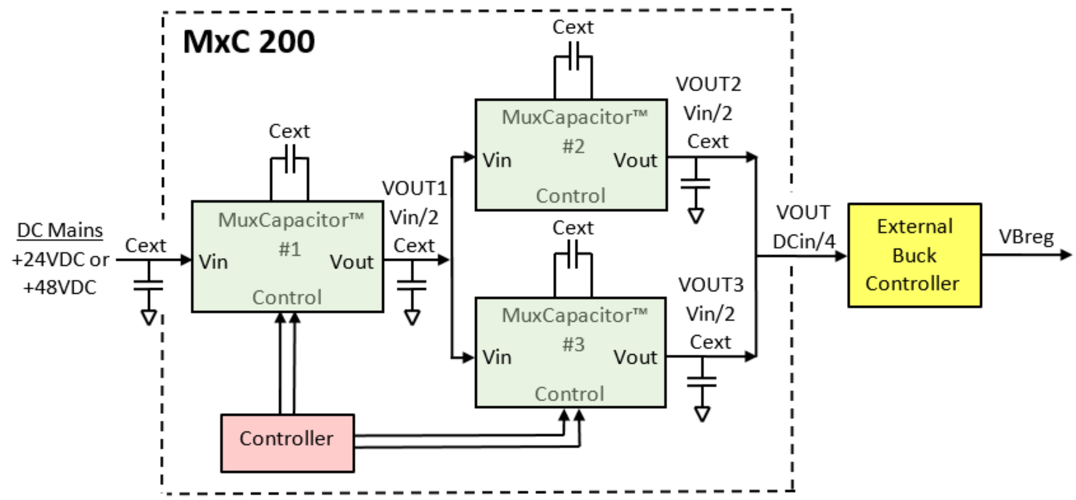


Figure 11: MxC 200+5V Buck Reg. Output EVB Block Diagram

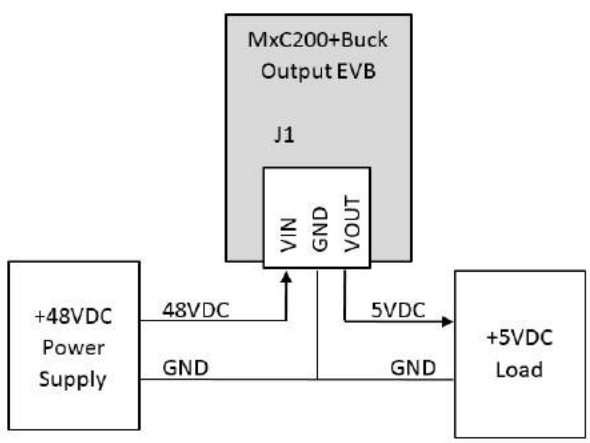


Figure 12: MxC 200+5V Buck Reg. Output EVB Standalone Wiring Diagram

Warning: Do not “Hot-Plug” the power supply or electronic load.

Recommended start-up procedure:

1) With power supply off, attach power supply wires.
2) With electronic load disabled (monitor mode), attach electronic load wires.
3) Turn on power supply.
4) Enable electronic load with no load current, and then ramp up load current.

Table 5: MxC 200+5V Buck Reg. Output EVB Connector – J1

Pin No.	Name	Description
1	VIN	+48VDC Input Power Pin
2	GND	Power GND Pin
3	VOUT	+5VDC Output Power Pin

Note:

1) Due to board’s small size, thermal dissipation is limited and may exceed the over-temperature shutdown threshold.
2) The MxC 200 can be powered from 24V delivering 6V to the buck regulator. The minimum VIN for the TPS565201 is 4.5V.
3) Other buck regulator output voltages are available by changing R4. Refer to the VOUT Table in Figures 13 and 14.

Table 6: MxC 200+5V Buck Reg. Output EVB Bill of Materials (BOM)

Qty	Ref. No.	Description	Package	Manufacturer
1	C8	CAP, 0.1µF±10%, 50V	0603 1608 Metric	Wurth Elektronik WCAP-CSGP 885012206095
1	C9	CAP, 4.7µF±10%, 35V	0603 1608 Metric	TDK C1608X5R1V475M080AC
1	C3	CAP, 10µF±10%, 50V	1210 3225 Metric	TDK C3225X7S1H106M250AB
4	C4, C5, C6, C7	CAP, 22µF±10%, 35V	1206 3216 Metric	TDK C3216X5R1V226M160AC
3	C1, C2A, C2B	CAP, 4.7µF±10%, 100V	1210 3225 Metric	TDK C3225X7S2A475M200AB
1	R1	RES, 100KΩ±10%	0603 1608 Metric	Rohm ESR03EZPJ104
1	R2	RES, 402KΩ±1%	0603 1608 Metric	Rohm MCR03ERTF4023
1	U1	IC, MxC 200, QFN5x5, 32P 0.5	QFN32	Helix Semiconductors MxC 200C-QFN32-1
1	J1	CONN, 3P, M, R/A, 0.100	SIP100P3	Wurth Elektronik WR-PHD 61300611021
1	C10	CAP, 1µF±10%, 16V	0603 1608 Metric	Wurth Elektronik WCAP-CSGP 885012106017
1	C11	CAP, 0.1µF±10%, 25V	0603 1608 Metric	Wurth Elektronik WCAP-CSGP 885012206071
2	C12, C13	CAP, 22µF±10%, 35V	1206 3216 Metric	TDK C3216X5R1V226M160AC
1	R3	RES, 100KΩ	0603 1608 Metric	Rohm ESR03EZPJ104
1	R4	RES, 54.9KΩ±1%	0603 1608 Metric	Rohm MCR03ERTF5493
1	R5	RES, 10.0KΩ±1%	0603 1608 Metric	Rohm MCR03ERTF1003
1	L1	IND, 4.7uH, 9A	PG0642	Wurth Elektronik WR-LHMI 74437349047
1	U2	IC, TPS565201	TSOP8	TI TPS565201D

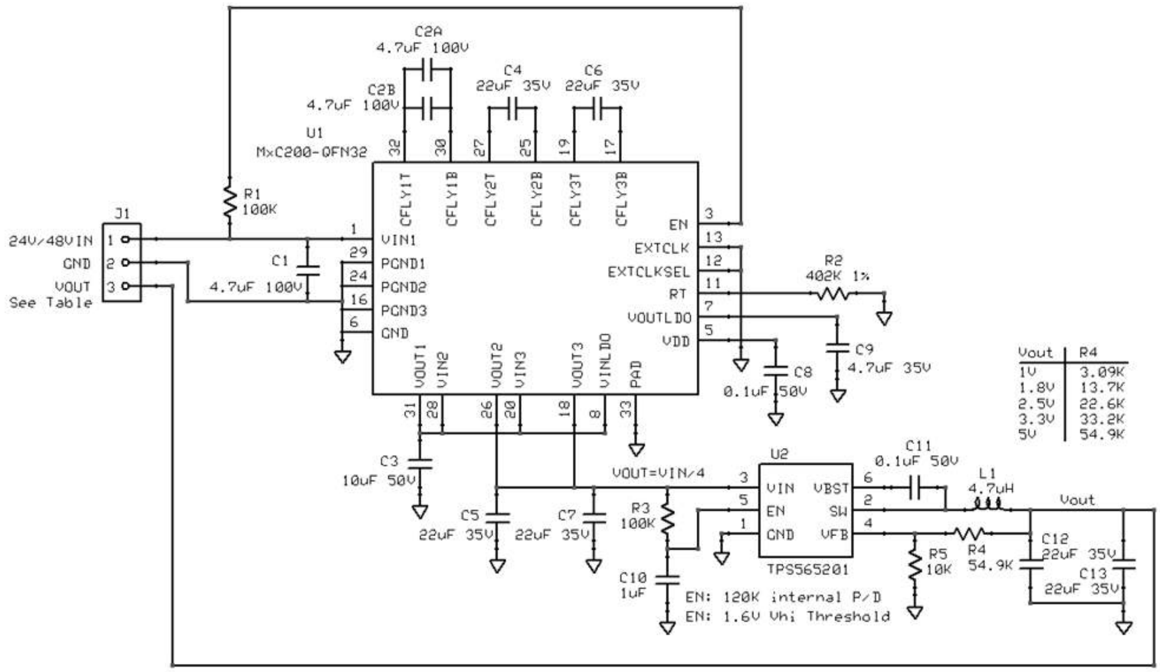


Figure 13: MxC 200+5V Buck Reg. Output EVB Schematic

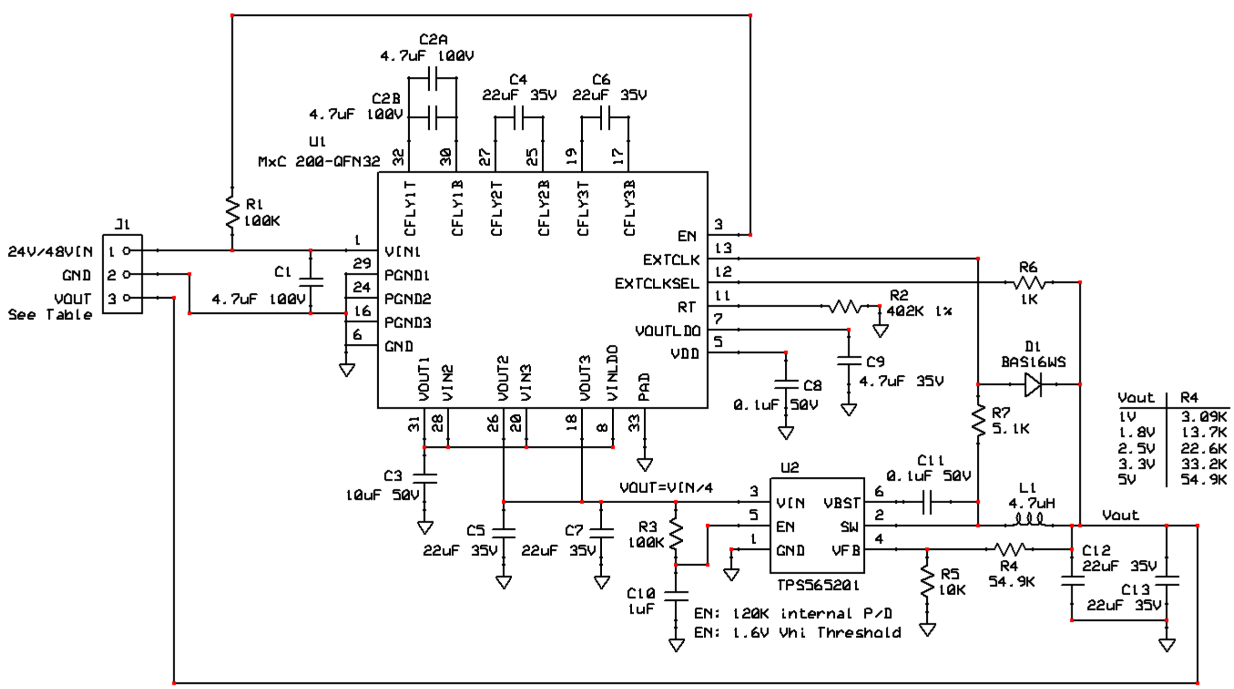
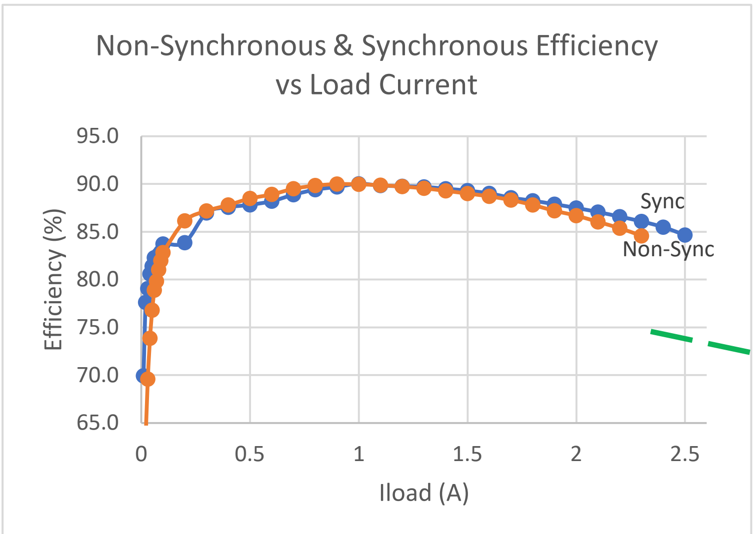


Figure 14: MxC 200 w/Synchronous 5V Buck Reg. Output EVB Schematic



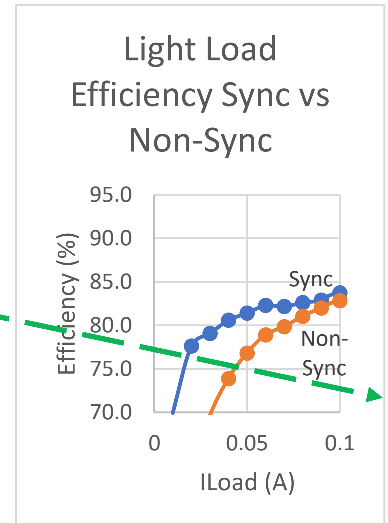


Figure 15: MxC 200 w/Synchronous Buck 5V Output EVB Efficiency Curve

7. 4x Voltage Boost Output EVB

The MxC 281C-EB3-1 4x Voltage Boost Output EVB can be operated as a standalone fixed frequency voltage boost (Figure 17) or synchronized with a SMPS. When being used in a voltage boost mode, the inputs and outputs on each stage are reversed, i.e., pin1 (Vin1) becomes Vout1, pin31 (Vout1) becomes Vin1, etc. In the block diagram in figure 16, this change in function is assumed, so the Vin and Vout labels are the functions, not the pin names. The schematic in figure 18 reflects this change in function.

When the MxC 200 is providing power to a SMPS, the synchronization feature of the MxC 200 allows the MxC 200 MuxCapacitor switching to slow down as the SMPS enters pulse skipping. Refer to Section 6 for enabling the synchronization operation.

The input voltage range is 6V to 12V for an output voltage range of 24V to 48V, respectively.

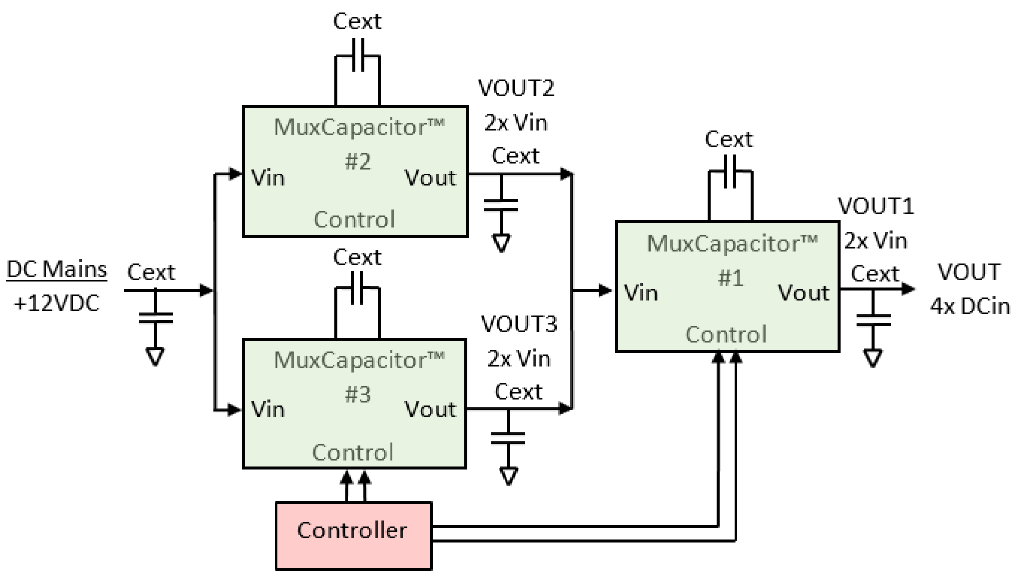


Figure 16: MxC 200 4x Voltage Boost Output EVB Block Diagram

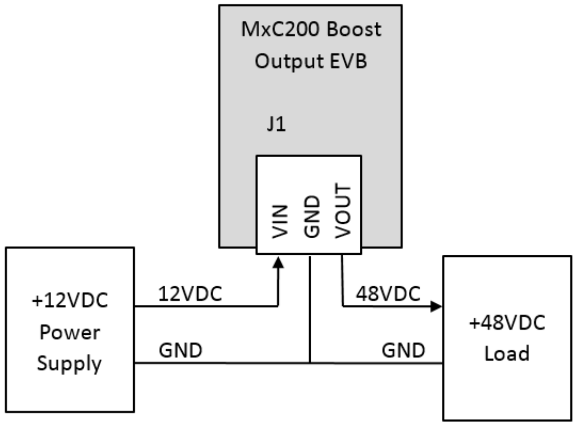


Figure 17: MxC 200 4x Voltage Boost Output EVB Standalone Wiring Diagram

Warning: Do not "Hot-Plug" the power supply or electronic load.

Recommended start-up procedure:

1) With power supply off, attach power supply wires.
2) With electronic load disabled (monitor mode), attach electronic load wires.
3) Turn on power supply.
4) Enable electronic load with no load current, and then ramp up load current.

Table 7: MxC 200 4x Voltage Boost Output EVB Connector – J1

Pin No.	Name	Description
1	VIN	+12VDC Input Power Pin
2	GND	Power GND Pin
3	VOUT	+48VDC Output Power Pin

Note:

1) Due to board's small size, thermal dissipation is limited and may exceed the over-temperature shutdown threshold.
2) The MxC 200 can be powered from 6V to 12V delivering 24V to 48V, respectively to the load.

Table 8: MxC 200 4x Voltage Boost Output EVB Bill of Materials (BOM)

Qty	Ref. No.	Description	Package	Manufacturer
1	C8	CAP, 0.1µF±10%, 50V	0603 1608 Metric	Wurth Elektronik WCAP-CSGP 885012206095
1	C9	CAP, 4.7µF±10%, 35V	0603 1608 Metric	TDK C1608X5R1V475M080AC
1	C3	CAP, 10µF±10%, 50V	1210 3225 Metric	TDK C3225X7S1H106M250AB
4	C4, C5, C6, C7	CAP, 22µF±10%, 35V	1206 3216 Metric	TDK C3216X5R1V226M160AC
3	C1, C2	CAP, 4.7µF±10%, 100V	1210 3225 Metric	TDK C3225X7S2A475M200AB
1	R1	RES, 100KΩ±10%	0603 1608 Metric	Rohm ESR03EZPJ104
1	R2	RES, 402KΩ±1%	0603 1608 Metric	Rohm MCR03ERTF4023
1	U1	IC, MxC 200, QFN5x5, 32P 0.5	QFN32	Helix Semiconductors MxC 200C-QFN32-1
1	J1	CONN, 3P, M, R/A, 0.100	SIP100P3	Wurth Elektronik WR-PHD 61300611021

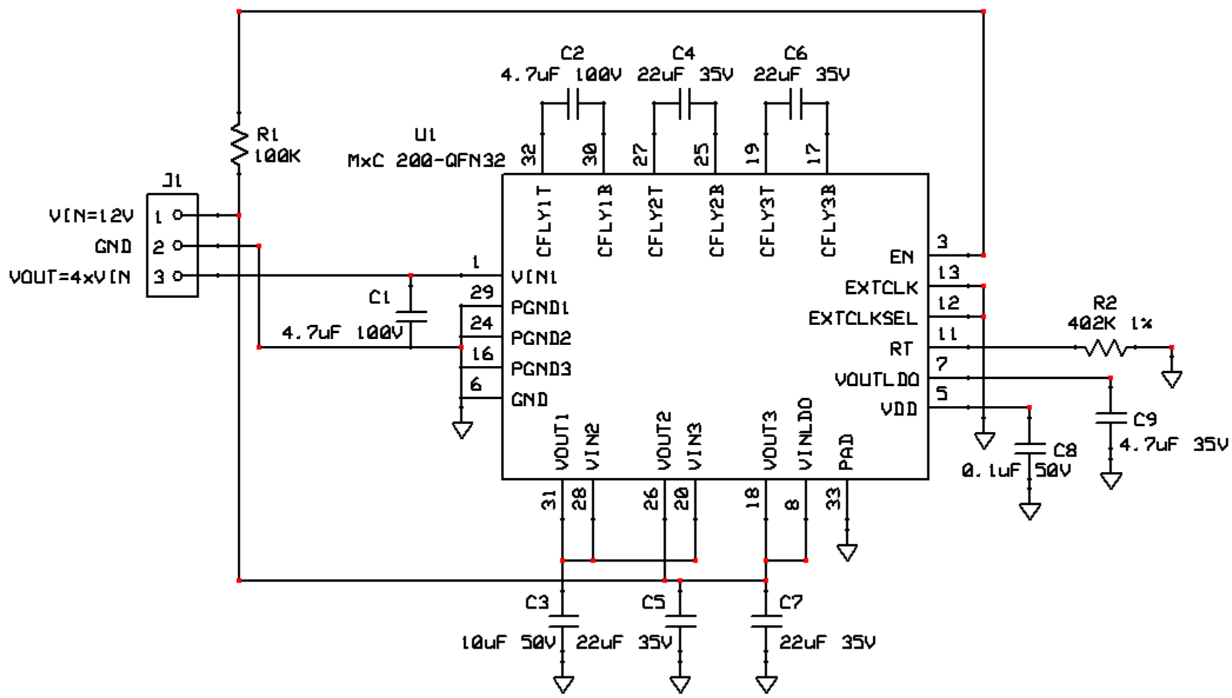


Figure 18: MxC 200 4x Voltage Boost Output EVB Schematic

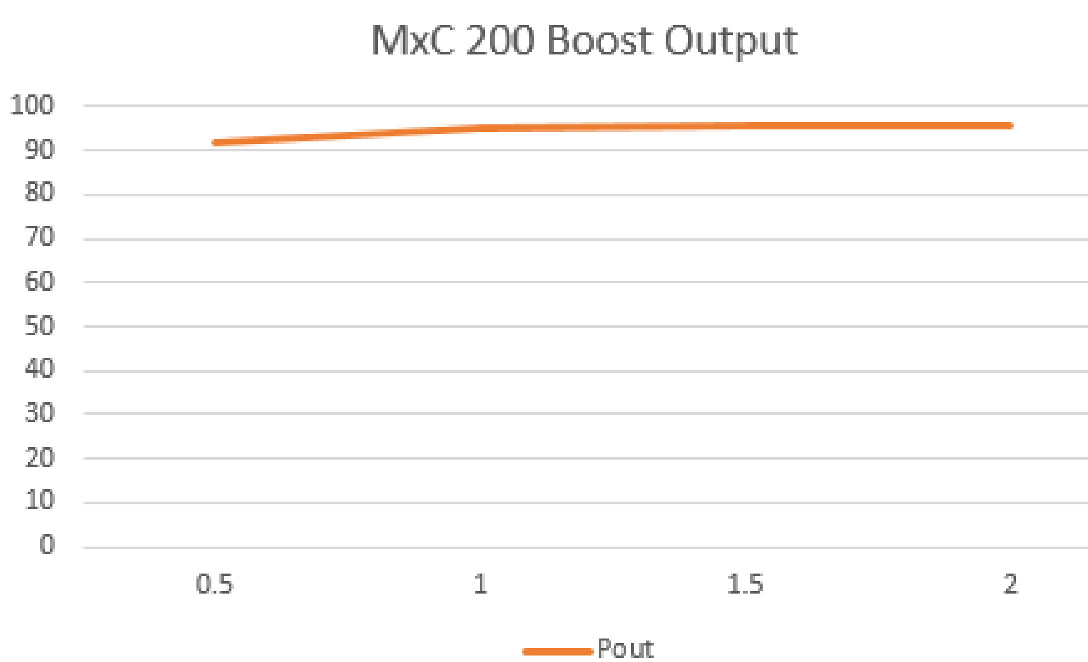


Figure 19: MxC 200 4x Voltage Boost Output EVB Efficiency Curve

8. Voltage Boost with LED Current Source Output EVB

The MxC 284C-EB2 Voltage Boost with LED Current Source Output EVB adds a current source regulator to the output of the MxC 200. The low 9V battery voltage is boosted to 36V to accommodate a high output, high efficiency LED. The MxC 284 is populated with a single high output white LED. Alternatively, the “spot” LED can be replaced with a LED back panel, see Figure 23.

When being used in a voltage boost mode, the inputs and outputs on each stage are reversed, i.e., pin1 (Vin1) becomes Vout1, pin31 (Vout1) becomes Vin1, etc. In the block diagram in figure 20, this change in function is assumed, so the Vin and Vout labels are the functions, not the pin names. The schematic in figure 22 reflects this change in function.

Higher LED currents can be supplied with a corresponding current source driver and additional MxC 200 fly and hold capacitance.

The input voltage range is 6V to 12V for an output voltage range of 24V to 48V, respectively.

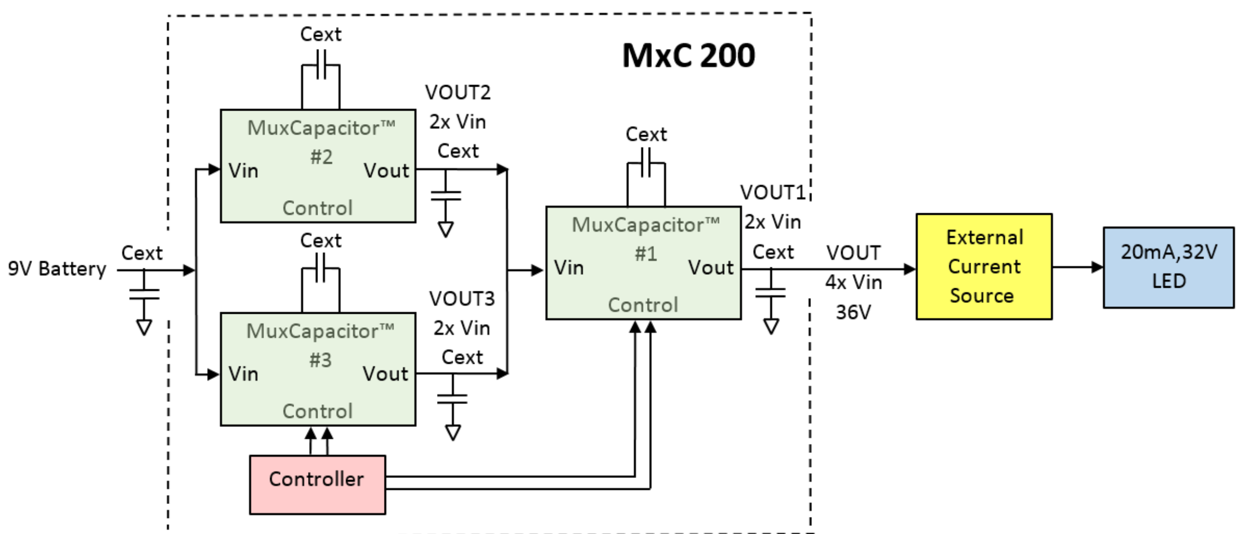


Figure 20: MxC 200 4x Voltage Boost + LED EVB Block Diagram

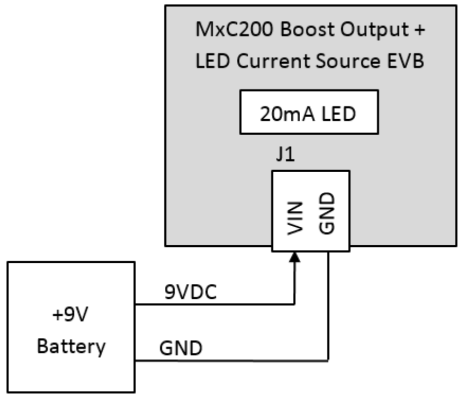


Figure 21: MxC 200 4x Voltage Boost + LED EVB Standalone Wiring Diagram

Warning: Do not "Hot-Plug" the power supply or electronic load.

Recommended start-up procedure:

5) With power supply off, attach power supply wires.
6) With electronic load disabled (monitor mode), attach electronic load wires.
7) Turn on power supply.
8) Enable electronic load with no load current, and then ramp up load current.

Table 9: MxC 200 4x Voltage Boost + LED EVB Connector – J1

Pin No.	Name	Description
1	VIN	+9VDC Input Power Pin
2	GND	Power GND Pin

Note:

3) Due to board's small size, thermal dissipation is limited and may exceed the over-temperature shutdown threshold.
4) The MxC 200 can be powered from 6V to 12V delivering 24V to 48V, respectively to the current source regulator.
5) Higher output current is possible with additional fly and hold capacitance.

Table 10: MxC 200 4x Voltage Boost + LED EVB Bill of Materials (BOM)

Qty	Ref. No.	Description	Package	Manufacturer
1	C8	CAP, 0.1µF±10%, 50V	0603 1608 Metric	Wurth Elektronik WCAP-CSGP 885012206095
1	C9	CAP, 4.7µF±10%, 35V	0603 1608 Metric	TDK C1608X5R1V475M080AC
1	C3	CAP, 10µF±10%, 50V	1210 3225 Metric	TDK C3225X7S1H106M250AB
4	C4, C5, C6, C7	CAP, 22µF±10%, 35V	1206 3216 Metric	TDK C3216X5R1V226M160AC
3	C1, C2	CAP, 4.7µF±10%, 100V	1210 3225 Metric	TDK C3225X7S2A475M200AB
1	R1	RES, 100KΩ±10%	0603 1608 Metric	Rohm ESR03EZPJ104
1	R2	RES, 402KΩ±1%	0603 1608 Metric	Rohm MCR03ERTF4023
1	U1	IC, MxC 200, QFN5x5, 32P 0.5	QFN32	Helix Semiconductors MxC 200C-QFN32-1
1	U2	IC, AL5809-20	SOD-123	Diodes Inc. AL5809-20S1-7
1	LED1	LED, 20mA @ 32V	2.8x3.5	Seoul Semiconductor SAW8WA2A
1	J1	9V Battery Strap	2 Wire	Keystone Electronics 232-234

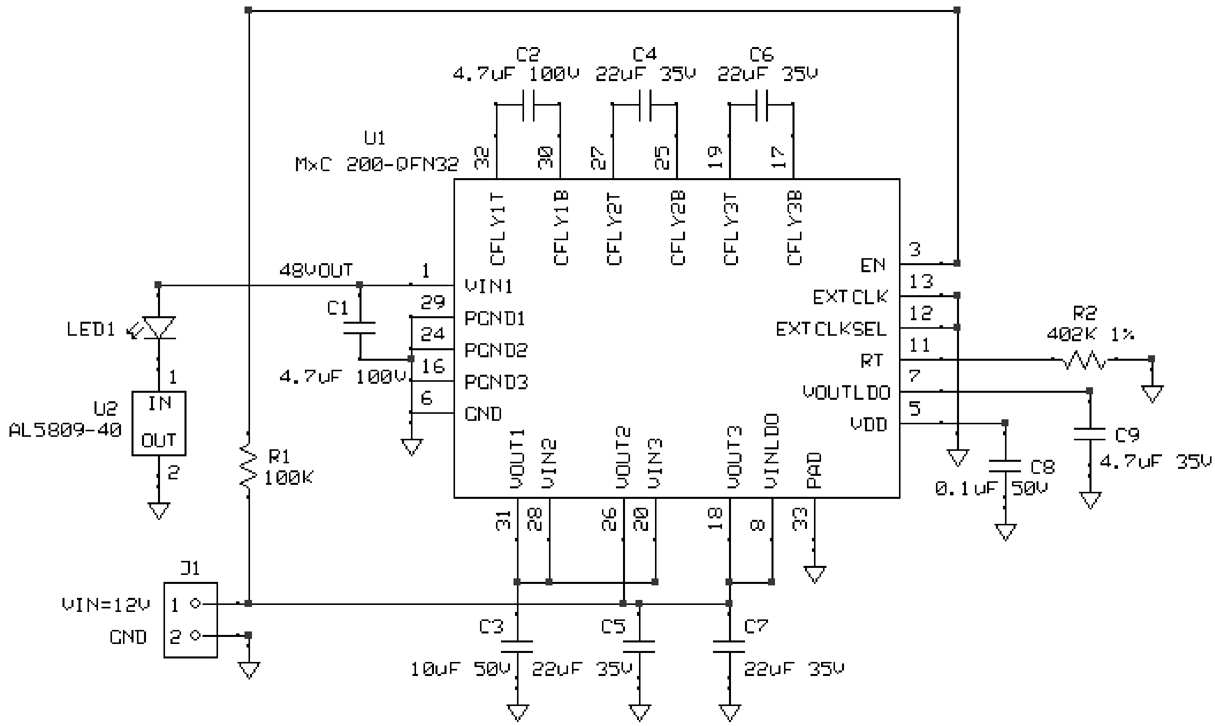


Figure 22: MxC 200 4x Voltage Boost + LED EVB Schematic

Figure 23: MxC 200 4x Voltage Boost with LED Back Panel

9. Output Current Sharing

The MxC 200 MuxCapacitor outputs can be wire-ORed for higher output current capacity. No special synchronization is required. The following examples use the Single 12V Output EVB schematic. Each individual MxC 200 cell is connected in parallel with adjacent cells: All the VIN1 pins are connected together. Similarly, all GND pins and all VOUT2 and VOUT3 pins are connected together, respectively. The VOUT2 and VOUT3 outputs of each MxC 200 cell are connected in parallel for maximum efficiency.

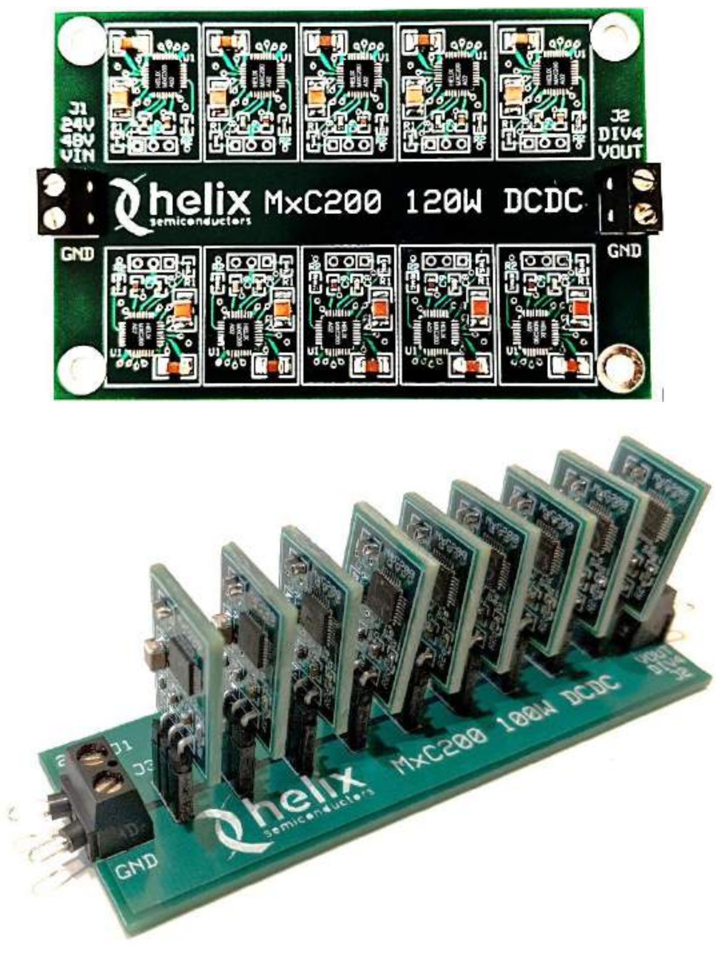


Figure 24: MxC 200 Output Current Sharing 120W 48V-to-12V Voltage Converter

10. Performance Data

The previous MuxCapacitor efficiency data was measured using a Tektronix PM3000 power meter. The figure below shows the test equipment wiring diagram.

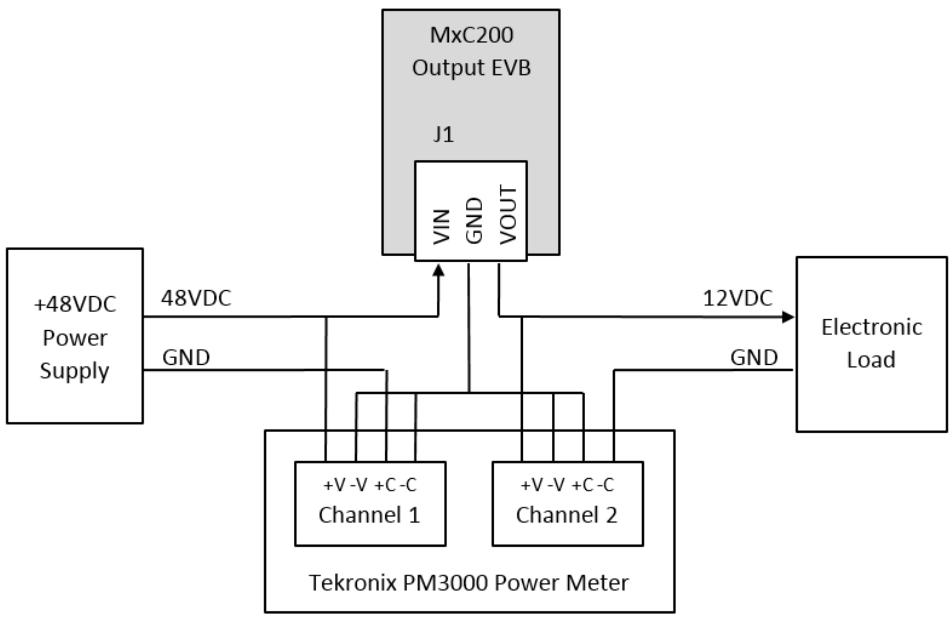


Figure 25: Efficiency Measurement Wiring Diagram

10.1. Operational Guidelines

It is recommended that the auto-ranging feature of current meters be disabled when performing efficiency measurements. The MxC 200 over current detector could trip when the current meter switches from one range to another.

The startup waveform of VIN must be monotonic.

Depending on the startup load and VIN rise time, the startup over current detector could trip. A high startup load condition plus distributed filter capacitance could cause an over-current shutdown.

11. Flying Capacitor Value Verses Efficiency

The MxC 200 flying capacitors can be reduced in value for lower output power applications. Lower cost, smaller package size, etc. are tradeoffs that can affect the efficiency performance.

The Flying Capacitor's value is critical to the maximum load operating performance of the MuxCapacitor. If the flying capacitance is too small the efficiency of the MuxCapacitor decreases. Too little capacitance for the required output current effectively behaves as an increase in the impedance of the MuxCapacitor cell.

The effective operating capacitance of ceramic capacitors are subject to a DC Bias derating. As the DC voltage across the capacitor increases, the capacitor's capacitance value decreases. This DC Bias effect must be considered when operating the capacitor too close to its maximum rated voltage or selecting smaller case sizes.

There are other trade-offs that must be analyzed for reliable, efficient and safe capacitor operation.

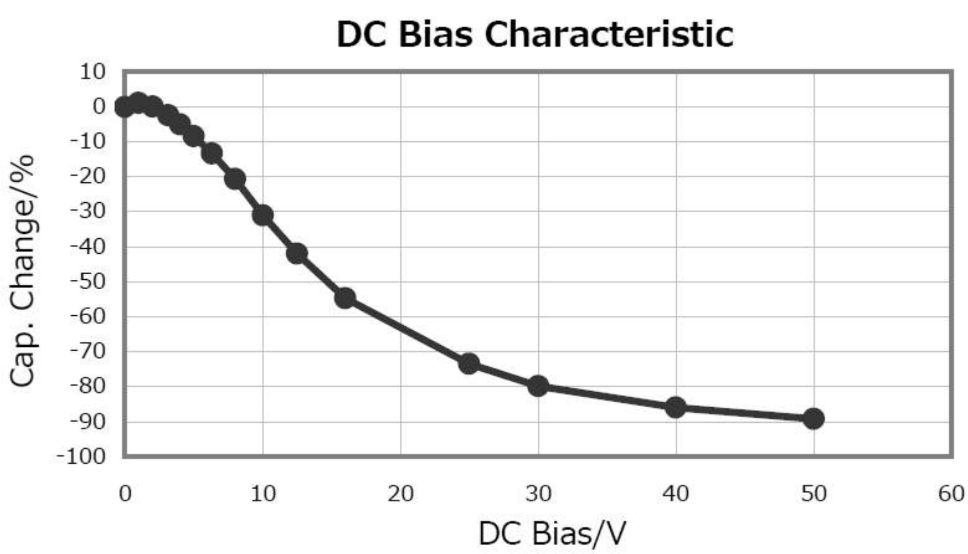


Figure 26: Typical Capacitance verses DC Bias, 50V Device

Table 11: Revision History

Date	Revision	Description
8.15.17	1	Initial Release
8.30.17	2	Add Fig. 11 Efficiency Data
9.19.17	3	Add Hot-Plug warning
11.12.17	4	Updated schematics
2.24.18	5	General Update
4.10.18	6	Add Part Numbers
10.8.18	6.3	Add voltage boost EVB

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