# DC/DC Input Bus Conditioner
# FLHGI-90 Series : 90 W Power

Industrial Grade

RoHS

## Key features

- Ultra wide input range 12-140 Vdc
- Transient 385Vdc (20ms) per RIA12
- Transient 165Vdc (1s)
- Reverse polarity protection
- Hold-up function
- Integrated EMI filter per 50121-3-2

## General characteristics

- Nominal power up to : 90 W
- Galvanic isolation input/output : No Isolation
- Protections : Reverse polarity, ASP
- dedicated to EN50155, EN50121, RIA12

## 1 - General

The input bus conditioner FLHGI-90 designates a 90 W input bus front end that enables and eases construction of power architectures for railway applications. The FLHGI-90 includes:

- An input EMI filter removing both common and differential input conducted noise to comply EN550155/EN 55022 EMC Standards.
- An input spike & surge limiter to comply EN50155/61000 and RIA12 over-voltages.
- A reverse polarity protection.
- A soft start function.
- An hold-up function.
- A synchronization output function.
- An ASP function that protects application from abnormal surge, bit switching off the down-converter supply.

Leveraging so many functions, the FLGHI-90 advantageously replaces all the input stage components of a power architecture such as filters, voltage limiter, ideal diodes, inrush current limiter and hold up modules. As a single component, the FLHGI-90 allows for a drastic reduction in space, as well as an incredible simplification of the power architecture design.

Thanks to its wide input range, the input bus conditioner operates with all standard batteries voltages, according to 3 modes of operation:

- Normal operation: When input bus voltage is within its steady state range, the FLHGI-90 acts like a buffer that transmits the input power to the DC/DC architecture with low losses, and conducted noise filtering.
- Transient operation: The FLHGI-90 clamps input transient, limiting its output voltage to the maximum voltage value acceptable by downstream DC/DC architecture. In addition, if transient operation enters an abnormal condition of voltage value or duration, an Abnormal Surge Protection function (ASP) shuts down FLHGI-90 output voltage to protect the downstream converter architecture.
- Hold-Up operation: The hold-up operation occurs when the input bus drops below a low voltage level determined by a simple external resistor. In this case, the FLHGI-90 connects the down stream converter input bus to the charged hold-up capacitor in order to pursue operation during application input bus drop.

The module is potted with a bi-component thermal conductive compound and packaged in a metallic case to ensure the module's integrity under severe environmental conditions.



## 1.1 - Product code construction

**Single output model : FLHGI - 90 - Input - Output / Options - Suffix**

**Input voltage**

. R : 12 - 140 Vdc (165 Vdc / 1 s)

**Output voltage range**

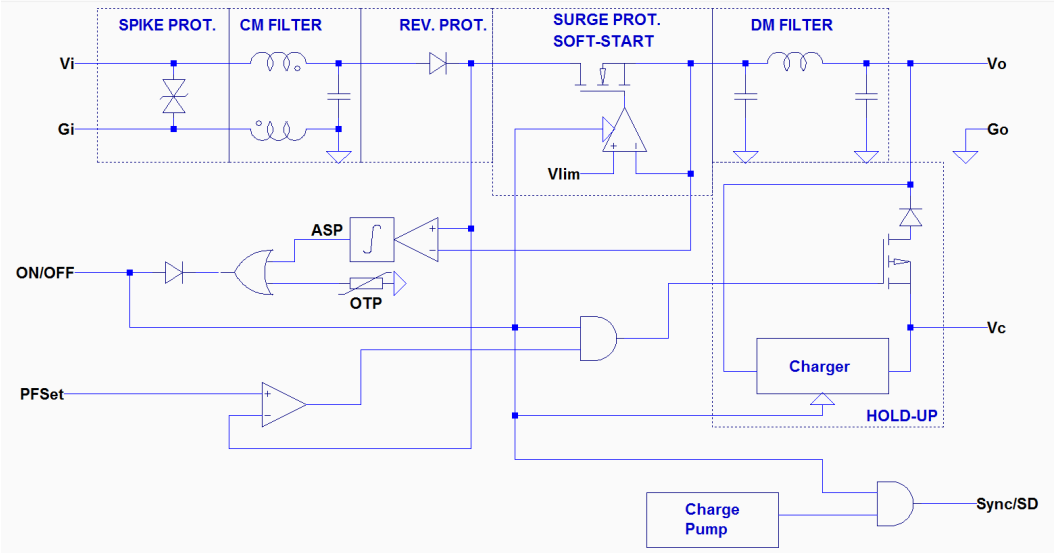
. R : 12 - 140 Vdc (Single)

Consult factory for customized specifications

## 1.2 Product selection

| Order code | Input voltage | Output voltage | Output current |
|---|---|---|---|
| FLHGI-90-R-R | 12 - 140 Vdc (Max. 165 Vdc / 1 s) | 12 - 140 Vdc | |

## 1.3 Block diagram



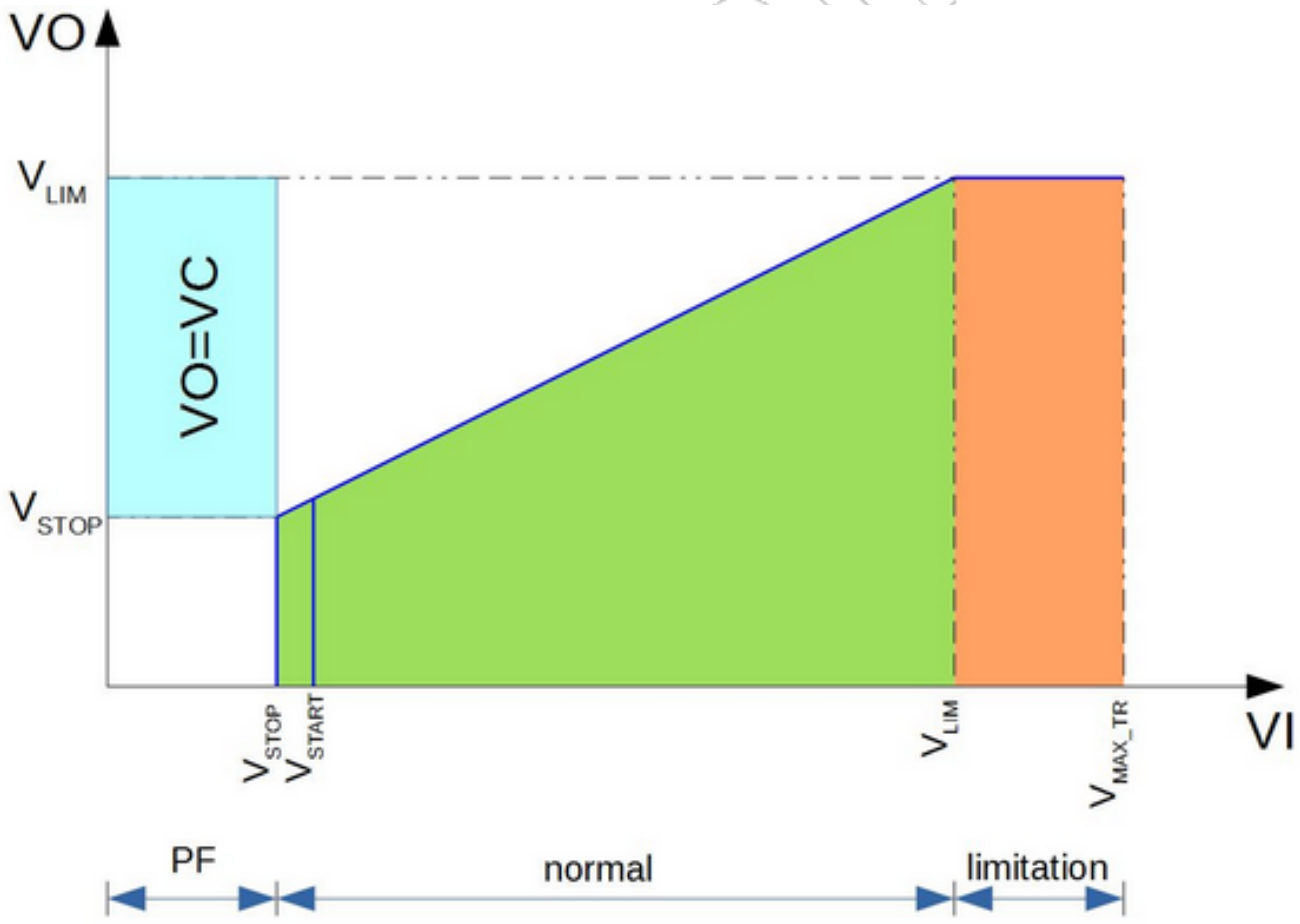
# 2 Mode of operation

## 2.2 Mode of operation

The FLHGI-90 operates according to different modesof operation that are depending on Input voltage values:

Normal operation :When input voltage is above a minimum thresholdvoltage named $Vi_{START}$ (for rising input voltage) or $Vi_{STOPS}$ (for falling input voltage), and below alimitation threshold value named $Vi_{LIM\ the}$ output pin of LHUGI-90 is connected to its output pin through an unidirectional switch.
Power fail operation : The power fail operation occurs when the input busdrops below a value (Vth) determined by the value of the resistor connected to the pin (PF-set). .In this case the switching MOSFET linking Vi toVo become open. An other internal switche connects the Pin Vc to the pin Vo, allowing downstream architecture converter to be supplied by the Hold-Up capacitor
Transient operation : when input voltage bus goes above $V_{LIM}$,The FLHGI-90 clamps the input transient, and limits the output to $V_{LIM}$:
On/Off operation : when On/off pin is tied to GO The FLHGI-9 output isdisconnected from the input. The on/off operation overrides the normaloperation and transient operation.
ASP Protection : when an abnormal transient voltage occurs at the input (transient longer than described in standards) the FLHGI-90 triggers the ASP function that place the module in off mode.

The figure opposite describes these modes of operation: $Vi_{START\ :}$starting voltage at rising- $Vi_{STOPS:}$ stop input voltage at falling, $Vi_{LIM\ :}$ maxinput voltage in normal operation mode, VimaxTR: max allowed surge voltage,VOLIM : max output voltage VOSTOP: min output voltage.



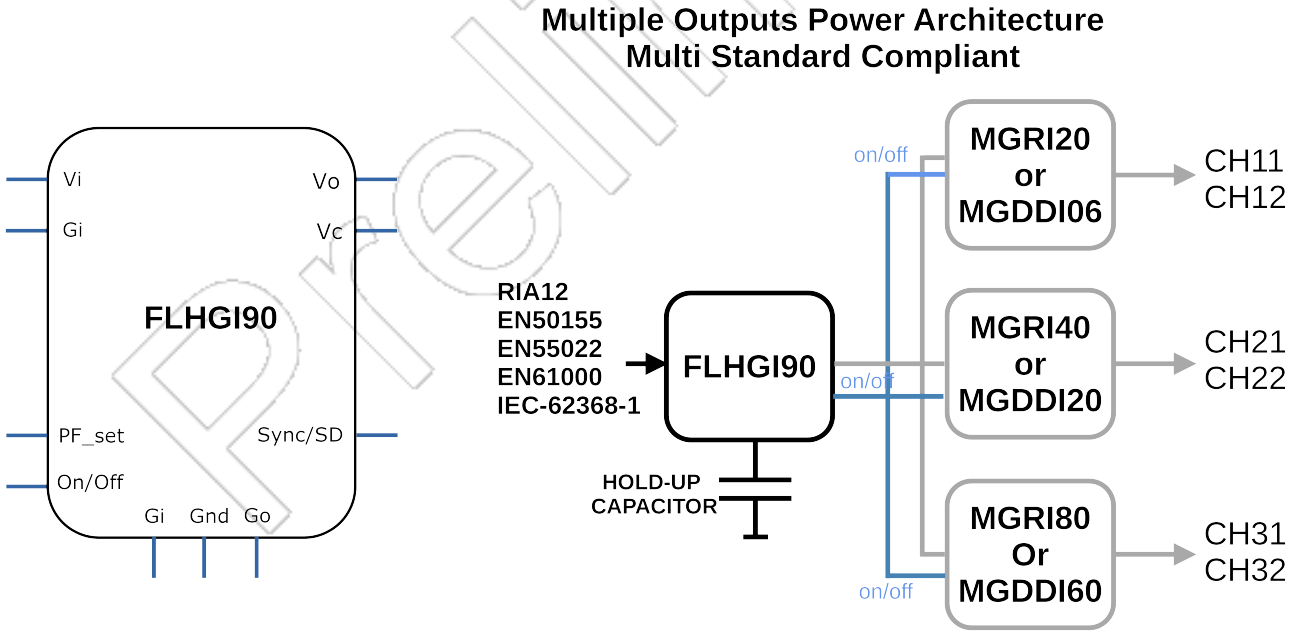
# 2 Mode of operation

## 2.3 Application

Pin functions:
Power Pins :
Vi (input) : Input power pin referenced to Gi.
Gi (input) : Power ground pin.
GND(Chassis) : terminal connected to internal common mode cap to tie to chassis.
Go (output) : Output power ground pin (this pin is internally connected to Gi through common mode inductor).
Vo (output) : Output power pin referenced to Go.
Vc (output) : Charger output pin to connect to Hold-up capacitor. This pin is referenced to Go

Control & Monitoring Pins :

PF_set (input/output) : a resistor connected between this pin and Go will adjust the power fail voltage level.
Syn/SD (output) : this pin is designed to be connected to the on/off pin of donwstream converter trhough a diode in order to control the on/off function
on/off (input): when this pin is tied to Go, the FLHGI90 stops operation and its Syn/SD falls to Go level.
Application to MGRI power archtecture :
The FLHGI90 is an input bus conditionner designed to drastically simplify the RailWay compatible power supplies construction. Developped to be used in conjuction with GAIA converter's reinforced isolation dc/dc of the MGRI families, the input bus conditionner requires only few external components to acheive multiple bus compliance. The bus conditioner application example is presented in the diagram below.



# 3 Electrical specifications

## 3.1 Input

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

| Parameter | Condition | Limit or typical | Unit | Values |
|---|---|---|---|---|
| Input voltage range | Full temperature range | Min. - Max. | Vdc | 12 - 140 |
| Transient input voltage | 1 s | Max. | Vdc | 165 |
| Voltage drop @ I max | 24 Vdc input voltage | Max. | Vdc | 1.6 |
| | 110 Vdc input voltage | Max. | Vdc | 1.2 |
| No load input current | 48V input voltage | Max. | mA | 2 |
| Start up time on power-up | Full load, Full temperature range | Max. | ms | 2 |
| Input Voltage Surge | RIA12 Waveform A, 0.2 Ohms source impedance | Max. | Vdc/ms | 385/20 |
| | RIA12 Waveform B, 0.2 Ohms source impedance | Max. | Vdc/s | 165/1 |
| | RIA12 Waveform D, 5 Ohms source impedance, with additional TVS | Max. | Vdc/µs | 1800V/50 |
| | RIA12 Waveform G, 100 Ohms source impedance, with additional TVS | Max. | Vdc/µs | 1800V/50 |
| | EN50155 /61000 Level 3, 2 Ohms source impedance, with externel TVS | Max. | Vdc/µs | 2000/50 |
| | EN50155 /61000 Level 4, 2 Ohms source impedance, with externel TVS | Max. | Vdc/µs | 4000/50 |
| Reverse input voltage | Full load, Full temperature range | Max. | Vdc | 385 |

Ui stands for Input voltage

## 3.2 Output

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

| Parameter | Condition | Output type | Output | Limit or typical | Unit | Values |
|---|---|---|---|---|---|---|
| Output voltage | | S | R | | Vdc | 12 - 140 |
| Nominal output voltage in normal operation | Full load, Full temperature range | | | Min. - Max. | Vdc | Ui-drop-out voltage |
| Output power (1) | Ui min to Ui max | | | Max. | W | 90 |
| Maximum outpul clamping voltage | Full load, Full temperature range | | | Max. | Vdc | 152 |
| Absolute Max output current | Full load, Full temperature range | | | Max. | A | 4 |
| Output current | 24 Vdc input voltage | | | Max. | A | 4 |
| | 110 Vdc input voltage | | | Max. | A | 0.9 |

(1) it is recommended to manage module cooling, with heatsink or cold plate.

## 3.3 Hold-Up function

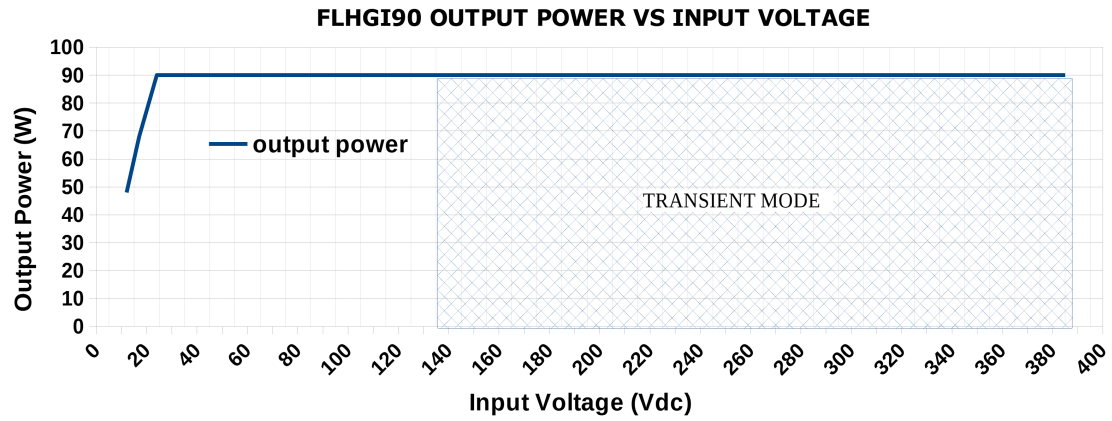
| Parameter | Condition | Limit or typical | Unit | Values |
|---|---|---|---|---|
| Maximum hold-up capacitor voltage (Vch) | Full temperature range 17 Vdc < Ui > 160 Vdc | Typical | Vdc | 110 |
| Charger power | Full temperature range 17 Vdc < Ui > 160 Vdc | Typical | W | 6 |
| Charger switching frequency | Full load, Full temperature range | Typical | KHz | 300 |
| Admissible hold-up capacitance | Full load, Full temperature range | | µF | 20000 |
| Power fail voltage threashold (Vth) | Adjustable with an external resistor | | Vdc | 18 to 60 |
| Recommended transistion capacitance | Full load, Full temperature range | Typical | µF | 47 |
| Power fail hysteresis | Full load, Full temperature range | Max. | Vdc | TBD |

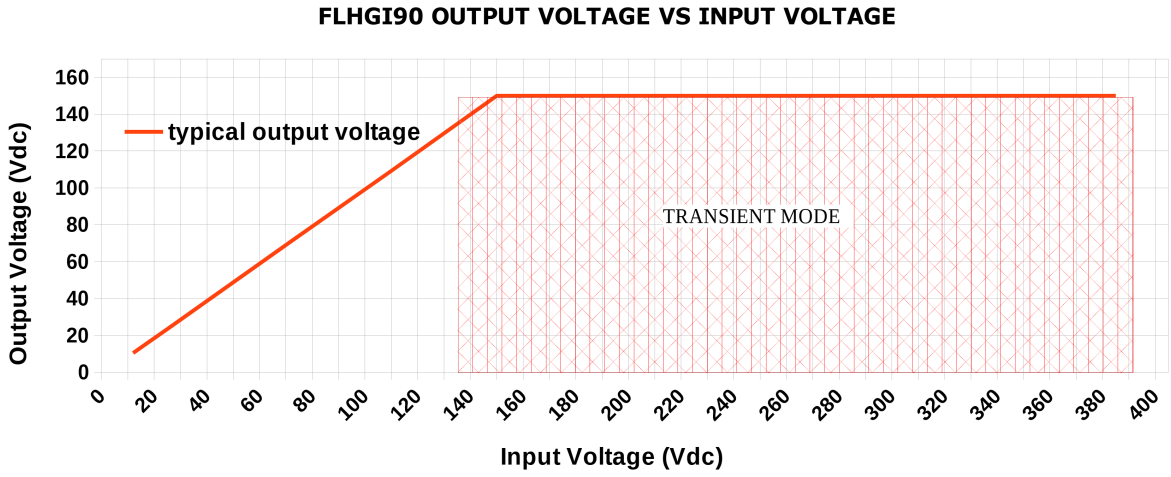
## 3.4 Protection functions

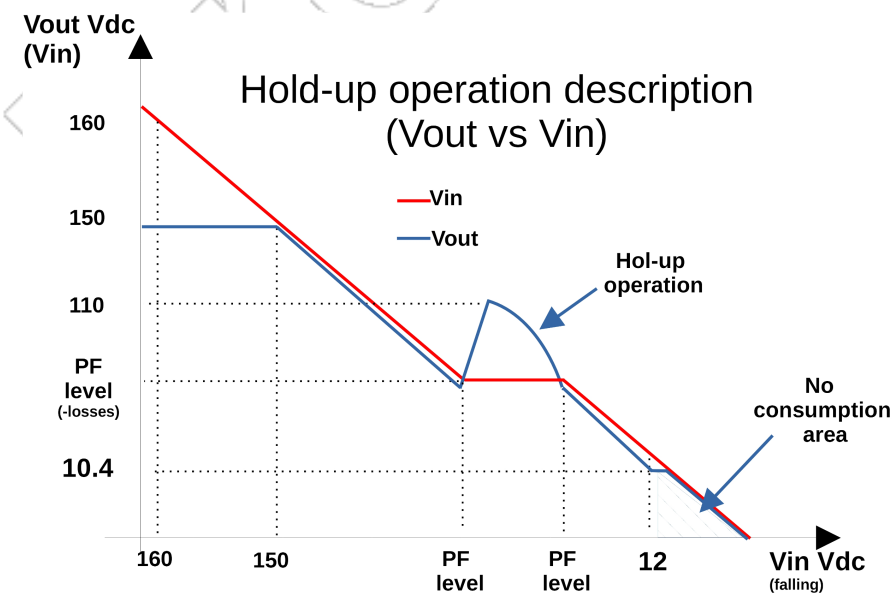
| Parameter | Condition | Limit or typical | Unit | Values |
|---|---|---|---|---|
| ASP : Abnormal Surge Protection | Stops operation after a duration depending on over voltage level | Typical | S.V | 19 |
| On/Off module disable delay | Ui nominal | Max. | µs | 100 |
| On/Off module enable voltage | Ui nominal | Min. - Max. | Vdc | 2 to 4.5 |
| On/Off module disable voltage | Ui nominal | Min. - Max. | Vdc | 0 to 0.5 |
| On/Off module enable delay | Ui nominal | Max. | ms | 30 |
| Over temperature protection (OTP) | Turn-off level | Nominal | % | 110 ± 5 |
| | Hysteresis | Nominal | °C | 10 |

## 3.5 Electrical plots

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




Hatched areas shows transient operation mode.
The no consumption area indicates that below the given voltage input bus will be transmited to input of dc/dc converter, that should not draw current.

## 3.6 Description of protections

| Parameter | Condition | Limit or typical | Unit | Values |
|---|---|---|---|---|
| On/Off module disable delay | Ui min to Ui max | Max. | µs | 100 |
| On/Off module disable voltage | Ui min to Ui max | Min. - Max. | Vdc | 0 to 0.5 |
| On/Off module enable delay | Ui min to Ui max | Max. | ms | 30 |
| On/Off module enable voltage | Ui min to Ui max | Min. - Max. | Vdc | 2 to 4.5 |
| Over temperature protection (OTP) | Turn-off level | Nominal | % | 110 ± 5 |
| | Hysteresis | Nominal | °C | 10 |

## 3.7 Isolation

| Parameter | Condition | Limit or typical | Unit | Values |
|---|---|---|---|---|
| Isolation test voltage | Input to output | Typical | | No Isolation |
| | Input to case | Min. | Vdc/s | 500 |
| | Output to case | Min. | Vdc/s | 1 500 / 60 |

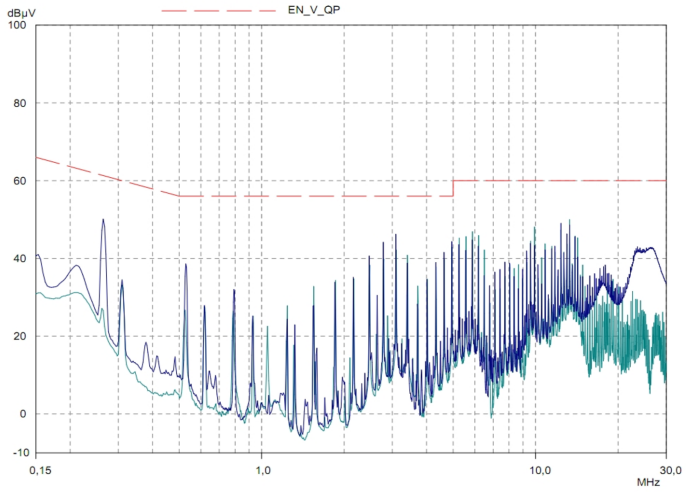
## 3.8 Reliability Data

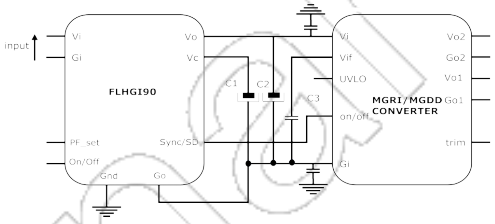
| Parameter | Condition | Limit or typical | Unit | Values |
|---|---|---|---|---|
| MTBF IEC62380-TR Reliability | Ambient temperature +55°C, Civilian avionics, calculators | | Hrs | TBD |
| MTBF MIL-HDBK217 Reliability | Case at 40°C, Ground fixed (Gf) | | Hrs | TBD |
| | Case at 85°C, Ground fixed (Gf) | | Hrs | TBD |
| | Airborne, inhabited, cargo (AIC), Case at 40°C | | Hrs | TBD |
| | Airborne, inhabited, cargo (AIC), Case at 85°C | | Hrs | TBD |

# 4 Electromagnetic interferences specifications

## 4.1 Compliance requirements

Electromagnetic Interference requirements according to EN55022 standards can be easily achieved as indicated in the following section




**EN 50022 conduced EMI plot @ 48V in 80W out (MRGDI80RE, C2 = 47µF C1 = 330µF )**

| Parameter | Standard | Level | Compliance |
|---|---|---|---|
| Railway application Electromagnetic compatibility | EN 50121-3-2 | | Compliant module stand-alone |
| Auxiliary DC power port | EN 5016-2-1 | | Compliant module stand-alone |
| Emission- Battery power supply | EN 5016-2-1 | | Compliant module stand-alone |
| conducted disturbance at main port | EN 50022 | | Compliant module stand-alone |

# 5 Thermal specifications

## 5.1 General

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, heat will be removed from the baseplate either with :

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

To calculate a maximum admissible ambient temperature the following method can be used. Knowing the maximum baseplate temperature **Tcasemax** of the module, the power used **Pout** and the efficiency :

- determine the power dissipated by the module **Pdiss** that should be evacuated: **Pdiss = Iin x(Vin-Vout) (A)** where In is the input current and Vin =Vi pin voltage and Vout=Vo pin voltage.
- determine the maximum ambient temperature :

- **Ta = Tcasemax °C - Rth(b-a) x Pdiss (B)** where Rth(b-a) is the thermal resistance from the baseplate to ambient.

This thermal Rth(b-a) resistance is the sum 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 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.

| Parameter | Condition | Limit or typical | Unit | Values |
|---|---|---|---|---|
| Operating case temperature range | With cooling device | Min. - Max. | °C | -40 to 105 |
| Storage temperature | Not operating | Min. - Max. | °C | -55 to 125 |
| Thermal resistance | | Typical | °C/W | 11 |

# 6 Description of functions

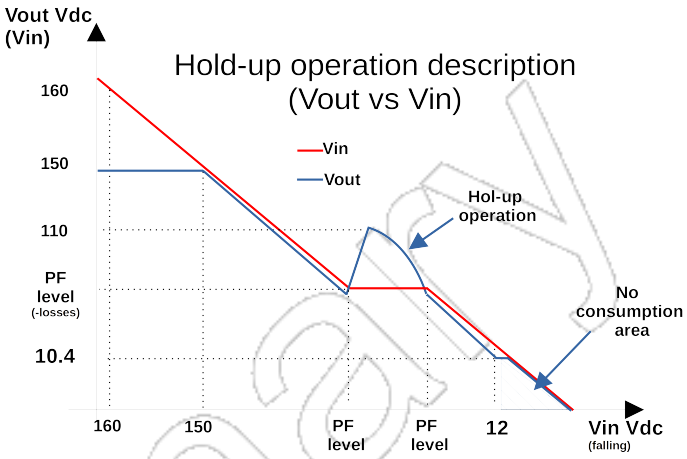
## 6.1 Hold-Up function

The Hold-up section of the LFLHGI90 features a constant power charger that allows to charge a Hol-up capacitor with a total control of inrush current. The hold-up function process follows the given sequence :

1) during normal operation, the internal charger maintains voltage accros hold-up capacitor to the specified value (see chapter 3.3). during this phase the capacitor is not connected to the output pin of FLHGI90.

2)During input bus interruption, when the input bus reaches the powerfail voltage (PF) set by Rth resistor, FLHGI90 connects Hold-up capacitor to the Vo pin, and disconnect the Vo pin from the Vin pin.

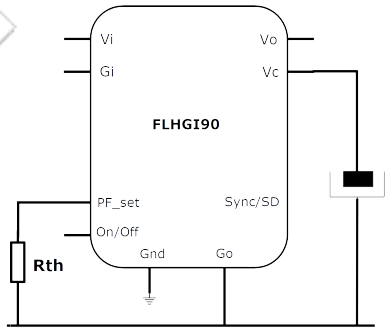
3) When input bus recovers power fail voltage + hysteresis value, the Vo pin is reconnected to Vin and Hold-up capacitor reconnected to the charger.




## 6.2 Power fail voltage threshold : Vth

The power fail voltage threshold of FLHGI90 can be adjusted with a simple low power resistor connected between PF_SET pin and GO. When input bus voltage is above the PF( power fail) voltage threshold , the input bus conditioner operates in normal mode.When voltage of input bus is below the PF voltage threshold , the input bus conditioner operates in hold-up mode mode, disconnecting input from output and connecting hold-up capacitor (Vc pin)to the Vo output pin.

The Rth value in KOhms can be calculated using the following formula where Vth is the power fail voltage threshold :
Rth = (770.4-12.4xVth) / (6.2xVth -75.2)




| Rth (KΩ) | PF_Set (Vth in Vdc) |
|---|---|
| 15 | 18 |
| 8.6 | 21.5 |
| 1 | 45 |
| 0.1 | 59 |

## 6.3 Hold-up capacitor selection

The hold-up capacitor final charged voltage is not trimmable and fixed to Vch (see section 3.2). To calculate the capacitor value for a given output power and a required hold-up time, the following formula (oposite) need to be applied.
* final hold-up capacitor voltage given section 3.3.
** trimmable power fail voltage threshold given section 3.3, see section 7.2
*** Downstream converters output power.

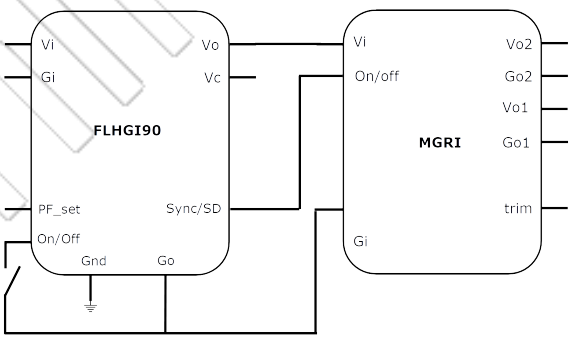
$$C = \frac{2 * P * T}{eff * (Vch^2 - Vth^2)}$$

C = Hold-up capacitor Value
P = converter output power
T = expected hold-up time
Vch = Capacitor final voltage *
Vth = Power fail voltage**
eff = Converter efficiency

| Hold-Up Capacitor value selection | | | | |
|---|---|---|---|---|
| Vth (Vdc) | 20 | 20 | 36 | 36 |
| Output Power*** | 20 | 80 | 20 | 80 |
| hold up capacitor value C (µF) | **220** | **820** | **220** | **900** |
| hold-up time :T (ms) | 50 | 50 | 50 | 50 |

## 6.4 On/Off function

The control pin (On/Off) can be used in applications requiring On/Off operation. This may be done with an open collector transistor, a switch, a relay or an optocoupler. Several input bus conditioners may be disabled with a single switch by connecting all On/Off pins together.
The input bus conditioners is disabled by pulling On/Off pin low, and output sync/SD pin will be also tied to Go, in order to desable downstrem converters. When input bus conditioners is in off mode, its output is disconnected from its input
No connection or high impedance on On/Off pin enables the input bus conditioners




## 6.5 Reverse polarity protection

The FLHGI90 incorporates reverse polarity protection that protects the downstream DC/DC architecture from damage.The maximum acceptable Vo- Vin level is given in section 3.1.
When an reverse voltage is applied to the input the FLHGI90 output is no longuer delivering power.

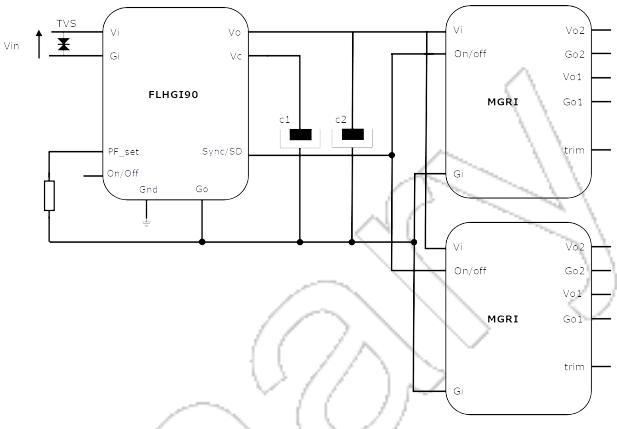
## 6.6 ASP Function

The FLHGI90 embeds an Abnormal Surge Protection (ASP) function that drops output voltage Sync-SD pin level to 0V when input voltage remains in transient range for too long. The ASP fucntion is caracterized with the product of input voltage by duration (see section 3.4)
.

# 7 Application notes

## 7.1 Typical architecture

As shown in the diagram opposite, the FLHGI90's high level of front-end integration makes it possible to build a complete power supply architecture, from the input connector to the output load. The FLHGI90 provides power supply reliability , standard compliance, and protection level in the simplest way possible.
C1 is the hold-up capacitor, C2 is the trnasition capacitor TVS value depends on input bus voltage.




Architecture drawing is a simplified diagram with only main components shown

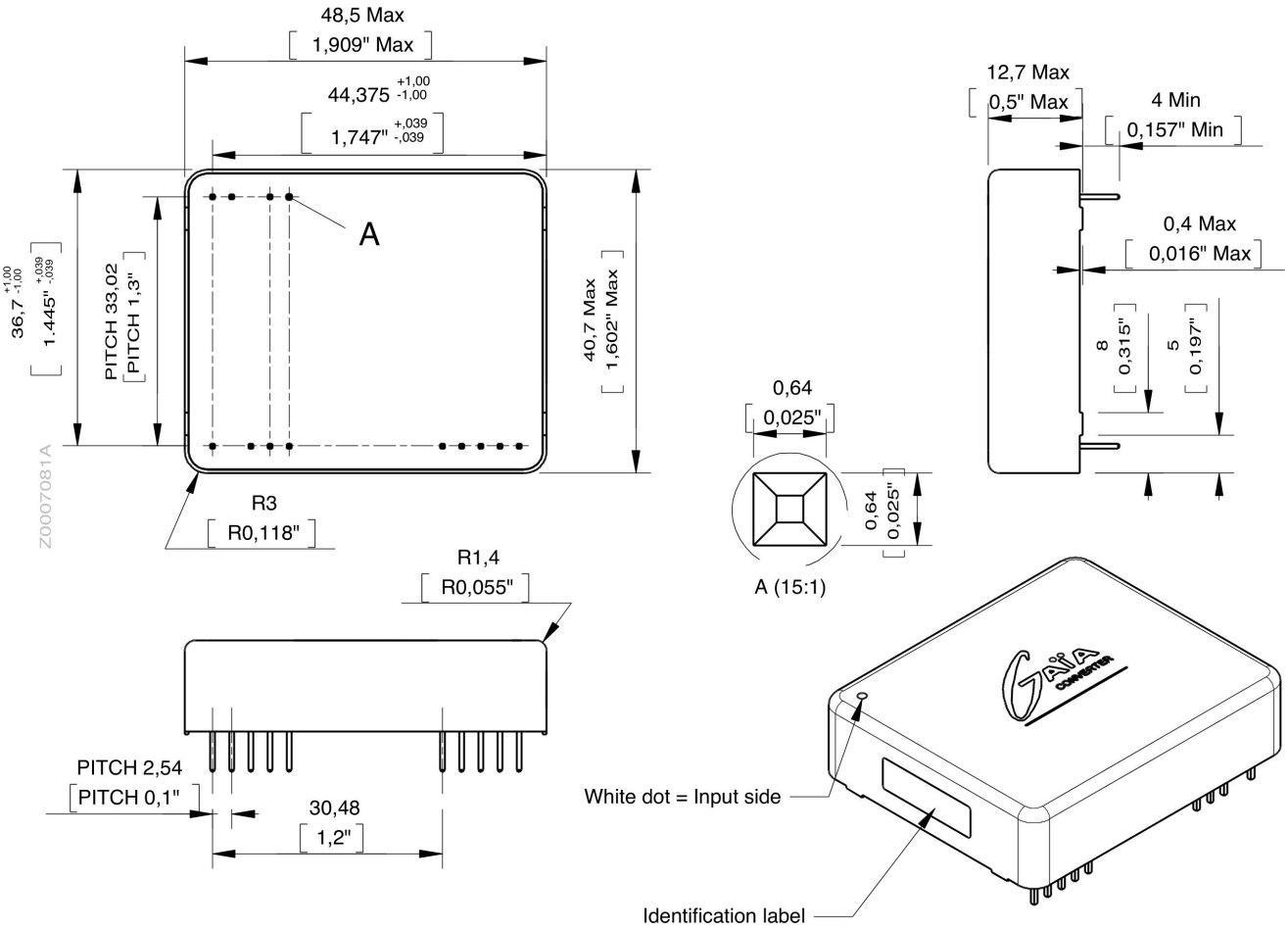
# 8 Mechanical specifications

## 8.1 Dimensions

Dimensions are given in mm (inches). Tolerance : +/- 0,2 mm (+/- 0.01 “) unless otherwise indicated.

| Parameter | Condition | Limit or typical | Unit | Values |
|---|---|---|---|---|
| Case dimensions | | Max. | mm | 48.5 x 40.7 x 12.7 |
| Height | | Max. | mm | 12.7 |
| Weight | | | Grams | 85 |
| | . | | Oz | 3 |
| GAIA Overall package | | | | 2.0-1.6-0.5 |

Dimensions are given in mm [inch].
General tolerance is +/-0.2mm [+/-0.008"] unless otherwise indicated.
All dimensions specified "min" or "max" are not subjected to the general tolerance.



## 8.2 Materials

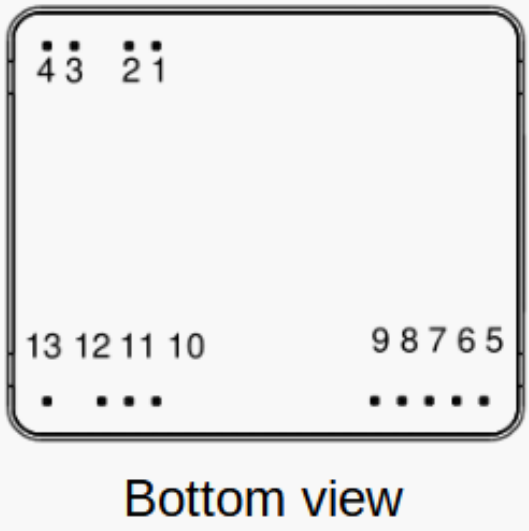
| Parameter | Condition | Limit or typical | Values |
|---|---|---|---|
| Case material | | | Metallic black anodized coating |
| Pins | | | Gold flash over nickel |

## 8.3 Product marking

Side :

- Company logo.
- Module reference
- Date code : year and week of manufacturing, suffix, /option.

## 8.4 Connections




Bottom view

| Pin | Function |
|---|---|
| 1 | GI |
| 2 | GI |
| 3 | VI |
| 4 | VI |
| 5 | SYNC_OUT |
| 6 | PF SET |
| 7 | ON/OFF |
| 8 | GO |
| 9 | GO |
| 10 | VC |
| 11 | VO |
| 12 | VO |
| 13 | GND |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