Hi-Rel DC/DC CONVERTER
MGDM-160 : 150W POWER

Hi-Rel Grade

3:1 High Input Voltage : 155 - 480 VDC
Single Output
Metallic case - 2 200 VDC Isolation

- Wide input range 180-480 Vdc
- 270Vdc input compliant with MIL-STD-704E/F
- Industry standard quarter brick package
- Power up to 155 W
- Wide temperature range : -40/+105°C baseplate
- High efficiency (up to 92%)
- Soft start
- Galvanic isolation 2 200 VDC
- Integrated input filter
- Synchronizable
- Parallelable in option
- No load to full load operation
- Fully protected by independant protection
    - Undervoltage lock-out
    - Overvoltage protection
    - Current limitation protection
    - Overtemperature protection
- No optocoupler for high reliability
- RoHS process

1-General

The MGDM-160 high input series is a complete line of high density wide input range DC/DC power modules designed for aerospace, military and high-end industrial applications. These modules use a patented fixed switching topology at 480 KHz providing wide input range, low noise characteristics and high power density. Standard models are available with wide input voltage range of 180-480 volts. The series include single output voltage of 26 volts.
The MGDM-160 high input series include synchronization, parallelable with load sharing, trim and sense functions.
The synchronization function allows to synchronize more than one converter to one frequency or an external source frequency.
The parallelable function allows increased power with a true N+1 redundancy.

All the modules are designed with LC network filters to minimize reflected input current ripple and output voltage ripple.
The modules have totally independant security functions including input undervoltage lock-out, output overvoltage protection, output current limitation protection, and temperature protection. Additionnally a soft-start function allows current limitation and eliminates inrush current during start-up.
The design has been carried out with surface mount components, and is manufactured in a fully automated process to guarantee high quality. The modules are potted with a bi-component thermal conductive compound to ensure optimum power dissipation under harsh environmental conditions.

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2-Product Selection

Single output model : MGDS - 160 - [input] – [output] / [option] – [suffix]

Input Voltage Range	Output
Permanent	
S : 180-480 VDC	26 : 26 VDC

Options :
/T : option for -55°C start up operating temperature
/S : option for screening and serialization

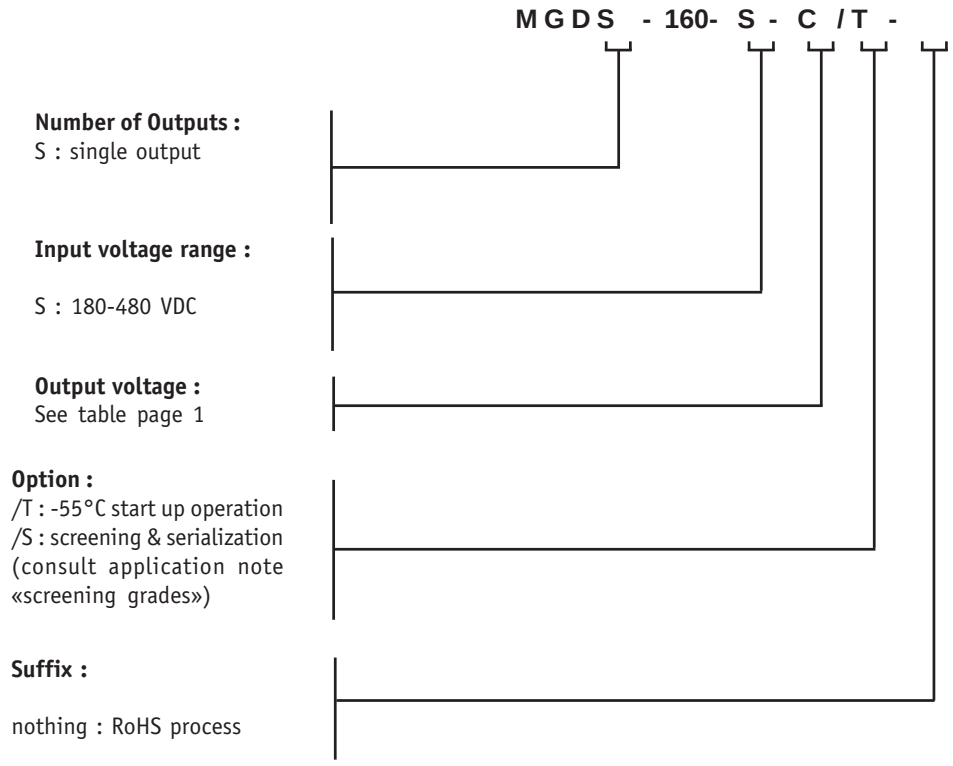
Suffix :
nothing : RoHS process

For locations, phone, fax, E-Mail see back cover

2- Product Selection (continued)

Input range	Output	Current	Reference	Options	Suffix
155-480 VDC	26 VDC	6 A	MGDS-160-S-26	/T, /S	/

Converter Selection Chart



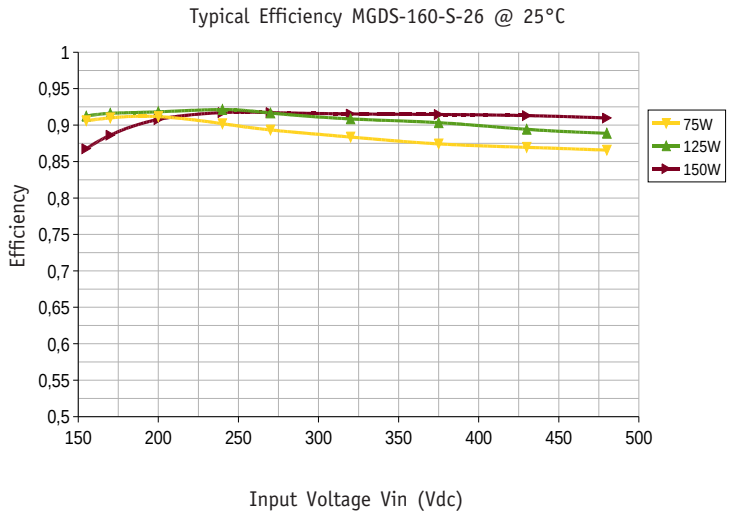
3- Electrical Specifications

Data are valid at +25°C, unless otherwise specified.

Parameter	Conditions	Limit or typical	Units	MGDS-155 - S
Input				
Nominal input voltage	Full temperature range	Nominal	VDC	270
Permanent input voltage range (Ui)	Full temperature range	Min. - Max.	VDC	180 - 480
Undervoltage lock-out (UVLO)	Turn-on voltage typical hysteresis	Maximum	VDC	180 10
Start up time	Ui nominal Nominal output Full load : resistive	Maximum	ms	30
Reflected ripple current****	Ui nominal, full load BW = 20MHz	Maximum	% of input current	10
Input current in short circuit mode (Average)	Ui nominal Short-circuit	Typical	mA	60
No load input current	Ui nominal No load	Maximum	mA	35
Input current in inhibit mode	Ui nominal Inhibit	Maximum	mA	2
Output				
Output voltage *	Ui min. to max.	lNominal	VDC	26
Set Point accuracy *	Ambient temperature : +25°c Ui nominal, 75% load	Maximum	%	+/- 2
Output power **	**steady state** 300<Ui<480Vdc (90°C Bp) 180<Ui<300Vdc (90°C Bp) 300<Ui<480Vdc (100°C Bp) 180<Ui<300Vdc (90°C Bp) **tran**sient(300ms) 180<Ui<300Vdc (90°C Bp) 180<Ui<300Vdc (90°C Bp)	Maximum	W	 155 120 140 110 155 140
Output current ** 26V output	Full temperature range Ui min. to max.	Maximum	A	6
Ripple output voltage *** 26V output	Ui nominal Full load BW = 20MHz	Typical	mVpp	250
Output regulation * (Line + load + thermal)	Ui min. to max. 0% to full load	Maximum	%	+/- 1
Output Voltage Trim	As function of output voltage	Minimum Maximum	% %	90 * 110
Maximum admissible Capacitive load 26V output	Ui nominal Full load	Maximum	µF	1 000
Efficiency	Ui nominal Full load	Typical	%	90

*Note * : These performances are measured with the sense line connected..*
*Note ** : It is recommended to mount the converter on a heatsink for this test, see section 9-3 and 9-9 for further details.*
*Note *** : The ripple output voltage is the periodic AC component imposed on the output voltage, an aperiodic and random component (noise) has also to be considered. This noise can be reduced by adding an external decoupling capacitor connected between Ginand Gout. These capacitor should be layed-out as close as possible from the converter. Please refer to page 8 for more details.*
*Note **** : These performances are given with LC input filter.*

4- Electrical Characteristics (continued)



4- Switching Frequency

Parameter	Conditions	Limit or typical	Specifications
Switching frequency	Full temperature range Ui min. to max. No load to full load	Nominal, fixed	480 KHz +/-6%

5- Isolation

Parameter	Conditions	Limit or typical	Specifications
Electric strength test voltage	Input to output Input to case Output to case	Minimum Minimum Minimum	2 200 VDC / 1 min 2 200 VDC / 1 min 2 200 VDC / 1 min
Isolation resistance	500 VDC	Minimum	100 MOhm

6- Protection Functions

Characteristics	Protection Device	Recovery	Limit or typical	Specifications
Input undervoltage lock-out (UVLO)	Turn-on, turn-off circuit with hysteresis cycle	Automatic recovery	Turn-on nominal Turn-off nominal	see section 3
Output current limitation protection (OCP)	Hiccup circuitry with auto-recovery	Automatic recovery	Nominal	120% of output current
Output overvoltage protection (OVP)	Overvoltage protection device with latch-up	Automatic recovery	Nominal	120% of output voltage
Over temperature protection (OTP)	Thermal device with hysteresis cycle	Automatic recovery	Nominal	120°C

7- Reliability Data

Characteristics	Conditions	Temperature	Specifications
Mean Time Between Failure (MTBF) According to MIL-HDBK-217F	Ground fixed (Gf)	Case at 40°C Case at 85°C	510 000 Hrs 145 000 Hrs
	Airborne, Inhabited, Cargo (AIC)	Case at 40°C Case at 85°C	285 000 Hrs 100 000 Hrs
Mean Time Between Failure (MTBF) According to IEC-62380-TR	Avionics Military Cargo	/	Consult factory

8- Electromagnetic Interference

Electromagnetic Interference requirements according to MIL-STD-461C/D/E standards can be easily achieved as indicated in the following section. The following table resumes the different sections covered by these standards.

Standard Requirements	MIL-STD-461C Standard	MIL-STD-461D/E Standard	Compliance with GAIA Converter Module & common mode capacitance
Conducted emission (CE) :			
Low frequency	CE 01	CE 101	compliant module stand-alone
High frequency	CE 03	CE 102	compliant with additionnal filter
Conducted susceptibility (CS) :			
Low frequency	CS 01	CS 101	compliant with additionnal filter
High frequency	CS 02	CS114	compliant with additionnal filter
Radiated emission (RE) :			
Magnetic field	RE 01	RE 101	compliant with additionnal filter
Electrical field	RE 02	RE 102	compliant with additionnal filter
Radiated susceptibility (RS) :			
Magnetic field	RS 01	RS 101	compliant with additionnal filter
Electrical field	RS 03	RS 103	compliant with additionnal filter

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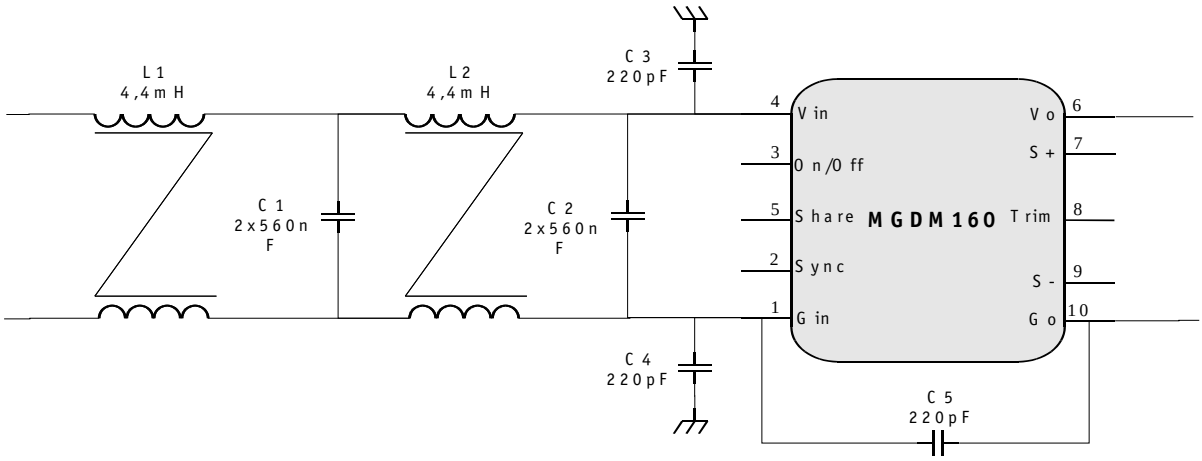
9-1 Module Compliance with MIL-STD-461C Standard

To meet MIL-STD-461C requirements and in particular CE03 requirement, Gaïa Converter recommends the use of the following front filter together with 4 external decoupling capacitors connected between inputs and case and between outputs and case. Please consult MIL-STD-461C EMI filter design note for further details.



L1 ..... : Common mode choke 4,4mH 0,6A
L2 ..... : Common mode choke 4,4mH 0,6A
C1 ..... : 2 x ceramic capacitors 560nF
C2 ..... : 2 x ceramic capacitors 560nF
C3, C4, C5* ..... : Low ESR and ESL ceramic capacitor 220pF

(*) Must be placed as close as possible to the converter in order to reduce the path length or the connections to the pins and the baseplate.

9- Thermal Characteristics

Characteristics	Conditions	Limit or typical	Performances
Operating ambient temperature range at full load	Ambient temperature *	Minimum Maximum	- 40°C see below
Baseplate temperature	Base plate temperature	Minimum Maximum	- 40°C see curves herafter
Storage temperature range	Non functionning	Minimum Maximum	- 55°C + 125°C
Thermal resistance	Baseplate to ambient Rth(b-a) free air	Typical	11°C/W

The following discussion will help designer to determine the thermal characteristics and the operating temperature.

Heat can be removed from the baseplate via three basic mechanisms :

- Radiation transfert : radiation is counting for less than 5% of total heat transfert in majority of case, for this reason the presence of radient cooling is used as a safety margin and is not considered.

- Conduction transfert : in most of the applications, heat will be conducted from the baseplate into an attached heatsink or heat conducting member; heat is conducted thru the interface.

- Convection transfert : convecting heat transfer into air refers to still air or forced air cooling.

In majority of the applications, we will consider that heat will be removed from the baseplate either with :

- heatsink,
- forced air cooling,
- both heatsink and forced air cooling.

To calculate the maximum admissible ambient temperature the following method can be used.

Knowing the power used Pout and the efficiency η:

- determine the power dissipated by the module Pdiss that should be evacuated :

$$\mathbf{Pdiss = Pout(1/\eta - 1) \quad (A)}$$

- then determine the thermal dissipation :

$$\mathbf{Tdiss = Rth(b\text{-}a) \times Pdiss \quad (B)}$$

where **Rth(b-a) is the thermal resistance from the baseplate to ambient**.

This thermal Rth(b-a) resistance is the summ of :

- **the thermal resistance of baseplate to heatsink (Rth(b-h)).** The interface between baseplate and heatsink can be nothing or a conducting member, a thermal compound, a thermal pad.... The value of Rth(b-h) can range from 0.4°C/W for no interface down to 0.1°C/W for a thermal conductive member interface.
- **the thermal resistance of heatsink to ambient air (Rth(h-a))**, which is depending of air flow and given by heatsink supplier.

The table hereafter gives some example of thermal resistance for different heat transfert configurations.

Heat transfert	Thermal resistance heatsink to air Rth(h-a)		Thermal resistance baseplate to heatsink Rth(b-h)		Global resistance
Free air cooling only	No Heatsink baseplate only :	11°C/W	No need of thermal pad		11°C/W
	Heatsink Thermaflo 424500B0000 :	7,64°C/W	Bergquist Silpad* :	0,21°C/W	7,85°C/W
	Heatsink Thermaflo 424800B0000 :	3,5°C/W	Bergquist Silpad* :	0,21°C/W	3,71°C/W
Forced air cooling 200 LFM	No Heatsink baseplate only :	6,9°C/W	No need of thermal pad		6,9°C/W
	Heatsink Radian HS1568EX :	3,5°C/W	Bergquist Silpad* :	0,21°C/W	3,71°C/W
	Heatsink Thermaflo 424800B0000 :	2,8°C/W	Bergquist Silpad* :	0,21°C/W	3,01°C/W
Forced air cooling 400 LFM	No Heatsink baseplate only :	4,8°C/W	No need of thermal pad		4,8°C/W
	Heatsink Radian HS1568EX :	2°C/W	Bergquist Silpad* :	0,21°C/W	2,21°C/W
	Heatsink Thermaflo 424800B0000 :	1,8°C/W	Bergquist Silpad* :	0,21°C/W	2,01°C/W
Forced air cooling 1000 LFM	No Heatsink baseplate only :	2,8°C/W	No need of thermal pad		2,8°C/W
	Heatsink Thermaflo 424800B0000 :	1°C/W	Bergquist Silpad* :	0,21°C/W	1,21°C/W

Radian and Thermaflo are heasink manufacturers. «Silpad» © is a registered trademark of Bergquist.
Note : Silpad performance are for Silpad 400 with pressure conditions of 50 Psi. Surface of MGDS-155 series is 3,3 inch2.*

9- Thermal Characteristics (continued)

The two formulas (A) and (B) described in previous page :

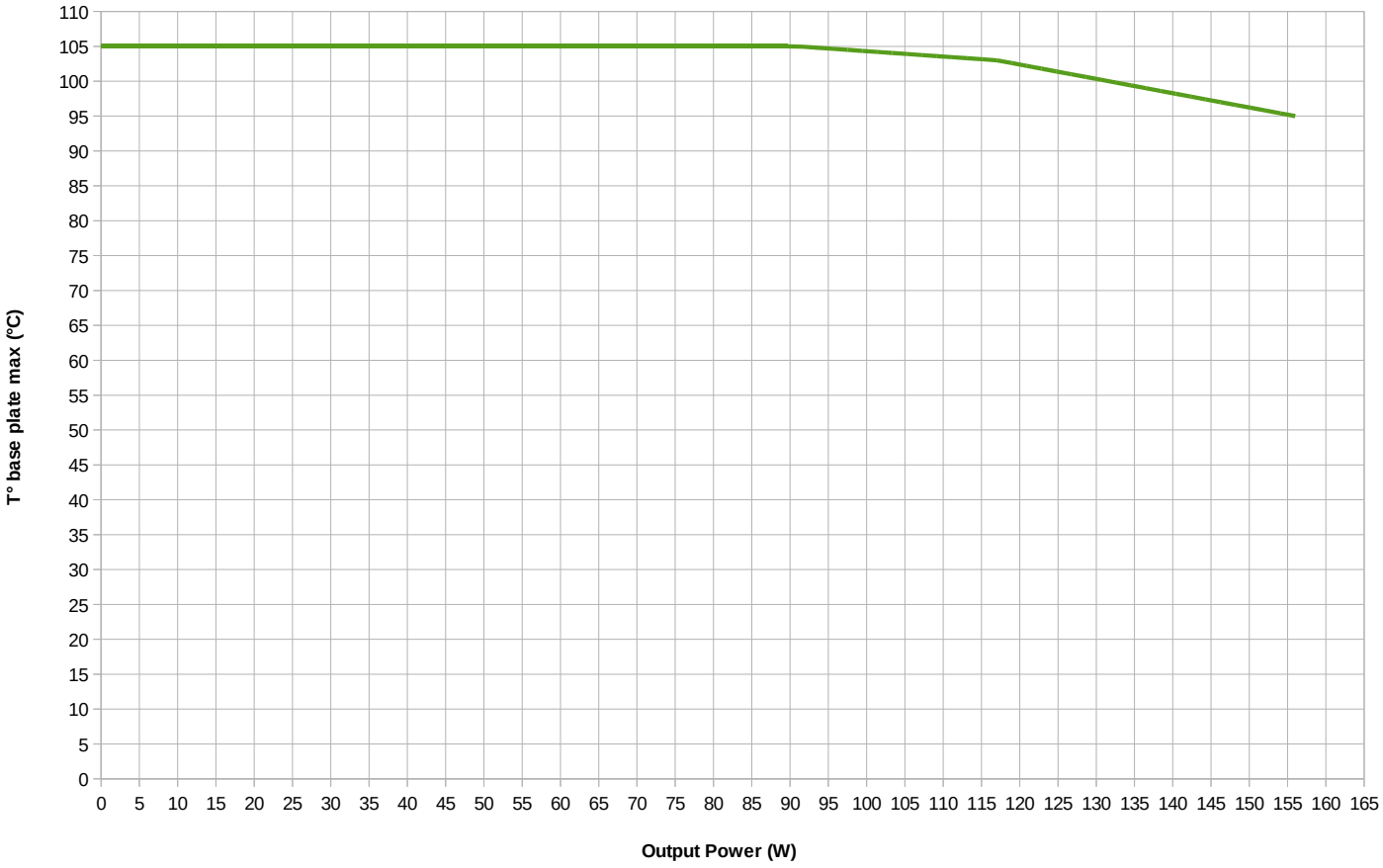
- **Pdiss = Pout(1/η - 1) (A)**
- **Tdiss = Rth(b-a) x Pdiss (B)**

conduct to determine the maximum ambient temperature admissible as a function of the maximum baseplate temperature of the module.

Knowing the maximum baseplate temparature $Tmax_{baseplate}$ the maximum ambient temperature is given by the following formula :

$Ta = Tmax_{baseplate} - Tdiss$ (C)

MGDM-160S Series Maximum Baseplate Temperature Versus
Maximum of Output Power @ Nominal Input



10- Environmental Qualifications

The modules have been subjected to the following environmental qualifications.

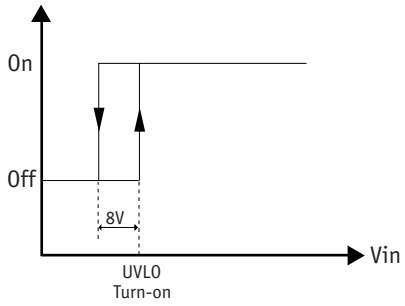
Characteristics	Conditions	Severity	Test procedure
Climatic Qualifications			
Life at high temperature	Duration Temperature / status of unit	Test D : 1 000 Hrs @ 125°C ambient, unit not operating	MIL-STD-202G Method 108A
Altitude	Altitude level C Duration Climb up Stabilization Status of unit	40 000 ft@-55°C 30 min. 1 000 ft/min to 70 000 f@-55°C, 30 min. unit operating	MIL-STD-810G Method 500.5
Humidity cyclic	Number of cycle Cycle duration Relative humidity variation Temperature variation Status of unit	10 Cycle I : 24 Hrs 60 % to 88 % 31°C to 41°C unit not operating	MIL-STD-810G Method 507.5
Humidity steady	Damp heat Temperature Duration Status of unit	93 % relative humidity 40°C 56 days unit not operating	MIL-STD-202G Method 103B
Salt atmosphere	Temperature Concentration NaCl Duration Status of unit	35°C 5 % 48 Hrs unit not operating	MIL-STD-810G Method 509.5
Temperature cycling	Number of cycles Temperature change Transfert time Steady state time Status of unit	200 -40°C / +85°C 40 min. 20 min. unit operating	MIL-STD-202A Method 102A
Temperature shock	Number of shocks Temperature change Transfert time Steady state time Status of unit	100 -55°C / +105°C 10 sec. 20 min. unit not operating	MIL-STD-202G Method 107G
Mechanical Qualifications			
Vibration (Sinusoidal)	Number of cycles Frequency / amplitude Frequency / acceleration Duration Status of unit	10 cycles in each axis 10 to 60 Hz / 0.7 mm 60 to 2 000 Hz / 10 g 2h 30 min. per axis unit not operating	MIL-STD-810G Method 514.6
Shock (Half sinus)	Number of shocks Peak acceleration Duration Shock form Status of unit	3 shocks in each axis 100 g 6 ms 1/2 sinusoidal unit not operating	MIL-STD-810G Method 516.6
Bump (Half sinus)	Number of bumps Peak acceleration Duration Status of unit	2 000 Bumps in each axis 40 g 6 ms unit not operating	MIL-STD-810G Method 516.6

11- Description of Protections

The MGDM-160 high input series include 4 types of protection devices.

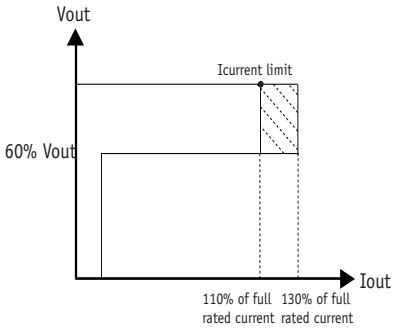
11-1 Input Undervoltage Lockout (UVLO)

An undervoltage protection is implemented to switch off the converter as long as the input voltage has not reached the UVLO turn-on threshold (see section 3 for value) which is the minimum input voltage required to operate without damaging the converter.



11-2 Output Over Current Protection (OCP)

The MGDM-160 high input series incorporates a foldback current limit and protection circuit. When the output current reaches 120% of its full-rated current, the output voltage falls and output current drops along the foldback line as described in the figure herein. The module falls in hiccup mode and automatically resumes to normal operation when the overcurrent is removed.

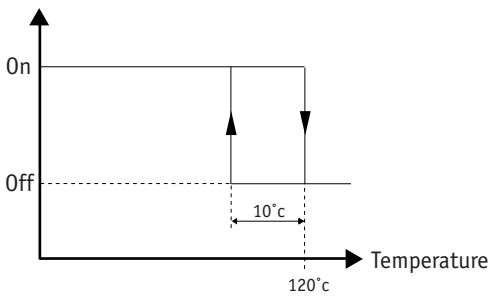


11-3 Output Overvoltage Protection (OVP)

The MGDM-160 high input series has an internal overvoltage protection circuit that monitors the voltage accross the output power terminals. It is designed to limit the converter at 120% (+/-5%) of output voltage.

11-4 Over Temperature Protection (OTP)

A thermal protection device adjusted at 120°C (+/-5%) internal temperature with 10°C hysteresis cycle will inhibit the module as long as the overheat is present and will restore to normal operation automatically once the overheat is removed. The effectiveness of the OTP function is warranty with the module mounted on a heatsink.



12- Description of Functions

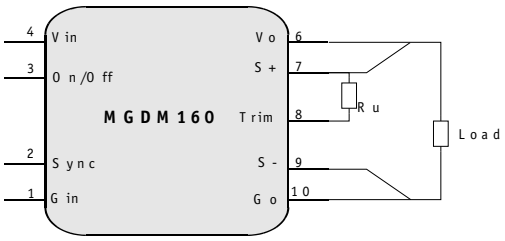
12-1 Trim Function

The output voltage Vo may be trimmed in a range of 90% to 110% of the nominal output voltage via an external trimmer or a fixed resistor.

Trim Up Function

Do not trim the module above 110% of nominal outp voltage as the overvoltage protection will trigger.
Also do not exceed the maximum rated output power wh the module is trimmed up.
The trim up resistor must be connected to the S+ pin.
The trim up resistor must be calculated with the followi formula :

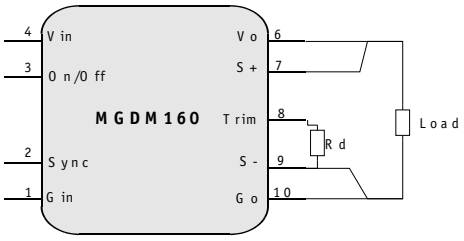
$$Ru = \frac{R1 \cdot (Vo - Vref) \cdot Vo_{nom}}{(Vo - Vo_{nom}) \cdot Vref} - R1 - R2$$



Trim Down Function

Do not trim down below 90% of nominal output voltage.
The available output power is reduced by the sam percentage that output voltage is trimmed down.
The trim down resistor must be connected to S- pin.
The trim down resistor must be calculated with the followin formula :

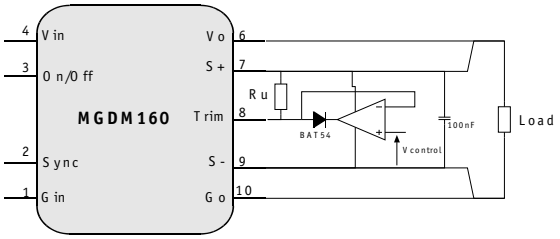
$$Rd = \frac{(R1 + R2) \cdot Vo - (R2 \cdot Vo_{nom})}{Vo_{nom} - Vo}$$



Trim via a voltage

The output voltage is given by the following formula :

$$Vo = \left(1 + \frac{R1}{R1 + R2} \cdot \left(\frac{Vcont}{Vref} - 1\right)\right) \cdot Vo_{nom}$$



In the schematics herein, Ru need to be calculated using the formula § **Trim Up Function** to determine the max output voltage required with no trim voltage.

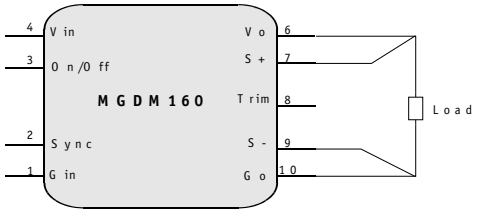
Trim resistor values calculated automatically:
On-line calculators for trim resistor values are available on the Gaia converter website at :
http://www.gaia-converter.com/calculator.

Parameter	Unit	Min.	Typ.	Max.
Trim reference	Vdc	2,45	2,5	2,55
Resistor R1	Ohm	/	39K	/
Resistor R2	Ohm	/	270	/

12- Description of Functions (continued)

12-2 Sense Function

If the load is separated from the output by any line lenght, some of these performance characteristics will be degraded at the load terminals by an amount proportional to the impedance of the load leads. Sense connections enable to compensate the line drop at a maximum of +/-10% of output voltage. The overvoltage protection will be activated and module will shut down if remote sense tries to boost output voltage above 110% of nominal output voltage. Connection is described in figure herein.

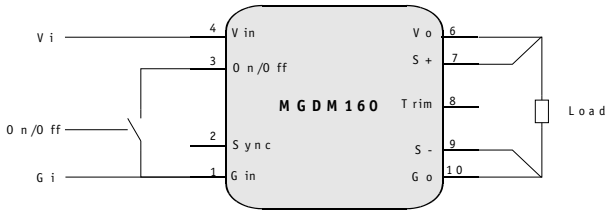


12-3 On/Off Function

The control pin 3 (On/Off) can be used for applications requiring On/Off operation. This may be done with an open collector transistor, a switch, a relay or an optocoupler. Several converters may be disabled with a single switch by connecting all On/Off pins together.

- The converter is disabled by pulling low the pin 3.
- No connection or high impedance on pin 4 enables the converter.

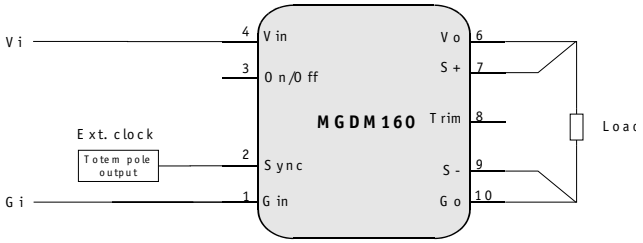
By releasing the On/Off function, the converter will restart within the start up time specifications given in table section 3. For further details please consult "Logic On/Off" application note.

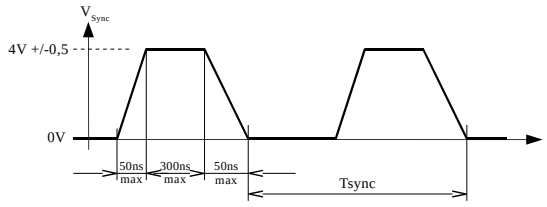


Parameter	Unit	Min.	Typ.	Max.	Notes, conditions
On/Off module enable voltage	Vdc	3.5	/	5	Open, the switch must not sink more than 100µA
On/Off module disable voltage	Vdc	0	/	0.5	The switch must be able to sink 1mA
On/Off alarm level	Vdc	0	/	0.5	OTP or OCP faulty module
On/Off module enable delay	ms	/	/	30	The module restarts with the same delay after alarm mode removed
On/Off module disable delay	µs	/	/	250	Vi nominal, full load

12-4 Synchronization Function

An external clock with pulse signals can be used to lock one or more converters (active on rising edge). The external clock signal should have a frequency range from 480KHz to 515KHz, a low level below 0,5V a high level of 4V (+/-0.5V), a rise time of 50 ns max., a fall time of 50ns max., and a pulse width of 300 ns maximum.
Several converters can be synchronized by connecting their Sync pin together.

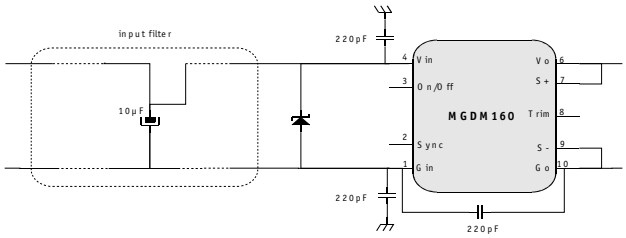




13- Application Notes

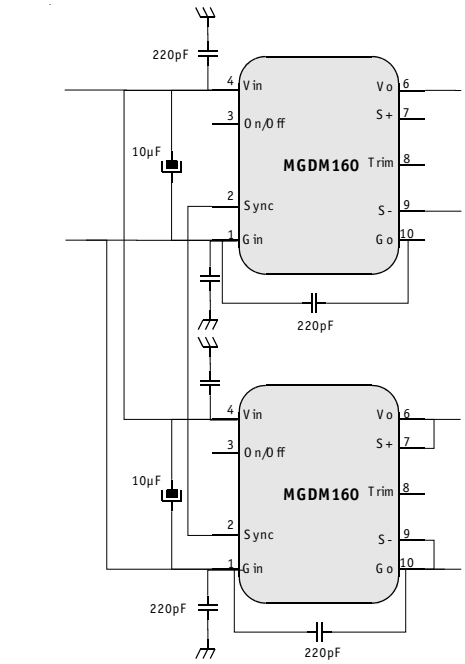
13-1 Input Capacitor Coupling

It is recommended to use a minimum of 10µF decoupling capacitor connected across the Vin anf Gin lines of the converter to restore a low line impedance and improve stability



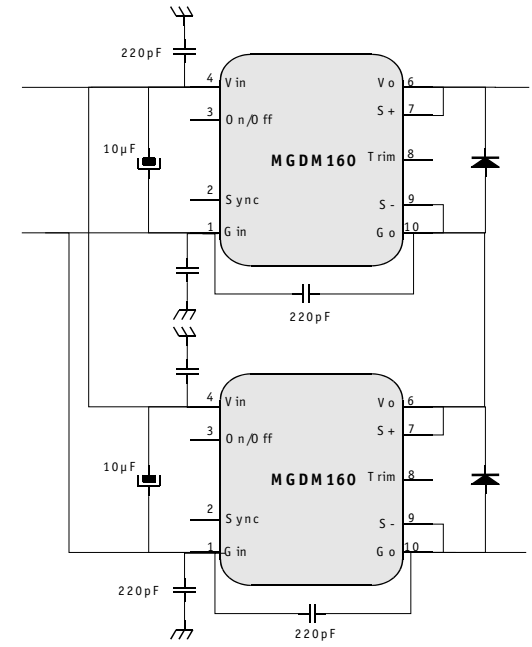
13-2 Synchronization of Modules

The MGDM-160 high input series provides a synchronization function trough the pin 2 (Synchro) to enable automatic synchronisation between several converters.
If several converters are used, they lock themselves into the highest switching frequency.
The synchronization signal available on pin 2 is referenced to ground in (Gi).



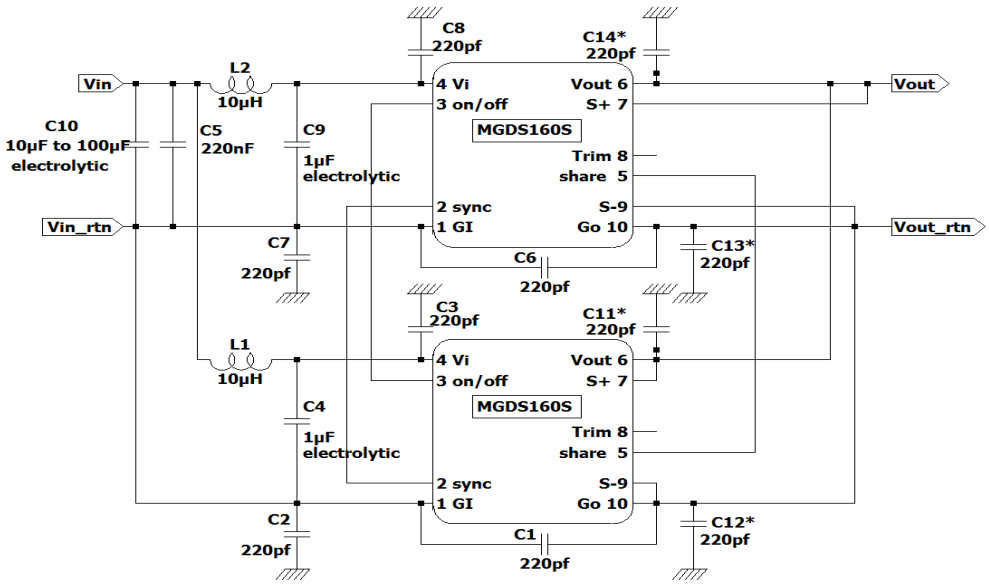
13-3 Connection of Modules in Series

The output of single output units can be connected in series without any precautions to provide higher output voltage level.
GAIA Converter recommends to protect each individual output with a Shottky diode rated with the maximum current of the converter to avoid reverse polarity at any output.
Reverse polarity may occur at start up if the output voltages are not synchronous.
Special care must be taken to layout properly low level signals Sync. and On/Off from high current tracks. They must be shielded with GIA signal to avoid any disturbances by noises and crosstalk.



13-4 Connection of Modules in Parallel

The output of single output units can be connected in parallel to provide higher output current.
routed, with coper plane around.
Special care must be taken to layout properly low level signals Sync. and On/Off from high current tracks. They must be shielded with GIA signal to avoid any disturbances by noises and crosstalk.
R are optional in case of required triming.

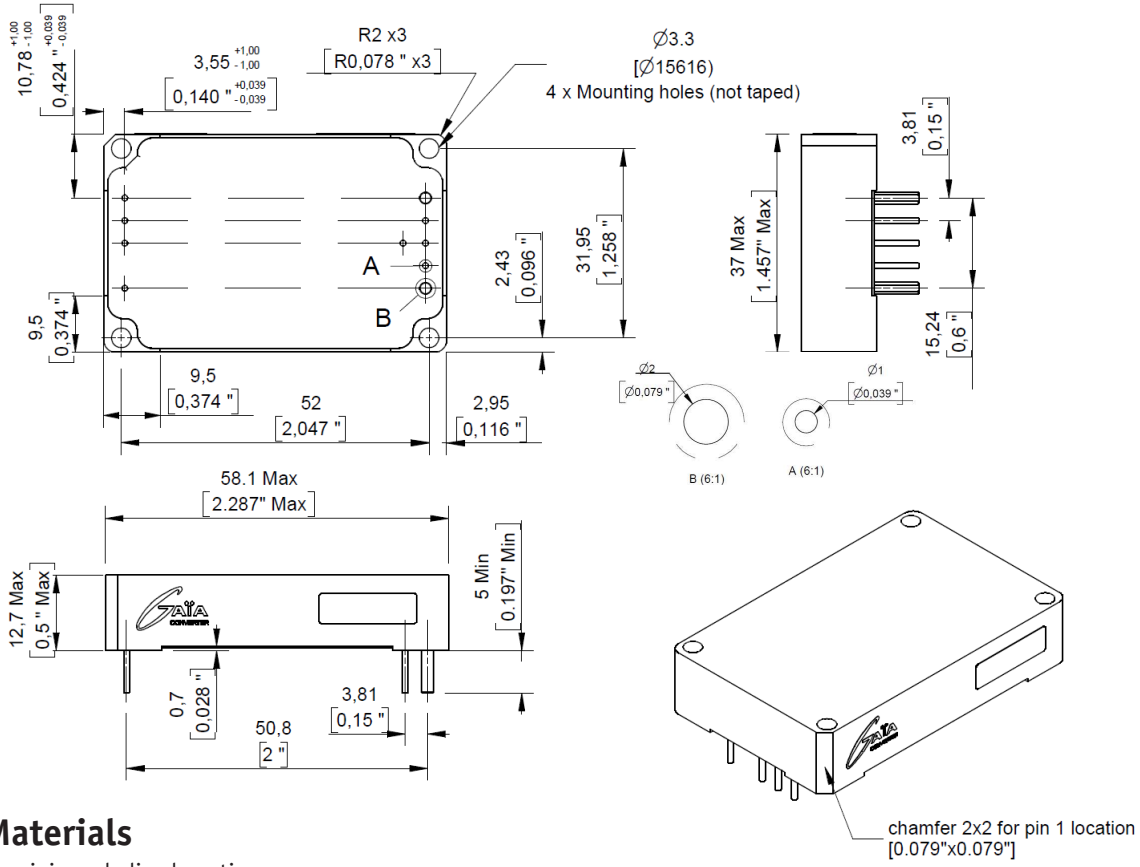


* C11,C12,C13,C14 are optional for noise reduction improvment

4

11- Dimensions

Dimensions are given in mm (inches). Tolerance : +/- 0,2 mm (+/- 0.01 ") unless otherwise indicated.
Weight : 75 grams (2.10 Ozs) max.



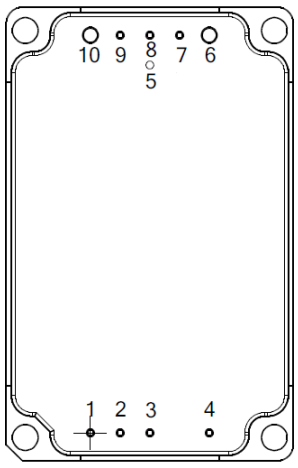
12- Materials

Case : Aluminium alodined coating.
Pins : Brass copper flash + Nickel 2 to 4µ + Flash Au.

13- Product Marking

Side face : Company logo.
: Module reference : MGDx-155-»X»-»Y».
Date code : year and week of manufacturing, suffix, /option.

14- Connections



Bottom view

Pin	Single Output
1	- Input (Gi)
2	Synchro (Sync)
3	On/Off
4	+ Input (Vi)
5	Share
6	+ Output (Vo)
7	Sense + (S+)
8	Trim (Trim)
9	Sense - (S-)
10	- Output (Go)

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