sales@calex.com +1 (925) 687-4411

A Murata Company

48S12.750BCE 750 Watt

48/12V Bi-Directional DC/DC Converter

Features

- E-Mobility 12V/48V battery system
- Buck and Boost modes of operation
- Low Side (LS): 12V Input Voltage Range: 9V to 16V
- Low Side (LS): 12V Output Voltage Range: 6V to 16V
- High Side (HS): 48V Input Voltage Range: 32V to 63.2V
- Overcurrent, Overvoltage, and Over-temperature Protection. All protections are latching.
- Disconnect switch LS (12V) and HS (48V)
- Reverse polarity protection
- Constant Voltage and Constant Current Mode
- Average Current Mode Control
- Internal Temperature Monitoring
- High-power density
- Efficiency up to 96.7%
- Dimensions 4.84” x 6.97” x 1.75” (123 x 177 x 44.5 mm)
- Weight 3.04 lbs. (1.38 Kg)
- Excellent thermal performance
- Constant switching frequency
- CAN 2.0b Interface including remote ON/OFF
- Good shock and vibration damping
- Highly Integrated Solution
- RoHS Compliant
- IP67 with mating connectors installed

Product Overview

The 750-Watt 48S12.750BCE Bi-directional non-isolated DC/DC converter provides a complete solution for in-vehicle power distribution with 12V/48V battery configurations for a variety of applications including micro and mild hybrid automotive systems. The bi-directional DC/DC converter charges a low side (12V) battery during normal operation (Buck mode) and charges or assists the high voltage (48V) battery in emergency situations (Boost mode).

The bi-directional DC/DC converter operates more as an ideal current source with variable direction, thus allowing energy transfer between two voltage domains. Voltage feedback maintains the output voltage within the acceptable operating range and eventually allows a custom charging profile for the battery pack.

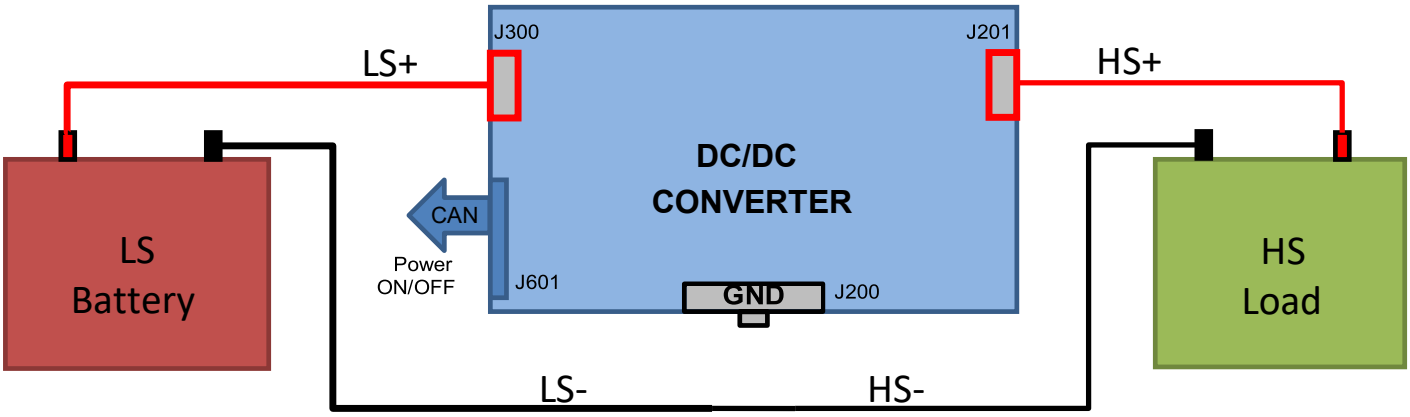
It regulates the average current flowing between the high voltage and low voltage ports in the direction selected via CAN interface. It is packaged in an unprecedented low profile 4.84” x 6.97” x 1.75” (123 x 177 x 4.45 mm) mechanically enclosed package weighing only 3.04 lbs. The package makes the unit ideal for harsh shock and vibration requirements as well as easy integration with a battery pack.

NOTE:

This product as designed is not intended for use in Power-train applications. This product was not designed in compliance to IOS-26262. Contact your local sales representative for application-specific design requests.

Operational Overview

Model				48S12.750BCE					
Input Voltage Range [V]				Output Current [A]		Output Power [W]		Efficiency [%] @ FL	
12V In		48V In		Buck	Boost	Buck	Boost	Buck	Boost
Min.	**Max.**	**Min.**	**Max.**	**Max@12V**	**Max@58.6V**	**Max.**	**Max.**	**Typ.**	**Typ.**
9	16	32	63.2	62.5	12.8	750	750	96.7	95.8



48S12.750BCE - Block Diagram

The 48S12.750BCE integrates a non-isolated two-phase DC/DC converter for bi-directional current flow between two batteries (LS = 12V and HS = 48V), a disconnect switch on low side, and a CAN interface with five connections:

1. Low Side Positive (+LS) Connector (J300): Amphenol C10-764863-2001 (Red, 180 deg keyway)
   Recommended Mating Connector: Amphenol SLP(l)PA16BSR1
2. High Side positive (+HS) Connector (J201): Amphenol C10-764863-2003 (Red, 120 deg keyway)
   Recommended Mating Connector: Amphenol SLP(l)PA16BSR3
3. GND Connector (J200): Amphenol C10-764863-1000 (Black, 90 deg keyway)
   Recommended Mating Connector: Amphenol SLP(l)PA16BSB0
4. CAN Interface Connecter (J601): Amphenol RTS010N6S03 - Signal connector for the CAN interface, ON/OFF signal and power connection. See the section entitled “CAN Functions” for more details.
   Recommended Mating Connector: Amphenol RTS6BS10N6P03

Functional Features

The 48S12.750BCE is fully controlled via CAN interface. It uses a high-speed CAN-Transceiver (TCAN1042HVDRQ1) for communication with the microcontroller. It provides control of the PWM control ICs, and protection and monitoring of the current and temperature monitoring features. The converter operates in buck and boost modes.

The 48S12.750BCE includes a disconnect switch based on a back to-back N MOSFET configuration for both low side (12V battery) and high side (48V battery). The converter has reverse voltage protection, short circuit protection as well as low standby current. The design includes a CAN 2.0b interface for complete control of the converter as well as monitoring LS and HS voltage and current and internal temperature of the converter. The 48S12.750BCE is designed to operate in a wide operational temperature range.

The converter's high efficiency and high-power density are accomplished using high-efficiency synchronous rectification technology, advanced electronic circuitry, and leading-edge packaging and thermal design. This results in a highly reliable product. The diode emulation mode of the synchronous rectifiers prevents negative currents, but also enables discontinuous mode operation for improved efficiency with light loads. The converter operates at a fixed frequency and follows conservative component derating guidelines.

Electrical Specifications

Conditions: T_A = 25 ºC, Vin = 48VDC, unless otherwise specified. Specifications are subject to change without notice.

48S12.750BCE					
Parameter	**Notes**	**Min.**	**Nom.**	**Max.**	**Units**
Absolute Maximum Ratings					
Input Voltage					
High Side (48V)	Continuous	0		66	V
	Load Dump	0	70	75	V
Low Side (12V)	Continuous	-26		26	V
	Load Dump			36	V
Operating Temperature	Natural Convection @ 100% Power	-40		75	°C
	Heatsink @ 100% power. See the Mechanical Specifications section for the monitoring location.			105	°C
Storage Temperature		-55		125	°C
Isolation Characteristics and Safety					
Isolation Voltage	Input to Baseplate and Output to Baseplate	250			V
Feature Characteristics					
Fixed Switching Frequency – Multiphase converter	Each phase		175		kHz
	Total two phases		350		kHz
TEMP monitor	PCB temperature	-40°C		+125	°C
	Accuracy	-2	1	+4	%
All Protections Latching					
Over-Temperature Shutdown	PCB Temperature – Fixed and Latching	120	123	128	°C
ON/OFF Remote Control – Positive Logic					
ON state	Pin voltage	8			V
OFF state				2	V
CAN Baud Rate			250		Kbps

Electrical Specifications - Buck Mode

Conditions: TA = 25 ºC, Vin = 48VDC, Vo = 13.8V unless otherwise specified. Specifications are subject to change without notice.

48S12.750BCE – Buck Mode					
Parameter	**Notes**	**Min.**	**Typ.**	**Max.**	**Units**
High Side (Input) Characteristics					
Input Voltage			48		V
Operating Voltage Range		32		63.2	V
Under Voltage Lockout	Latching				
Turn-on Threshold	Default		32		V
Turn-off Threshold	Default		30		V
	Programmable	29		63.2	V
Lockout Hysteresis Voltage	Default		2		V
Overvoltage Protection	Default		66		V
	Programmable	33		66	V
Maximum High-Side Current	VHS = 36V, VLS=12V, ILS=62.5A (750W)		21.5		A
	VHS = 48V, VLS=12V, ILS=62.5A (750W)		16.2		A
	VHS = 58.6V, VLS=12V, ILS=62.5A (750W)		13.3		
Stand-by Current	Converter Disabled		390		µA
Low-Side (Output) Characteristics					
Overvoltage Protection	Default		20		V
	Programmable	8		20	V
Undervoltage Protection	Default		5.4		V
	Programmable	5.4		15	V
LS Stand-by Current	Converter Disabled and in hibernation		290		µA
Constant Voltage Mode					
Output Voltage			13.8		V
Output Voltage Range	Programmable	6		16	V
Output Voltage Set Point Accuracy	At 10A load current		±1		%
Constant Current Mode					
Output Current Range	Programmable via CAN interface (ISET)	1		62.5	A
Output Current Regulation	6.25A < Load Current < 62.5A		±1		%
Output Current Set Point Accuracy	6.25A < Load Current < 62.5A		±1		%
Low Side Current Monitor (read back)	6.25A < Load Current < 62.5A		+/-1		%
High Side Current Monitor (read back)	6A < IHS < 24.2A		+/-1		%
Efficiency					
Half Load (375W)	Vin = 58.6V, Vo = 13.8V[1]		95.9		%
Full Load (750W)	Vin = 58.6V, Vo = 13.8V[1]		96.7		%

[1] Voltages measured at converter terminals.

Electrical Specifications - Boost Mode

Conditions: TA = 25 °C, Vin = 13.8VDC, Vo = 48V unless otherwise specified. Specifications are subject to change without notice.

48S12.750BCE – Boost Mode					
Parameter	**Notes**	**Min.**	**Typ.**	**Max.**	**Units**
Low-Side (Input) Characteristics					
Input Voltage			13.8		V
Operating Voltage Range		9		16	V
Under Voltage Lockout	Latching				
Turn-on Threshold	Default		9		V
Turn-off Threshold	Default		8		V
	Programmable	8		15	V
Lockout Hysteresis Voltage	Default		1		V
Overvoltage Protection	Default			20	V
	Programmable	10		20	V
Maximum Low Side Current	VLS = 12V			62.5	A
Stand-by Current (converter disabled)	VHS > VLS (buck or boost)		390		µA
High-Side (Output) Characteristics					
Overvoltage Protection	Default		66		V
	Programmable	33		66	V
Undervoltage Protection	Default		30		V
	Programmable	29		61	V
Stand-by Current	Converter disabled and in hibernation		290		µA
Constant Voltage Mode					
Output Voltage			48		V
Output Voltage Range	Programmable via CAN interface (ISET)	32		63.2	V
Output Voltage Set Point Accuracy	At 3A load current		±1		%
Constant Current Mode					
Current Range (set from LS current)	Programmable via CAN interface (ISET)	1		62.5	A
Output Current Regulation			1		%
Output Current Set Point Accuracy	At ILS = 31.3A		+/-7.5		%
	At ILS = 62.5A		2.7		%
Low- Side Current Monitor (Read back)	6.25A < ILS < 62.5A		2		%
High- Side Current Monitor (Read back)	6A < IHS < 24A		±1		%
Efficiency					
Half Load (375W)	Vin =13.8V, Vo = 58.6V[1]		95.1		%
Full Load (750W)	Vin =13.8V, Vo = 58.6V[1]		95.8		%

[1] Voltages measured at converter terminals.

Environmental and Mechanical Specifications

Specifications are subject to change without notice.

General Parameters					
Parameter	**Notes**	**Min.**	**Typ.**	**Max.**	**Units**
Environmental					
Operating Humidity	Condensing			100	%
	Non-condensing			95	%
Storage Humidity	Condensing			100	%
	Non-condensing			95	%
ROHS Compliance[1]	See the Calex Website http://www.calex.com/pdf/ROHS.pdf for the complete RoHS compliance statement.				
Shock and Vibration	Designed to meet the following standards: • Shock - IEC 60068-2-27 • Vibration - IEC 60068-2-64				
Water Washability	Not recommended for the water wash process. Contact the factory for more information.				
Mechanical					
Weight			3.04 1.38		lbs. kg
Case Dimension	Not including connectors		4.84 x 6.97 x 1.75		inches
			123 x 177 x 44.5		mm
	Including connectors		5.57 x 6.97 x 1.75		inches
			141.5 x 177 x 44.5		mm
Cover	Material		.031" [0.8mm] THK Steel		
	Finish		Brushed		
Mounting Hardware	Fastener		M6 or ¼-20 screw		
	Torque		15		Nm

Note:

1 The RoHS marking is:

CAN Functions

The following functions are fully controlled via CAN interface:

- ON/OFF
- Current and voltage set points
- Current direction
- Protection thresholds: Undervoltage, Overvoltage, and Overtemperature

In addition, the 48S12.750BCE provides low side current monitoring and internal PCB temperature monitoring.

High speed CAN-Transceiver (TCAN1042HVDRQ1) is employed for communication between the CAN interface and the microcontroller inside the converter. The converter requires both voltages to be present, the high side and low side voltages must be inside the specified range to operate.

All protective functions are latching and reset can only be accomplished via the CAN interface. The converter has default limits (minimum and maximum) for current and voltage set points as well as for undervoltage and overvoltage thresholds. Note that the threshold for all protective features can be programmed via CAN, as long as the programmed value is inside the default limits (see Specification). If a setting point or threshold for protection through the CAN interface is outside its programmable range, the values will be set to the corresponding value as specified in the datasheet. Contact the factory for CAN interface: Command and Status Message.

The 48S12.750BCE regulates the average current flowing between the high voltage and low voltage ports in the direction specified by the DIR signal. It is designed to operate in constant current mode (CCM) or constant voltage mode (CVM). In the constant current mode, the low side current is programmed and regulated regardless if the converter is in buck or boost mode. When the programmable current (ISET) is greater than the actual LS current, the converter operates in constant voltage mode.

The direction of the current can be changed on the fly, in which case the converter will reduce the LS current to zero first, then start in different mode (reversing the current direction) with a time delay of 30 msec (typ). Note that ISET needs to be inside the default limits for the given mode of operation (see Specification).

The 48S12.750BCE includes a disconnect switch based on a back to-back N MOSFET configuration for both the low side (+12V battery) and high side (+48V battery) and has reverse voltage protection, overcurrent, short circuit protection as well as low standby current for the low side.

Digital I/O Pinout		
Pin #	**Label**	**Function**
1 (A)	CAN-L	CAN-L bus line
2 (B)	CAN-H	CAN-H bus line
3 (C)	ON/OFF	Reference to GND pin, used to turn the converter ON and OFF. Positive logic.
4 (D)	GND	Connected to GND terminal.
5 (E)	POWER[1]	External power supply voltage
6 (F)		

[1] External power supply is needed only when both HS and LS batteries are not connected to provide voltage for the internal bias converter, which powers the converter control circuit and CAN transmitter.

Operational Notes

Fusing

The 48S12.750BCE converter provides an electronic disconnect switch based on back–to-back 40V rated N MOSFETs on the low side and 100V rated N-MOSFETs on the high side. External fuses should be connected between the batteries and the converter power terminals.

Reverse Voltage Polarity Protection

The 48S12.750BCE converter has input reverse polarity protection on both low side (12V battery) and high side (48V battery).

Undervoltage Protection

For proper operation, it is required to have voltage present on both the HS and LS terminals. The 48S12.750BCE converter monitors the high side and low side voltages and will start and regulate properly only if both voltages exceed the corresponding Turn-on thresholds (see Specification) and remain at or above Turn-on threshold.

The converter will turn-off when either of the two voltages drop below their corresponding Turn-off threshold (see Specification) and will latch off. The built-in hysteresis prevents the converter from shutting down at the low input voltage near the Turn-on threshold. The converter can be restarted only via CAN interface once both voltages are above their Turn-on thresholds and the ON/OFF pin is in logic level high state. Note: the undervoltage circuit has hysteresis only for the high side voltage when the converter operates in the buck mode and for low side voltage when the converter operates in the boost mode.

Once the undervoltage threshold is reached, the converter shuts down and latches off. The user should consider the voltage drop due to resistive (I*R) and inductive voltage drops in the power lines to make sure the voltage at the converter's terminals is always above the Turn-off threshold level under all operating conditions.

If the values for the undervoltage protection are not provided via the CAN interface, the converter will use default values (see Specification).

Input Source Impedance

Because of the switching nature and negative input impedance of DC/DC converters, the input of these converters must be driven from the source with both low AC impedance and DC input regulation.

The low profile of the 48S12.750BCE converter is optimized for a power source cable length of 6m (20 ft) for High Side battery and up to 6m (20 ft) for low side battery.

The DC input regulation, associated with the resistance between the input power source and the input of the converter, plays a significant role in low-input voltage applications such as 12V battery systems.

Note that the input voltage at the input terminals must never decrease below the Turn-off threshold under all load conditions during operation.

ENABLE (J601 – pin 3)

The ON/OFF pin is used in conjunction with the CAN interface and needs to be in the active state (logic level high > 8V) to enable the converter via CAN interface.

Switching voltage level on the ON/OFF pin from high to low <2V) or shorting to GND will shut down and latch the converter. Switching the ON/OFF voltage from logic low to logic high will not enable the converter until the next command for enabling the converter via CAN interface is generated.

Constant Current Mode and Direction Select

The converter operates as an ideal current source with variable direction when the output voltage is lower than the voltage specified by the CAN interface. This configuration allows energy transfer between the two voltage domains (batteries). Only the low side domain current is directly programmed and regulated in both modes of operation (buck and boost). The current can be programmed in the range of ISET = 1A-62.5A.

The converter has an internal soft start for ISET to reduce inductive voltage drop in the power cables during both turn-on and turn-off. The converter will not operate if ISET =0 or it is outside the limits. Current level ISET can be changed on the fly. The direction of the current can be changed dynamically during operation. In that case, the converter will shut down and change the mode of operation through the internal soft start thus eliminating surge current during the direction change.

Current Monitoring

The converter provides LS and HS current monitor read back value via CAN interface. It has a positive value when the converter operates in buck mode and a negative value when converter operates in boost mode.

Constant Voltage Mode

When the load current is lower than the programmed current, ISET, the converter will operate in the voltage mode regulating the output voltage at the level set by the CAN interface. The range of both voltages is provided in the specification table.

The output voltage will set to the value of the range limit if the request via the CAN interface is out of the limit range.

Output Overcurrent Protection (OCP)

The converter senses both LS and HS currents. Average LS current is limited at ISET level when converter operates in constant current mode. Additional protection on the LS is provided by cycle-by-cycle peak current limit. Low side (Inductor current) is monitored and limited to the current level set by the CAN interface (ISET =1A-62.5A). HS current is also monitored and provides additional protection at typ. +/- 30A in case of overload or short circuit. Once OCP threshold is tripped, internal logic disconnects the converter from both, LS and HS batteries via corresponding disconnect switches.

Buck Mode

In Buck Mode, the LS voltage will be regulated to the setting voltage if the LS current is lower than the set current. When the LS current reaches the setting point, the LS voltage will drop, and the converter enters constant current mode.

When the LS voltage drops below the turn-off threshold, the converter will shut down and latch off and the HS and LS disconnect switches will be turned off.

The LS voltage must be no less than 6V to turn on the Buck Mode output.

Boost Mode

In the boost mode, the output current on the high side terminal is indirectly limited by the inductor (LS) current. If the load current increases above the setting level defined by ISET, the converter operates in constant current mode and the high side voltage (output voltage) will be reduced. When it drops below the turn-off threshold for the high side terminal, the undervoltage protection will be activated and the converter will shut down, turning off both the low side and the high side disconnect switches and latch off.

The converter can only turn-on via the CAN interface. Note: that the converter will not start if the high side voltage is below the turn-on threshold so that startup into a shorted high side is prevented.

Output Overvoltage Protection (OVP)

The converter shuts down if either of the terminal voltages (low side or high side) are above their corresponding thresholds of the OVP circuitry. Once the converter has shut down, it remains latched off. Overvoltage thresholds can be programmed via the CAN interface; however, must be inside the limits provided in the spec table.

Over-Temperature Protection (OTP)

The 48S12.750BCE converter has two temperature monitors on PCB with a threshold of 123°C.

Once the over temperature protection is tripped, the converter will shut down and latch off. Restarting the converter requires an enable from the CAN interface after the PCB temperature drops below 110°C.

Thermal Consideration

The cooling of 48S12.750BCE can be through natural convection or by forced airflow on fins of the enclosure.

At natural convection conditions (no forced airflow), the converter can supply full output power (750W) at ambient conditions of -40°C to +75°C.

Murata Power Solutions recommends that the customer monitors the PCB temperature via CAN to ensure that it remains below 110°C. If the PCB temperature reaches 123°C, OTP is triggered; the converter shuts down and latches off. CAN bus enable is required to restart the converter after the PCB temperature drops below 110°C.

The converter can deliver full power (750W) provided the ambient temperature does not exceed 75°C under natural convection.

Characteristic Curves — Efficiency and Power Dissipation in Buck and Boost Mode

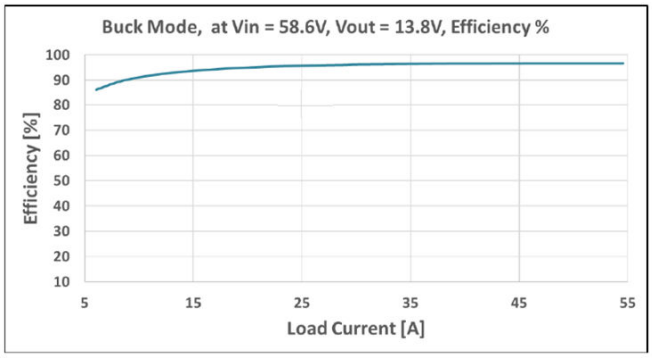


Figure 1: 48S12.750BCE Efficiency Curve – Buck Mode: Vin = 58.6V, Vout = 13.8V

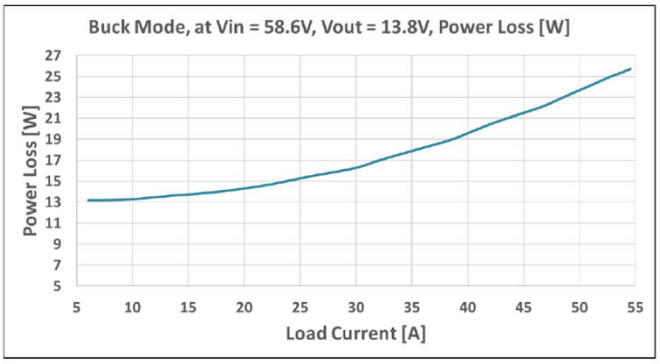


Figure 2: 48S12.750BCE Power Dissipation – Buck Mode: Vin =58.6V, Vout = 13.8V

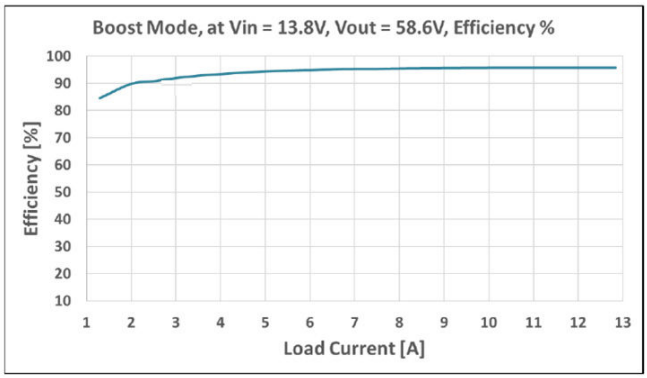


Figure 3: 48S12.750BCE Efficiency Curve – Boost Mode, Vin = 58.6V, Vout = 13.8V

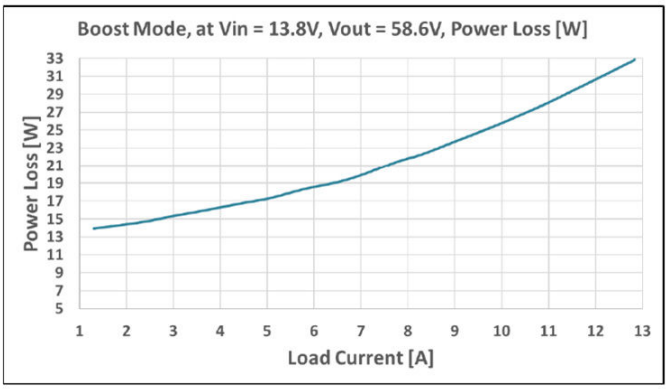
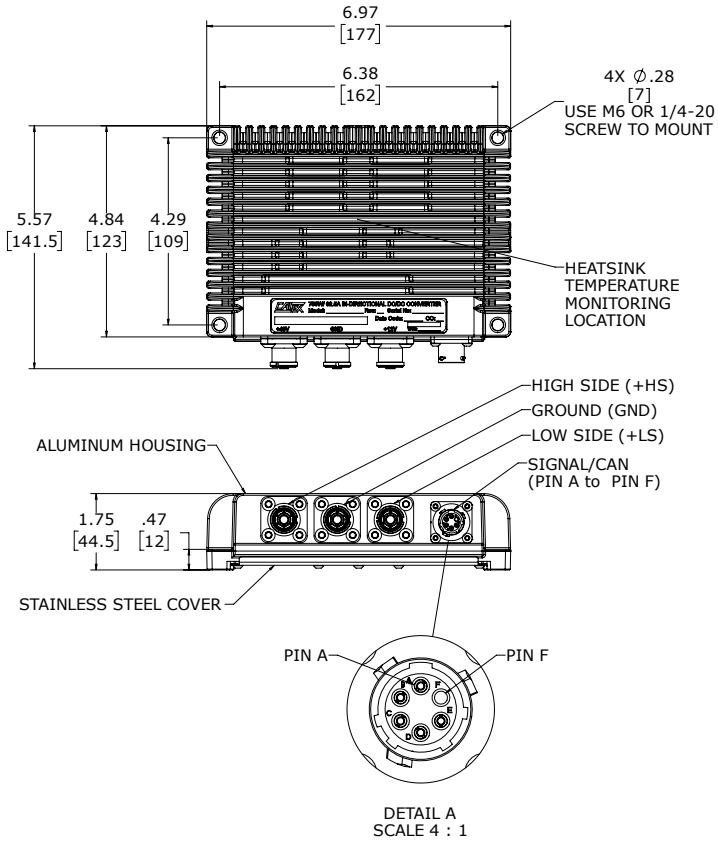
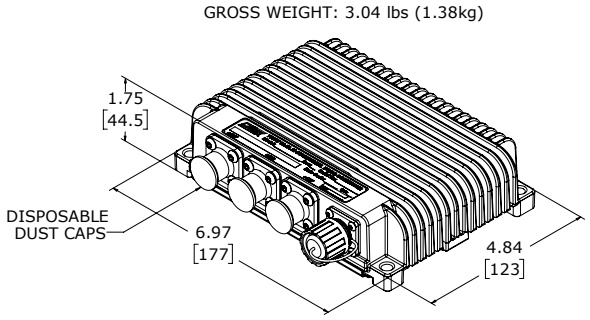


Figure 4: 48S12.750BCE Power Dissipation – Boost Mode: Vin = 58.6V, Vout = 13.8V

Mechanical Specifications





ISOMETRIC VIEW (REFERENCE)

TABLE 1 - PINOUT DETAILS

Ref.	Function	Connector	Mates with
+HS	+48V	Amphenol C10-764863-2003	Amphenol SLP(I)PA16BSR3
GND	GND	Amphenol C10-764863-1000	Amphenol SLP(I)PA16BSB0
+LS	+12V	Amphenol C10-764863-2001	Amphenol SLP(I)PA16BSR1
PIN A	CAN-L	Amphenol RTS010N6S03	Amphenol RTS6BS10N6P03
PIN B	CAN-H		
PIN C	ON/OFF		
PIN D	GND		
PIN E	POWER		
PIN F	UNUSED		

NOTES:

Unless otherwise specified:
All dimensions are in inches Tolerances: x.xx
in. ±0.02 in.