Hi-Rel DC/DC CONVERTER
MGDD-06 Ultra Wide Input : 6W POWER

Hi-Rel Grade

12:1 Ultra Wide Input
Dual Outputs
Metallic Case - 2 250 VDC Isolation

- Ultra wide input range
- Nominal power up to 6 W
- Nominal dual output voltage from 5V to 48V
- High efficiency over the entire range
- Soft start
- Galvanic isolation 2 250 VDC
- Integrated LC input filter
- Permanent short circuit protection
- External trim adjustment : -20/+10%
- No optocoupler for high reliability
- RoHS process

1-General

The MGDD-06 ultra wide input series designates a full family of DC/DC power modules with a permanent ultra wide input voltage range of 9-160. The family is designed for use in distributed power architecture where variable input voltage and transient are prevalent making them ideal particularly for avionics and military applications.
The MGDD-06 is ideal for applications where high power density is required. The MGDD-06 series is compliant with the DO-160, MIL-STD-704 and MIL-STD-1275 transient voltage standards without additional voltage limiter.
The serie includes dual output voltage choices individually isolated of 2 x 5 volts , 2 x 12 volts, 2 x 15 volts and 2 x 24 volts wih easy configuration in series, parallel or symmetry.

The total power is 6W with one single channel able to provide up to 5.4W.
All the modules are designed with LC network filters to minimize reflected input current ripple. The modules include a soft-start, an input undervoltage lock-out, a permanent short circuit and overload protection and an output overvoltage limitation to ensure efficient module protections. The soft-start allows current limitation and eliminates inrush current during start-up. The short circuit protection completely protects the modules against short-circuits of any duration by a shut-down and restores to normal when the overload is removed.
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

Dual output model : MGDD - 06 - *input* – *output*

Input Voltage Range	Output
Permanent	
R : 12-160 VDC	C : 2 x 5 VDC E : 2 x 12 VDC F : 2 x 15 VDC I : 2 x 24 VDC

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

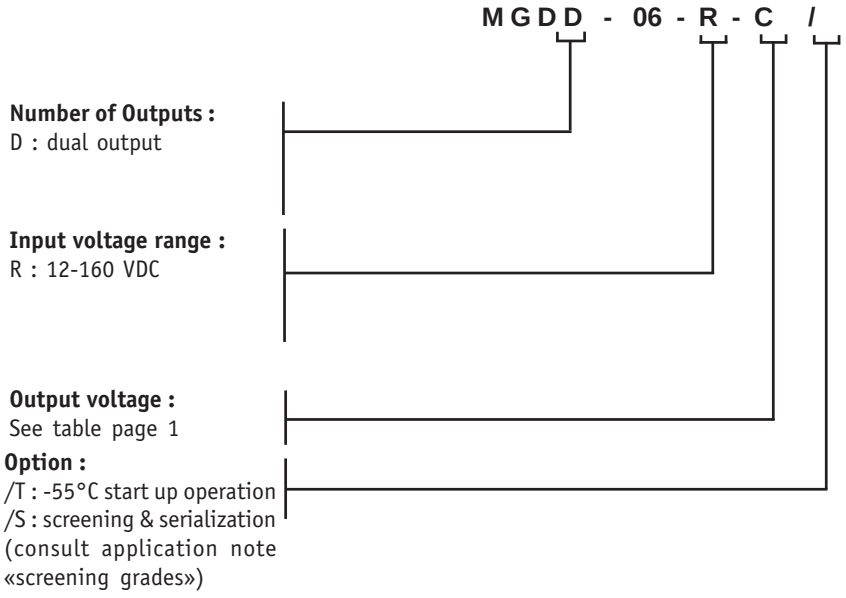
2- Product Selection (continued)

Input range	Output	Current per Output	Reference	Options
12-160 VDC	2 x 5 VDC	0,60 A	MGDD-06-R-C	/
12-160 VDC	2 x 12 VDC	0,25 A	MGDD-06-R-E	/
12-160 VDC	2 x 15 VDC	0,20 A	MGDD-06-R-F	/
12-160 VDC	2 x 24 VDC	0,125 A	MGDD-06-R-I	/
				/

Using various parallel or series connections of outputs, and the 80/110% trim capability, allows to cover almost the complete range of output voltages from 4V to 52V as shown in the table below.

Reference	Parallel Connection	Series Connection
MGDD-06-R-C	4 - 5,5 VDC	8 - 11 VDC
MGDD-06-R-E	9,6 - 13,2 VDC	19,2 - 26,4 VDC
MGDD-06-R-F	12 - 16,5 VDC	24 - 33 VDC
MGDD-06-R-I	19,2 - 26,4 VDC	38,4 - 52,8 VDC

Converter Selection Chart



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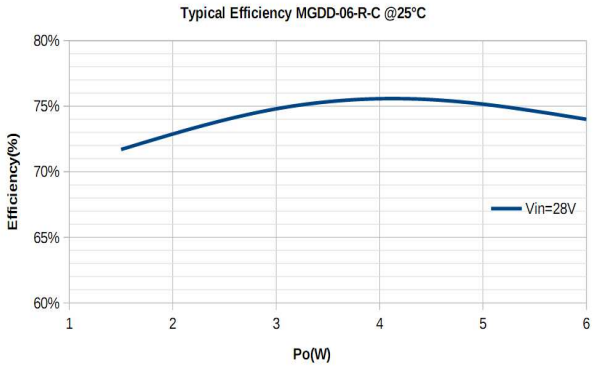
3- Electrical Specifications

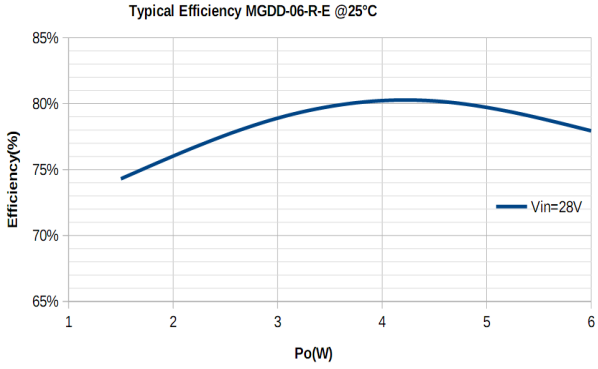
Data are valid at +25°C, unless otherwise specified.

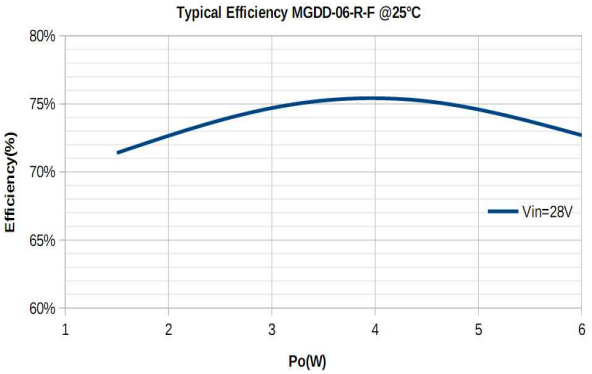
Parameter	Conditions	Limit or typical	Units	Dual Output MGDD-06-R
Input				
Nominal input voltage	Full temperature range	Nominal	VDC	28
Permanent input voltage range (Ui)	Full temperature range Full load	Min. - Max.	VDC	12-160
transient Input Voltage	Full temperature range Full load	Maximum	VDC/ms	165/1000 176/100
Undervoltage lock-out (UVLO)	Turn-on voltage (pin Uvlo open) Turn-off voltage (pin Uvlo open)	Maximum Maximum	VDC VDC	11,8 10,8
Start up time	Ui nominal within 3 ms Nominal output Full load : resistive	Maximum	ms	30
Reflected ripple current	Ui nominal, full load at switching freq. BW = 20MHz with 47µF on Vi 4,7µF on Vif	Maximum	% Inom.	10
No load input power	Ui nominal No load	Maximum	W	0,5
Standby input power	Ui nominal	Maximum	W	0,15
Output				
Output voltage	Full temperature range Ui min. to max. 75% load	Nominal Nominal Nominal Nominal	VDC VDC VDC VDC	2 x 5 2 x 12 2 x 15 2 x 24
Set Point accuracy	Ambient temperature : +25°c Ui nominal, 75% load	Maximum	%	+/- 2
Total output power with both outputs	Full temperature range Ui min. to max.	Maximum	W	6
Output current per output 5V output 12V output 15V output 24V output	 Full temperature range Full load Ui min. to max.	 Nominal Nominal Nominal Nominal	 A A A A	 0,60 0,25 0,20 0,125
Unbalanced output	Minimum load on VO1 for VO2 proper operation	Typical	W	2
Ripple output voltage ** 5V output 12V output 15V output 24V output	 Ui nominal Full load BW = 20MHz	 Maximum Maximum Maximum Maximum	 mVpp mVpp mVpp mVpp	 100 240 300 520
Output regulation * (Line + load + thermal)	Ui min. to max. 0% to full load	Maximum	%	+/- 1,5
Cross load output regulation	Ui nom VO1 at nominal load VO2 25%	Maximum	%	+10/-2
Output voltage trim	As a function of output voltage	Minimum Maximum	% %	80 110
Maximum admissible capacitive load 5V output 12V output 15V output 24V output	Ui nominal Full load Per output	 Maximum Maximum Maximum Maximum	 µF µF µF µF	 680 330 220 110
Efficiency	Ui nominal Full load	Typical	%	up to 80

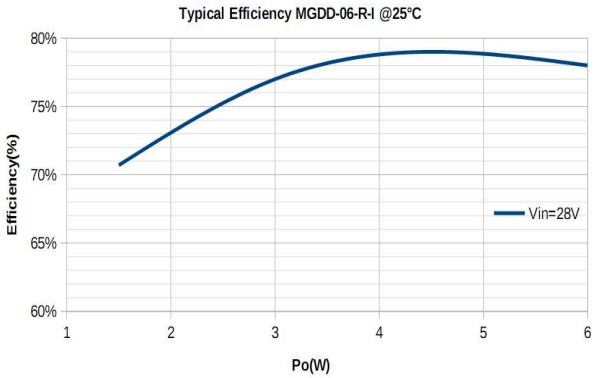
*Note * : Regulation is measured with both outputs in parallel configuration.*
*Note ** : The ripple output voltage is the periodic AC component imposed on the output voltage, an aperiodic and random component (noise) has also to be considered. This noise can be reduced by adding 1 external decoupling capacitor connected between Gin and Gout. These capacitance should be layed-out as close as possible from the converter. The ripple output voltage is measured by connecting a ceramic chip capacitor Co accross Vo and Go pins (C=100µF if Vo<5Vdc C=10µF if Vo>5Vdc)*

3- 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	270 KHz

5- Isolation

Parameter	Conditions	Limit or typical	Specifications
Electric strength voltage (Case not connected)	Input to output	Functional	2 250 VDC
	Between outputs	Functional	300 VDC
Isolation resistance	Input to case 500 VDC Output to case 500 VDC	Minimum Minimum	100 MOhm 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	Typical	130%

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 70°C	1 200 000 Hrs 700 000 Hrs
	Ground mobile (Gm)	Case at 40°C Case at 70°C	800 000 Hrs 374 000 Hrs
Mean Time Between Failure (MTBF) According to IEC-62380-TR	Railway, Payphone	Ambient at 25°C 100% time on	Consult factory

8- Electromagnetic Interference

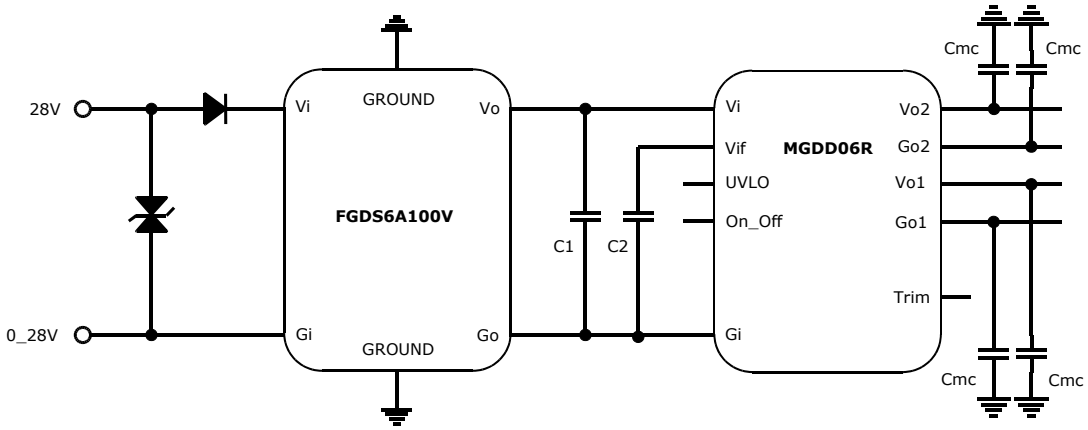
Electromagnetic interference requirements according to MIL-STD-461D/E/F/G standards can be easily achieved as indicated in the following sections. The following table summarizes the different sections covered by these standards.

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 module stand-alone
Electrical field	RE 02	RE 102	compliant module stand-alone
Radiated susceptibility (RS) :			
Magnetic field	RS 01	RS 101	compliant module stand-alone
Electrical field	RS 03	RS 103	compliant module stand-alone

8-1 Module Compliance with MIL-STD-461 Standards

To meet the latest US military standards MIL-STD-461 requirements and in particular the conducted noise emission CE102 (and also CE03) requirements, Gaïa Converter can propose an EMI filter module. In addition,common mode capacitances C_{mc} (10nF/ rated voltage depending on isolation requirement) connected between power pins and chassis or ground power-plane need to be implemented. When output channels are intended to be connected to load through long wire, it could be necessary to use additionnaly common mode inductors on each outputs. For a use at 28Vdc C1 can be rated to 47µF.

Please consult FGDS-series datasheets for further details.



MIL-STD-1275 compliant architecture.

9- Thermal Characteristics

Characteristics	Conditions	Limit or typical	Performances
Operating case temperature range at full load	Case temperature	Minimum Maximum	- 40°C 105°C
Storage temperature range	Non functionning	Minimum Maximum	- 55°C + 125°C

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, therefore the presence of radient cooling is used as a safety margin and is not considered.

- Conduction transfert : in most 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.

The majority of applications, it will be consided 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)	Conditions	Global resistance
Free air cooling only	Rth(c) : no Heatsink baseplate only	Ambient 60°C, converter on PCB	20°C/W
	Rth(tot) with heatsink ABL BGA-STD-050	Ambient 60°C, converter on PCB	14°C/W

9- Thermal Characteristics (continued)

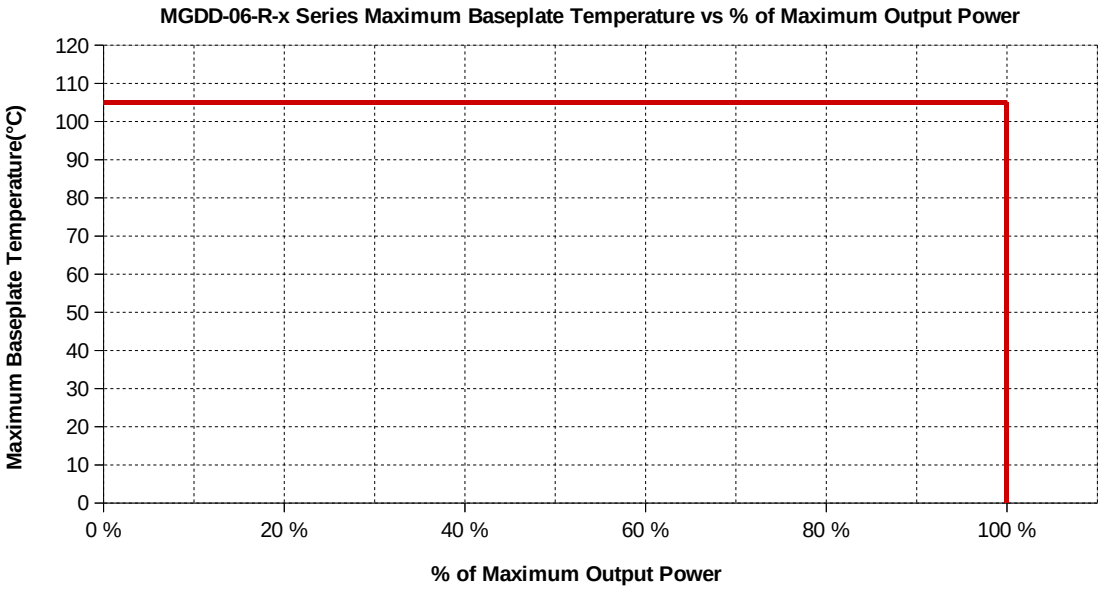
The two formulas (A) and (B) described in previous page :

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

allow 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 :

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



10- Environmental Qualifications

The modules have been subjected to the following environmental qualifications.

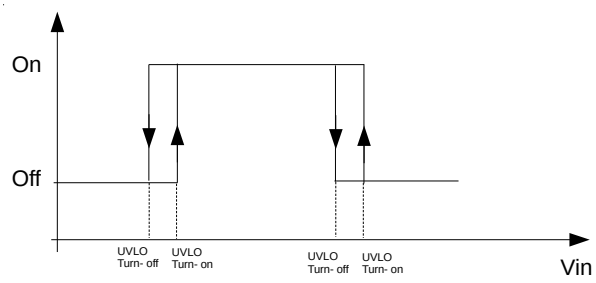
Characteristics	Conditions	Severity	Test procedure
Climatic Qualifications			
Life at high temperature	Duration Temperature / status of unit	Test D : 1 000 Hrs @ 105°C case, unit operating @ 125°C ambient, unit not operating	MIL-STD-202G Method 108A
Altitude	Altitude level C Duration Climb up Stabilization Status of unit	40 000 ft@-55°C 30 min. 1 000 ft/min to 70 000 ft@-55°C, 30 min. unit operating	MIL-STD-810E Method 500.3
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-810E Method 507.3
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-810E Method 509.3
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-810D Method 514.3
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-810D Method 516.3
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-810D Method 516.3

11- Description of Protections

The MGDD-06 series includes 2 types of protection devices.

11-1 Input Undervoltage Lockout (UVLO)

An input undervoltage protection will inhibit the module when input voltage drops below the lock-out turn-off threshold (see section 3 for value) and restores to normal operation automatically when the input voltage rises the lock-out turn-on threshold.

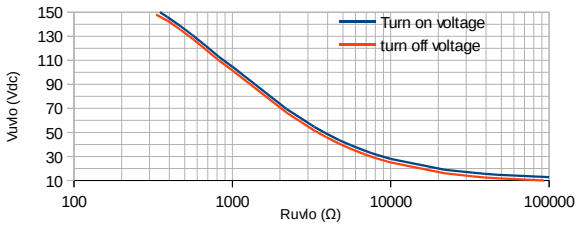


The UVLO voltage can be adjusted using a resistor (Ruvlo) connected between pin 2 and Gi. This value can be ajusted in order to allow converter to stop properly accordingly to the input bus (or battery) voltage value. The Ruvlo can be determined using the following formula :

Ruvlo (KΩ) = [200.3-Vuvlo]/[Vuvlo-11.8]
Ruvlo = trimming resistance
Vuvlo = desire turn-on voltage

Without resistor, the turn on voltage is 11.8V and turn off voltage is 10.8V

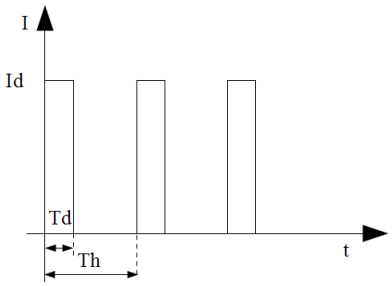
UVlo Voltage trimming



11-2 Output Over Current Limitation Protection (OCP)

The MGDD-06 Series incorporates a overcurrent protection circuit. The overcurrent protection detects short circuit or over curent and protects the module according to the hiccup graph . The maximum detection current Id is depending on input voltage Vin, temperature, and is higher than 105 % maximum nominal output curent.

When OCP is triggered, the converter falls in hiccup mode by testing periodically if the overload is still present. The module restart automatically to normal operation when overcurrent is removed. Td (detection time) and Th (hiccup period) are depending on Vin and temperature. In hiccup mode the average curent is arround 25 % of Inom.



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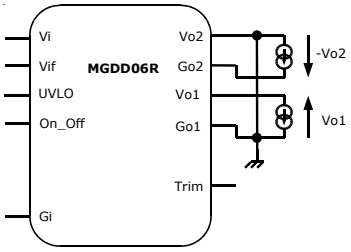
12- Description of Functions

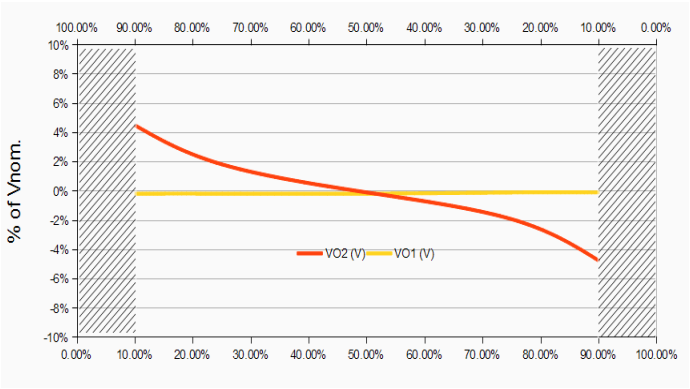
12-1 Connection of Outputs

The outputs of MGDD-06 can be connected in various configurations such as :

- connections in series
- connection in parallel
- connection in symmetry
- connection in independance

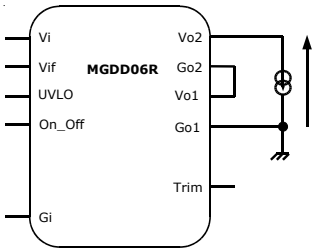
Please note that regulation is achieved through output VO1/GO1 referenced as primary output. When connected in symetrie or independant configurations with unbalanced loads, VO1/GO1 has to be loaded at 0,5W minimum to insure proper operating of the converter. The VO2/GO2 output referenced as secondary output may stay unloaded, but in that case its regulation may drift up as shown in curve below. There is no minimum load when the two outputs are connected in parallel or balanced serie.





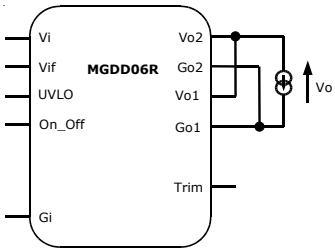
12-1-1 Connection of Outputs in Series

Outputs connected in series allow to achieve 10V, 24V, 30V or 48V output voltages up to 6W total power. These values can be extended using trim adjustment.



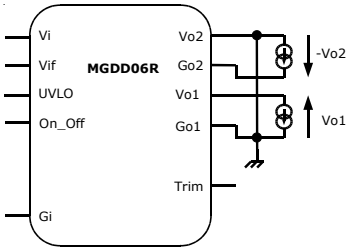
12-1-2 Connection of Outputs in Parallel

Outputs connected in paralell allow to achieve single output 5V, 12V, 15V or 24V up to 6W power. These values can be extended using trim adjustment.



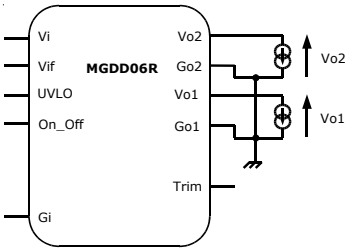
12-1-3 Connection of Outputs in Symmetry

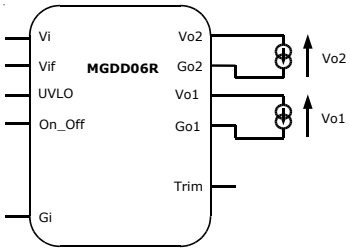
Outputs connected in symetrie allow to achieve +/-5V, +/-12V, +/-15V or +/-24V voltages (+/-3W each) with possible unbalanced loadup to 5W on primary outout, 1W on secondary output and vice versa.



12-1-4 Connection of Outputs in Independance

Outputs connected independantly with floating DC between each other can be achieved for 2x5V, 2x12V, 2x15V or 2x24V voltages (3W each) with possible unbalanced load up to 5W on primary output 1W on secondary output and vice versa.





12- Description of Functions (continued)

12-2 Trim Function

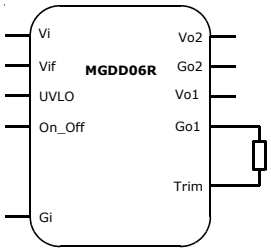
The output voltage Vo1 may be trimmed in a range of 80%/110% of the nominal output voltage (100%/110% for 3,3 Vdc output voltage) via a single external trimpot or fixed resistor.

The VO2 output will be automatically trimmed in the same value than VO1, whatever the outputs combination is.

Trim Up Function

Do not attempt to trim the module higher than 110% of nominal output voltage as the overvoltage protection may occur.

Also do not exceed the maximum rated output power when the module is trimmed up.



The trim up resistance must be calculated with the following formula :

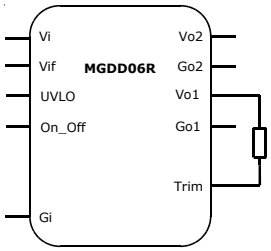
$$R_U(k\,\Omega) = 4{,}7 \cdot \frac{VO_{nom} - 1{,}225}{VO - VO_{nom}} - 0{,}27$$

Ru is trim resistor value in KOhm
VO_{nom} is nominal output voltage
VO is desired trimmed output voltage

Trim Down Function

Do not trim down more than -20% of nominal output voltage otherwise the module may be damaged.

The available output power is reduced by the same percentage that output voltage is trimmed down.



The trim down resistance must be calculated with the following formula :

$$R_D(k\,\Omega) = 4{,}7 \cdot \left(\frac{VO_{nom}}{1{,}225} - 1\right) \cdot \frac{VO - 1{,}225}{VO_{nom} - VO} - 0{,}27$$

Rd is trim resistor value in KOhm
VO_{nom} is nominal output voltage
VO is desired trimmed output voltage

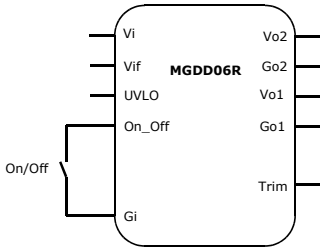
12- Description of Functions (continued)

12-3 On/Off Function

The control pin 1 (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 1.
- No connection or high impedance on pin 1 enables the converter.

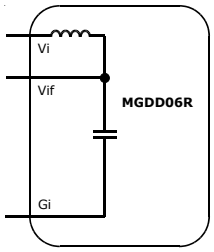
By releasing the On/Off function, the converter will restart within the start up time specifications given in table section 3



Parameter	Unit	Min.	Typ.	Max.	Notes, conditions
On/Off module enable voltage	Vdc	2.5	/	3.3	Open, the switch must not sink more than 50µA
On/Off module disable voltage	Vdc	0	/	0.5	The switch must be able to sink 0,5mA
On/Off module enable delay	ms	/	/	30	The module restarts with the same delay after alarm mode removed
On/Off module disable delay	µs	/	/	100	Vi nominal, full load

12-4 Input Filter Compensation (VIF)

The «VIF» pin is a direct access to the capacitor of the LC input filter and allows to increase the C value to enhance the converter's stability and performance and to reduce the input current ripple for improved EMI performance.
It is recommended to provide for at least 10uF/low ESR ceramic capacitors.
These capacitors should have the proper voltage rating and should be connected between «VIF» and «Gin» as close as possible from the converter, using large copper traces.



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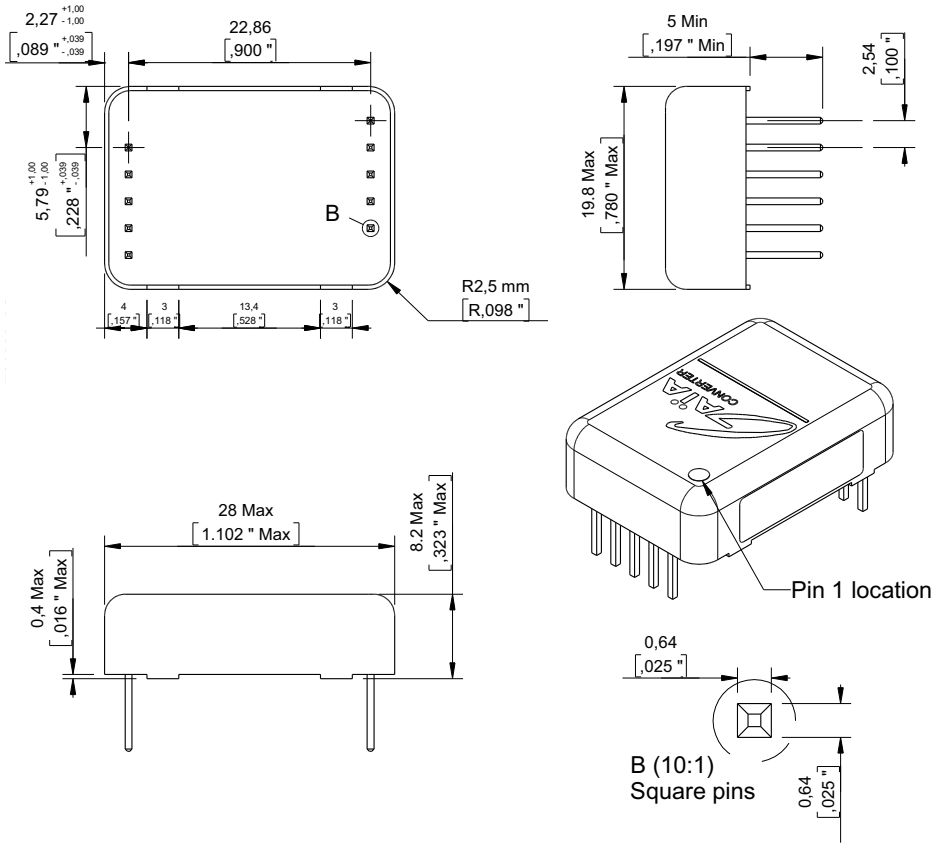
13- Dimensions

Dimension are given in mm. Tolerance : +/- 0,2 mm (+/- 0.01 “) unless otherwise indicated.
All dimensions specified “Min” or “Max” are subjected to tolerance Min$^{+0,5/-0mm}$ and Max$^{+0/-0,5mm}$.
Weight : 12 grams (0.4 Ozs) max.



14- Materials

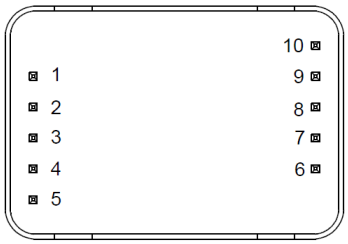
Case: Metallic black anodized coating.
Pins: Flash gold plating over nickel underplate.

15- Product Marking

Upper face: Company logo.
Side face: Module reference, option, date code : year and week of manufacturing.

16- Connections

The MGDD-06 series has been designed for on-board mounting.
it is recommended not to lay-out any component under the module.



Bottom view

Pin	Dual
1	On/Off
2	UVLO
3	- Input (Gi)
4	VIF
5	+ Input (Vi)
6	+ Output 2 (Vo2)
7	- Output 2 (Go2)
8	+ Output 1 (Vo1)
9	- Output 1 (Go1)
10	Vtrim

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CONVERTER

Represented by :

Printed in France by GAIA Converter Gaia Converter FC22-115.09/22 Revision B. Graphisme : Philippe Clicq